

**Determinants of infant mortality in Luapula province, Zambia: A further
analysis of the 2018 Zambia Demographic and Health Survey**

By

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**A dissertation submitted to the University of Zambia in Partial fulfilment
of Requirements of the Degree of Master of Arts in Population Studies**

The University of Zambia,

Lusaka

2021

DECLARATION

I, **PETER MUMBA** hereby declare that this dissertation; represents my work, has not previously been submitted for a degree at this or any other University and does not incorporate any published work or material from another dissertation.

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APPROVAL

This dissertation of **PETER MUMBA** is approved as a fulfilling part of the requirements for the award of the degree of Master of Arts in Population Studies at the University of Zambia.

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DEDICATION

This dissertation is dedicated to my paternal grandfather (**Barthlomeu Mumba**) who answered the Lords call in February 2021 and to all the Zambian mothers who lost their children before celebrating their first birthday.

ACKNOWLEDGEMENTS

"It always seems impossible until it's done" Nelson Mandela. Throughout the writing of this dissertation I have received a great deal of support and assistance from family and friends. This work would not have been possible without their financial and moral support during the course of this academic journey. I extend my gratitude to you all.

I would first like to thank my supervisor, **Dr.V.H Chisumpa**, whose expertise was invaluable in formulating the research proposal. Your insightful feedback pushed me to sharpen my thinking and brought my work to a higher level. Your office was always open and you provided quick feedback in times of need, which enabled me to complete my dissertation in time.

I would like to acknowledge **Ronald Mungoni** and colleagues from the 2018/2019 MA Population Studies cohort for the wonderful collaboration.

Most importantly, I wish to thank my parents, **Esto Mumba**, and **Gift Namwawa** not forgetting my two wonderful sisters, **Diana** and **Faidessy Mumba**, who provide unending inspiration.

Lastly, I am grateful to the Almighty God for the continued good health and enabling me to complete my studies.

ABSTRACT

Infant mortality still remains a subject of growing interest and debate among researchers as it is an indicator of quality life. Luapula province has been consistently experiencing the highest number of infant deaths in Zambia as evidenced by the Zambia Demographic and Health Survey. Luapula province had the highest infant mortality of 158, 154, 97 and 67 deaths per 1000 live births in 1996, 2002, 2007 and 2018 respectively, with an exception of 2014 when it had the second highest infant mortality of 55 deaths per 1000 live births. Therefore, the study aimed to investigate the determinants of infant mortality in Luapula province by applying the Cox proportional regression model which incorporates the aspect of time. The study used the 2018 Zambia Demographic and Health Survey. The study used descriptive statistics (levels), log-rank tests and multivariate Cox proportional regression model.

The study found that 1 in every 15 children dies before the age of 1 in Luapula (67 deaths per 1000 live births). The study indicated that children born in a household with 6 or more members [AHR: 0.45; 95% CI: 0.298-0.691] had significantly reduced hazards of dying compared to children born in households with less than 6 members. The study also showed that children born to mothers aged less than 20 years were two times more likely to die compared to children born to mothers aged 20-29 years [AHR: 2.09; 95% CI:1.354-3.244]. Further, the study revealed that children who were not breastfed by their mothers were 72 per cent more likely to die compared to children breastfed by their mothers [AHR: 1.72; 95% CI: 1.185-2.054]. Children born in a preceding birth interval of less than 24 months had significantly increased risks of dying compared to children born to mothers with a preceding birth interval of 24-47 months [AHR: 2.88; 95% CI:2.005-4.146].

The results further reveal that children born to mother's not using contraceptives were 66 per cent more likely to die compared to children born to mothers using contraceptives [AHR: 1.66; 95% CI:1.157-2.386]. The following maternal and child explanatory factors were not significant: marital status, maternal education, maternal employment status, wealth quintile, sex of household head, paternal education, residence, religion and child's sex.

In conclusion, only bio-demographic factors were significant determinants of infant mortality in Luapula. There is need to examine the dynamics of household size and its relative effect on child survival in Luapula.

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ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
BDHS	Bangladesh Demographic and Health Survey
CDC	Centre for Disease Control and Prevention
CSO	Central Statistical Office
DLHS	District Level Household Survey
DHS	Demographic and Health Survey
EAs	Enumeration Areas
EPI	Expanded Programme on Immunization
GDP	Gross Domestic Product
HIV	Human Immune Virus
ICCM	Integrated Community Case Management
IMCI	Integrated Management of Childhood Illnesses
IMR	Infant Mortality Rate
MDGs	Millennium Development Goal
NDHS	Nigeria/Nepal Demographic and Health Survey
RDHS	Rwanda Demographic and Health Survey
SDGs	Sustainable Development Goals
TDHS	Tanzania/Turkey Demographic and Health Survey
UNICEF	United Nations Child Fund
WHO	World Health Organisation
ZDHS	Zambia/Zimbabwe Demographic and Health Survey

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 Background

It is every country's goal in Sub Saharan Africa (SSA) to reduce fertility to ensure a balance between population growth and the demand for natural resources. However, this has not been the case because of high child mortality experienced in these countries. Parents opt to have more children to replace those that might die. The Millennium Development Goals (MDGs) were implemented from 2000 to 2015 to reduce child mortality indicators by two thirds. In most SSA countries including Zambia, the MDG number four was not met (Ministry of National Development and Planning, 2008).

Despite most of the countries, especially SSA countries, failing to meet the MDGs, the world began working towards Sustainable Development Goals (SDGs) seeking to achieve them, by 2030. The proposed SDGs target for child mortality is to reduce neonatal mortality to at least as low as 12 deaths per 1,000 live births and under-5 mortality to at least as low as 25 deaths per 1,000 live births (UNICEF, 2019).

There has been a gradual decline in infant mortality at global and regional levels over the last 100 years. However, SSA countries experienced the reversal because of the HIV pandemic which hit the region in the 1990s (Sartorius and Sartorius, 2014).

The leading causes of infant mortality in 2017 were preterm birth complications, acute respiratory infections, intrapartum-related complications, congenital anomalies, and diarrhoea. Children less than one month old, accounted for 47 per cent of under-five deaths in 2017. Infant mortality can be reduced significantly by training and improving access to skilled health professionals for antenatal and postnatal care. In addition to this, sensitising families on the dangers signs or symptoms would also help in reducing infant mortality. Improving access to water, sanitation, hygiene and providing immunizations reduces infant mortality to a great extent. Most of these lifesaving interventions are beyond the reach of the world's poorest communities especially in SSA countries communities because of inadequate health system (WHO,2017).

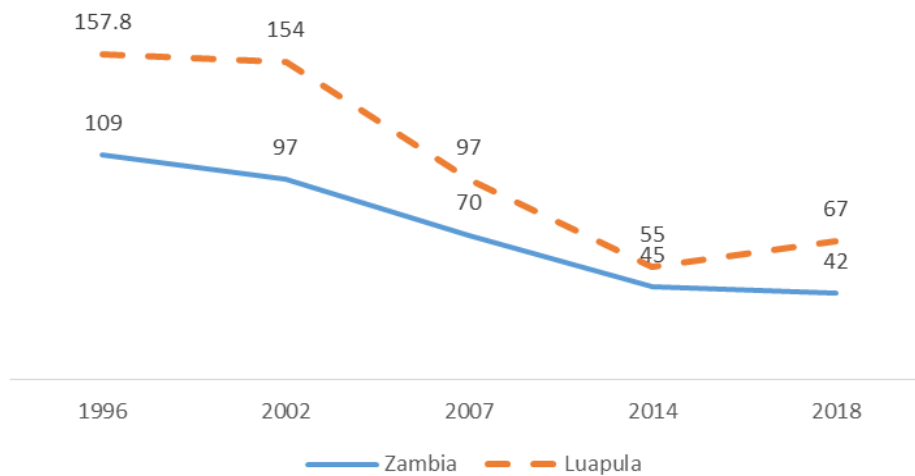
According to UNICEF *et al.*, (2018) in 2017 over 4.1 million infant death occurred within the first year of life representing 75 per cent of all the under-five deaths. The probability of a child dying before reaching their first birthday was the highest in the WHO African Region (51 deaths per 1000 live births), over six times higher than that in the WHO European Region which was at 8 deaths per 1000 live births. At a global level, the infant mortality rate (IMR) reduced from an estimated IMR of 65 deaths per 1000 live births in 1990 to 29 deaths per 1000 live births in 2017. Furthermore, annual infant deaths have dropped from 8.8 million in 1990 to 4.1 million in 2017.

According to census data, Luapula province infant mortality rate in 2010 was 99.6 deaths per 1000 live births. In rural areas, the IMR was 100.7 deaths per 1000 live births and 93.8 deaths per 1000 live births in urban areas. Estimated IMR was higher for male children than female children in both rural and urban areas. The infant mortality rate has been showing a declining trend since 1990. The IMR declined from 166.0 deaths per 1,000 live births in 1990 to 99.6 deaths per 1,000 live births in 2010. The decline in IMR occurred in both rural and urban areas since 1990 (Central Statistical Office, 2014).

Furthermore, census data shows that in 2010 Nchelenge district had the highest infant mortality rate at 129.6 infant deaths per 1,000 live births and was the only district with an infant mortality rate above the province's average of 99.6 infant deaths per 1,000 live births. Milenge district had the lowest infant mortality rate at 55.6 infant deaths per 1,000 live births. However, these estimates on district level may not be very useful today because Luapula province is now divided into 12 districts unlike in 2010 when it only had seven districts (Central Statistical Office, 2014).

Survey data from the ZDHS shows that the trend of infant mortality can be observed by comparing the preceding from 1996, 2002, 2007, 2014 and 2018 ZDHS. Figure 1.1 shows that the overall infant mortality rate reduced from 109 to 67 in the period 1996 to 2018. Further, it shows that the infant mortality rate from Luapula province has been showing a downward trend. However, the observed infant mortality in Luapula has been significantly higher than the national average from 1996 to 2018 ZDHS. The 1992 ZDHS is not included because the estimate for IMR for Luapula and Northern were combined due to insufficient mortality cases (Central Statistical Office, *et al.*, 2014).

Figure 1.1 Trend of Infant Mortality Rate in Zambia and Luapula.



Source: Central Statistical Office (1996, 2002, 2007, 2014 and 2018)

1.2 Statement of the problem

Most of the studies reviewed focused on national level factors to understand the determinants of infant mortality. This may not be applicable at subnational level because of the variation in socioeconomic characteristics across regions. Zambia has made significant progress to improve child survival. This progress can be attributed to intervention introduced by the government. These interventions include the following, Expanded Programme on Immunization (EPI) and Integrated Management of Childhood Illnesses (IMCI). The impressive immunisation coverage, averaging 80 per cent for the past 10 years, has also contributed to a reduction in infant mortality (Ministry of Health (MOH), 2017).

Despite the interventions, however, Luapula still remains the province with one of the highest infant mortality rate in the country. Census data shows that in 1980 and 2000 Luapula experienced the second-highest infant mortality rate of 127 and 132 deaths per 1000 live births respectively (Central Statistical Office, 2014).

Furthermore, Census data also shows that in 1990 and 2010 Census, Luapula experienced the highest infant mortality rate of 161 and 100 deaths per 1000 live births respectively. According to survey data from the ZDHS, Luapula province has been having the highest infant mortality rate consistently from 1996 to 2018, except for 2014 when it was the second highest with 55 deaths per 1000 live births (Central Statistical Office, *et al.*, 2014).

It is evident that infant mortality has been consistently high and requires urgent attention to improve infant survival in Luapula province.

Table 1.1: Trend of Infant Mortality Rate by Region in Zambia

Province	1996	2002	2007	2014	2018
Zambia	109	97	70	45	42
Central	95	92	64	43	30
Copperbelt	81.9	68	79	42	33
Eastern	131.1	84	82	68	40
Luapula	157.8	154	97	55	67
Lusaka	100.3	70	85	42	47
Northern	125.3	113	94	49	39
North-western	91.1	74	65	39	19
Southern	66.2	76	64	44	46
Western	129.1	139	97	44	42
Muchinga	-	-	-	51	50

Source: Central Statistical Office (1996, 2002, 2007, 2014 and 2018)

1.3 Research questions

1.3.1 General Research Question

What are the determinants of infant mortality in Luapula province, Zambia?

1.3.2 Specific Research Questions

- i. What are the levels of infant mortality by demographic and socio-economic characteristic of mother and child in Luapula province?
- ii. What demographic and socio-economic characteristics are associated with infant mortality in Luapula province?

¹

¹ Muchinga province was created in 2011 by president Sata

The 1992 ZDHS is left out because the IMR for the provinces were combined

1.4 Research objectives

1.4.1 General Objective

To investigate the determinants of infant mortality in Luapula province.

1.4.2 Specific Objectives

- i. To establish the level of infant mortality by demographic, and socio-economic characteristics of child and mother in Luapula province.
- ii. To determine the association between demographic and socio-economic characteristics and infant mortality in Luapula province.

1.5 Justification

Previous studies on infant mortality in Zambia focused only on national level factors associated with infant mortality. Little research exists on determinants of infant mortality at subnational level. This study focuses on Luapula province as noted earlier, as it has consistently had high infant mortality rates.

An earlier study by Kapungwe (2005) on under-five mortality in Luapula province was limited in that it was qualitative and focused only on two districts: Kawambwa and Samfya. Therefore, this research will provide an understanding on the determinants of infant mortality in Luapula. A research of this nature is of great benefit in the academic circles as it adds to the literature on infant mortality at subnational level.

CHAPTER 2: LITERATURE REVIEW, THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter looked at studies that have been conducted by researchers to examine the predictors of infant mortality in different countries and Zambia. Most of the studies that have been reviewed used the Mosley and Chen framework of 1984. The focus of this chapter is mainly on socio-economic, demographic/child and proximate determinants and how these influence infant mortality.

2.2 Socio-economic factors

2.2.1 Marital status

Marital status of the mother is likely to influence child survival as married women are less likely to lose a child (Dwonoh *et al.*, 2019). A study done by Kananura *et al.*, (2016) obtained data from a cross-sectional baseline survey implemented in Kibuku, Pallisa and Kamuli districts in rural Eastern Uganda. The study used Cox regression model and found no association between infant mortality and marital status. Equally, a study done in Zambia using data from the 1991 and 2002 ZDHS found that there was no association between infant mortality and marital status of the mother (Madise *et al.*, 2003). However, a trend analysis study done in America from 2005 to 2009 by He *et al.*, (2015) employed analysis of variance and found that infants born to unmarried mothers had significantly higher risk of dying compared to those born to married ones, with rates almost twice as high.

2.2.2 Maternal education

Maternal education is reported to have an inverse relationship with infant mortality. Maternal education is associated with better infant feeding and care practices, late marriage and motherhood as well as proper utilization of prenatal care and immunization services of the infant (Abate *et al.*, 2020). Mugo *et al.*, (2019) using data from the 2015-2016 Myanmar Demographic and Health Survey (MDHS) found that infants born to women with no education had significantly higher risks of dying. Another study done by Musafili *et al.*, (2015) using data from two Rwanda Demographic and Health Survey (RDHS) from 2005 and 2010 found that neonates born to women with no primary education had higher chances of dying compared to those born to mothers with secondary and higher education. However, the differences were not statistically significant. In contrast, a study done in Zambia by Lukonga and Michelo, (2015)

found that neonates born to mothers with higher education had significantly higher odds of dying compared to those born to mothers with no education.

2.2.3 Maternal literacy

Maternal literacy plays an important role in child survival. Children born to literate women are more likely to survive in infancy because their mothers are knowledgeable about health care and respond effectively to problems concerning the health of the child (Suman *et al.*, 2016). Mukherjee *et al.*, (2019) using data from the Sample Registration System to investigate the determinants of infant mortality in rural India found a strong negative correlation between the proportions of female literacy and infant mortality. The only variable that was left in the final model was female literacy which was significantly associated with infant mortality. Similarly a study done by Suman *et al.*, (2016) using regression found a strong negative correlation between infant mortality and maternal literacy in India.

2.2.4 Residence

Residence does not have a direct effect on infant mortality. It may affect infant mortality through the availability of health facilities. Mostly in rural areas, the health facilities are not close to homes, as a result, women tend to deliver at home. In case of emergence to an infant, the time taken to get to the hospital reduces the chances of a child surviving (Ogbo *et al.*, 2019). Koç and Eryurt (2017) used data from four Turkish Demographic and Health Surveys (TDHS) conducted in 1993, 1998, 2003 and 2008. The study used Cox regression model and revealed that infants born to mothers in rural areas had significantly increased chances of dying compared to those born to mothers residing in urban areas in all the surveys. Similarly, using data from three NDHS in Nigeria from 2003, 2008 and 2013, Morakinyo and Fagbamigbe (2017) applied probit regression and found that there was a significant reduction in infant mortality for children born in urban areas compared to those in rural areas in all the three surveys.

A study done by Ogbo *et al.*, (2019) using data from three Tanzania Demographic and Health Survey (TDHS) from 2005, 2010 and 2015. This data was combined to investigate the determinants of infant mortality. Unlike the other two, this study found that infants whose mothers resided in rural areas were less likely to die compared to those whose mothers lived in urban areas. The reason for these results could be presence of slums in urban areas.

2.2.5 Wealth index

The variables covered by wealth index include household assets such as television, bicycle, car and public health facilities such as the source of water, sanitation facilities and type of material used in flooring (Sahu *et al.*, 2015). Infants from wealthier families are expected to live longer than those in poor families' (Adedini *et al.*, 2015; Vijay and Patel, 2020). Ranjan *et al.*, (2017) examined the determinants of infant mortality for the tribal and non-tribal population in India using 2007 data from the District Level Household Survey (DLHS). The study found no association between infant mortality and wealth index for tribal populations. Further, the study revealed that infants born in middle quintile had significantly reduced hazards of dying compared to those born in a poor household for non-tribal populations.

Uthman *et al.*, (2008) investigated the significant determinants of infant mortality in Nigeria by using data from the 2003 NDHS. The study found that compared to children in poor households, infants in richer households were less likely to die. A study done by Musafili *et al.*, (2015) found no statistically significant association between wealth index and infant mortality.

2.2.6 Maternal employment status

The children of non-working class mothers are likely to experience higher rates of infant death than those of working mothers because they cannot afford adequate medical care (Bankole, 1989). A retrospective cohort study done in Brazil by Kropiwiec *et al.*, (2017) investigated the factors associated with infant mortality by using logistic regression and found no association between infant mortality and maternal employment status. Similarly, a study done by Khadka *et al.*, (2015) using 2006 and 2010 Nepal Demographic Health Survey (NDHS) data found that the relationship between infant mortality and maternal employment status was not significant. Ogbo *et al.*, (2019) in Tanzania used data from three TDHS (2005, 2010 and 2015) and found no association between infant mortality and maternal employment status.

2.2.7 Religion

Literature shows that a greater proportion of women who are religious have higher rates of infant mortality (Glavatskaya *et al.*, 2018; Ibrahim *et al.*, 2019). There is a relationship between the presence of religion and poorer infant health at later ages. This may be due to traditions that enforce norms related to the rejection of education and science (Garcia *et al.*, 2019; Mishra *et al.*, 2018).

Mishra *et al.*, (2018) used data from India's National Family Health Survey 2005–06 (NFHS) and applied Cox regression model to examine the relationship between birth order and infant mortality. The study found that religion was only associated with neonatal deaths and not post neonatal deaths. Similarly, Khadka *et al.*, (2015) in Nepal used data from the 2011 NDHS to investigate the socio-economic determinants of infant mortality using the logistic regression model. The study found that religion was not a significant predictor of infant mortality.

2.2.8 Paternal education

Women with educated partner adopt simple health knowledge contrary to fatalistic acceptance of health outcomes, they adopt alternatives in child care and recent treatments because their partners take keen interest in their health and child care (Mosley and Chen, 1984). Oritogun and Bamgboye (2018) used data from the 2008 NDHS to investigate the predictors of infant mortality in Nigeria by applying the zero inflated poisson model and found a significant association between infant mortality and partner education. The study found that children of fathers with no education and primary education had significantly higher chances of dying than those with secondary or higher education.

2.3 Demographic/Child Factors

2.3.1 Sex of Child

It has been observed that at birth there are more males than females. However, as they progress male babies die more compared to female children (Kananura *et al.*, 2016). Morakinyo and Fagbamigbe (2017) used data from three NHDS to investigate the trends and determinants of neonatal, infant mortality and under-five mortality in Nigeria. The study found that females had significantly reduced chances of dying than male children in all three surveys. Similarly, a study done by Mishra *et al.*, (2018) found that female children had significantly lower risks of dying than male children. Ogbo *et al.*, (2019) used combined data from the 2004–2005, 2010 and 2015–2016 TDHS to investigate determinants of infant mortality in Tanzania by applying Cox regression model. The study found that male infants had significantly increased hazards of dying than female children.

2.3.2. Birth order

Most researchers agree that first-born and second-born children are at a lower risk of dying in the infancy stage (Adedini *et al.*, 2015; Ranjan *et al.*, 2017). A study done by Weldearegawi *et al.*, (2015) used data from Kilite Alwaleed Health and Demographic Surveillance System and used the Cox regression model. The study found that infants of second and higher birth order

were more likely to die compared to infants of first birth order. However, the differences were not significant. Similarly, Lukonga and Michelo (2015) used the 2007 ZDHS and found that neonatal mortality was not associated with birth order in Zambia. Ogbo *et al.*, (2019) used data from three NDHS and applied Cox regression model. The study found infants of fourth or higher birth order to be significantly associated with infant mortality in Nigeria.

2.3.4 Sex of household head

According to a study conducted by Baraki *et al.*, (2016) to assess the factors affecting infant mortality in the general population in Ethiopia. However, a study found that sex of household head was not a significant predictor of infant mortality. The study conducted by Morakinyo *et al.*, (2015) in Nigeria to assess the effects of wealth index and sex of household in Nigeria found that children born in households headed by females were more likely to die in infancy compared to children born in households headed by males. This is because households headed by women normally tend to be poor and are unable to afford quality medical care to improve the health outcomes of infants.

2.3.4 Household size

According to a study done by Ibrahim *et al.*, (2019) to assess child's risk attributes at birth and infant mortality disparities in Nigeria using the 2013 NDHS. The study used Cox regression model and found that infants born in larger households had significantly reduced risks of dying compared to children born in smaller households. Similarly, a study done by (Dwomoh *et al.*, 2019) in Ghana using three rounds of GDHS (2003, 2008 and 2014) applied Cox regression model and found that children born in larger households had significantly reduced risk of dying compared to children born in smaller households.

2.4 Proximate Determinants

2.4.1 Mothers age at birth

Typically mothers below 20 years normally tend to have biological, emotional, social, and economic problems that frustrate their entire childbearing process (Abate *et al.*, 2020). A retrospective trend analysis study done in the South Eastern states of America from 2005 to 2009 with data collected from Centre for Disease Control and Prevention (CDC), American Community Survey and the US Census Bureau used analysis of variance to investigate the determinants of infant mortality. The study showed that infant mortality was the highest in the youngest and old mothers. Infant mortality for mothers below 20 was three times higher than those aged (25-29, 30-34 and 35-39) the age groups with the lowest risks. Furthermore, infant

mortality for mothers aged 45-49 and 50-54 was twice the rate for the mothers in the three age groups with the lowest rates. (He *et al.*, 2015).

A cohort study done by Weldearegawi *et al.*, (2015) in Ethiopia from 2009 to 2013 which applied Cox regression model to examine the determinants of infant mortality found that infants born to mothers below 20 years old were three times more likely to die compared to infants born to mothers aged 25–29 years. However, the risk of death was not significant for all other age groups compared to the reference group (25-29) except for the age group 15-19. Ezeh *et al.*, (2015) in Nigeria used data from three Nigeria Demographic and Health Survey (NDHS) from 2003, 2008 and 2013. The study employed Cox regression model to investigate the risk factors associated with infant mortality and found that children born to mothers below 20 were three times more at risk of dying compared to those born to mothers aged 30-39. Infants born to mothers aged 20-29 and 40-49 were more likely to die compared to those born to mothers aged (30-39). However, the differences were only significant for those infants born to mothers below 20.

Using data from the 2007 ZDHS in Zambia, Lukonga and Michelo (2015) employed logistic regression to investigate the factors associated with neonatal mortality and found that neonates born to mothers in older age groups had significantly higher risks of dying compared to those in the age group 12-17. A cohort study done in California in the United States of America by Satyan *et al.*, (2020) to investigate the maternal and child predictors of infant mortality by using logistic regression found that women at the extremes of age, in the younger and older age groups, had an increased risk of infant mortality.

2.4.2 Breastfeeding

Research has shown that breast milk improves the health of the child because it is rich in nutrients; it can provide all the nutritional requirements for an infant up to six months (Biks *et al.*, 2015; Brahm and Valdés, 2017). Ware *et al.*, (2019) in the United States of America found breastfeeding as a significant predictor of infant mortality. Similarly, a comparative study done by Lamichhane *et al.*, (2017) in Nepal using data from the 2006 and 2011 NDHS found that children who were not breastfed had significantly higher risks of dying than children breastfed. However, for the 2006 survey, the differences were not significant. Furthermore, a prospective open cohort study conducted by Biks *et al.*, (2015) involving 1752 undertaken from 2009 to 2011 in Ethiopia used Poisson regression and found exclusive breastfeeding as a significant

predictor of infant mortality. Infants who were not breastfed were 8 times more likely to die than those breastfed.

2.4.3 Parity

Researchers agree that women having a child for the first time are more likely to lose the child (Hellerstedt *et al.*, 1995; Naoko *et al.*, 2014). A retrospective cohort study done by Santos *et al.*, (2016) based on secondary data of births and deaths of infants of mothers living in Teresina Brazil in 2011 found that infants born to mothers who were having a child for the first time had higher chances of dying compared to those with mothers who were multiparous. However, the differences observed were not significant. Similarly, a study done by Dev *et al.*, (2017) in Nepal using data from the 2011 NDHS used found no significant associations.

A study done by Kananura *et al.*, (2016) obtained data from a cross-sectional baseline survey implemented in Kibuku, Pallisa and Kamuli districts in rural Eastern Uganda and applied logistic regression to investigate the predictors of neonatal mortality. The study found that women who were of parity 5 and above were three times more likely to lose their new-borns within 28 days compared to those who were of parity 4 and below.

2.4.4 Previous birth interval

Researchers agree that a short preceding birth interval (<24 months) affects the survival of the index child due to maternal depletion (Biks *et al.*, 2015; Ogbo *et al.*, 2019). This is because the mother has not had enough time to recover from the previous birth and this results in the next birth with low birth weight (Madise *et al.*, 2003). A study done in Nepal using data from the NDHS 2011 found that a short preceding birth interval (less than 24 months) is a significant predictor of infant mortality (Khadka *et al.*, 2015).

Similarly, Madise *et al.*, (2003) in Zambia using ZDHS data found that longer preceding birth interval to be associated with low infant mortality. A prospective open cohort study done by Biks *et al.*, (2015) involving 1752 infants undertaken from 2009 to 2011 in Ethiopia, applied Poisson regression and found that infants with a preceding birth interval of less than 24 months were four times more likely to die. Another study done by Abate *et al.*, (2020) in Ethiopia using the 2016 EDHS found that infants in birth interval greater than 24 months had lower chances of dying compared to infants in a less than 24 months birth interval.

2.4.5 Birth type

Births including twins and higher order multiples such as triplets and quadruplets are high-risk pregnancy and birth (Aheto, 2019). These are accompanied by several associated foetal and neonatal complications that require special and expensive medical care. Uthman *et al.*, (2008) found that infants born among multiple births had significantly higher chances of dying compared to children born among single births in Nigeria. Similarly, Bills *et al.*, (2018) using data from demographic, historical and current clinical data related to both maternal and neonatal care in a prospective observational study. The study found multiple births to be a significant predictor of neonatal mortality in India. Though for this study only neonates were considered. Equally, a study done by Abate *et al.*, (2020) in Ethiopia using EDHS data and found that infant mortality among multiple births was four times higher than singleton birth.

Furthermore, a study done by Dwomoh *et al.*, (2019) in Ghana using 2004, 2008 and 2014 GDHS data found infant mortality among multiple births was over three times higher than singleton births in all the three surveys. Similarly, a study done in Ethiopia by Baraki *et al.*, (2020) using data from the EDHS found that infant deaths among multiple births was five times higher compared to singleton births.

2.4.6 Contraceptive use

A longitudinal study done in North-western Ethiopia to determine whether exclusive breastfeeding is a strongest predictor of child survival found that mothers who were not using contraceptives were nearly two times likely to lose a child compared to mothers using contraceptives (Biks *et al.*, 2015). A study done in Bangladesh using Demographic and Health Survey (BDHS) data (2004-2011) also found that children born to mothers using contraceptives had reduced odds of dying compared to children born to mothers not using contraceptives (Abir *et al.*, 2015). A study done in Nepal using data from NDHS (2001-2016) found that women not using contraceptives were two times likely to lose a child before age 1 compared to mothers using contraceptives (Ghimire *et al.*, 2019).

2.5 Deficiencies in Literature

It has been noted that most of the studies reviewed used data from cross sectional studies which are done at a point in time. These studies require mothers of the infants to recall the birth date and age of death of the infant. There may be recall bias on the part of the mother especially if the timeframe is long. Longitudinal studies would give a clearer picture.

The literature reviewed with regards to the determinants of infant mortality has yielded mixed results. The findings of these studies in terms of the association of infant mortality with the predictors have been consistent but, in some cases, there are inconsistencies.

The studies that have been done in Zambia focused on national level factors, (Lukonga and Michelo 2015; Madise *et al.*, 2003). The study done by (Kapungwe, 2005) done in Luapula looked at under-five mortality in two districts (Kawambwa and Samfya). This study was also qualitative in nature. There is very little information that is known on the determinants of infant or child mortality at the provincial level. The provinces have different socio-economic conditions; therefore using policies from national level studies may not yield positive results in all the provinces. A study of this nature will provide insights on the determinants of infant mortality at the provincial level in Zambia.

2.6 Theoretical Framework

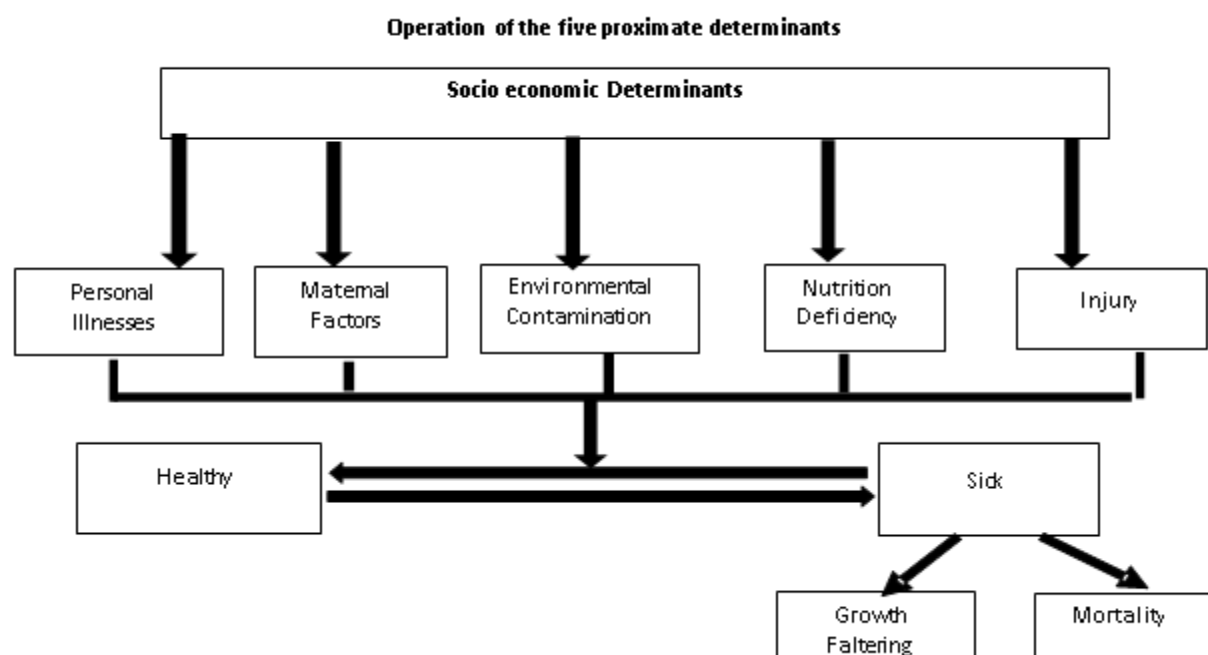
From the theoretical standpoint of view, Mosley and Chen (1984) identified three levels of socio-economic determinants of child survival. Mosley and Chen argued that socio-economic determinants are at individual, household and community level. At individual level productivity is key and is measured by three elements skills (education), health and time. Father's education may influence attitudes towards child health care services. This is most likely to be significant when more educated fathers are married to less educated mothers. For mothers, it is different because of the biological link between mother and infant during pregnancy. When it comes to a woman, her education level can influence child survival through the choices she makes such as nutrition, hygiene, preventive care and disease treatment.

Further, Mosley and Chen noted that wealth/income at a household level is very critical as it influences several choices which are very important for child survival. Income will determine the type of food which will be consumed in the house. Food is key for nutrients required for an infant's growth and health. Another important aspect is water which is a key determinant of disease exposure depending on the quality and quantity. Other variables at the household level are clothing, housing, fuel, information, transportation and sickness care.

At a community level, ecological settings are key in determining the survival of children. These include rainfall patterns, climate and temperature. These have a very strong impact on child survival especially in rural areas by affecting the quantity and the variety of food crops and vector-borne diseases.

According to Mosley and Chen, the socio-economic determinants identified at three levels affect infant and child mortality indirectly. They operate through what Mosley and Chen called proximate determinants. They came up with five categories: maternal factors (age, parity, birth interval); environmental contamination (air, food, water); nutrition deficiency (calories; protein; micronutrients (vitamins and minerals); injury (accidental; intentional.); and personal illness (personal preventive measures, medical treatment) control of proximate determinants through which the socio-economic operate to influence child mortality.

Figure 2.1: Mosley and Chen framework



Source: Mosley and Chen (1984). An Analytical Framework for studying child survival in developing countries.

This study was based on the application of the 1984 Mosley and Chen Survival framework of child mortality for investigating the determinants of infant mortality in Luapula province.

The Mosley and Chen framework has been used in many studies of child mortality in Africa. However, the framework has failed to directly incorporate the complex social dimension of health such as socio-political problems affecting infant and child survival. The model also does not include political unrest, civil war, famine and HIV/AIDs situations that still occur in many African countries and affect child survival to a great extent (Macassa *et al.*, 2011).

2.7 Conceptual Framework

The conceptual framework identifies a set of proximate determinants, through which socio-economic determinants operate to influence infant mortality.

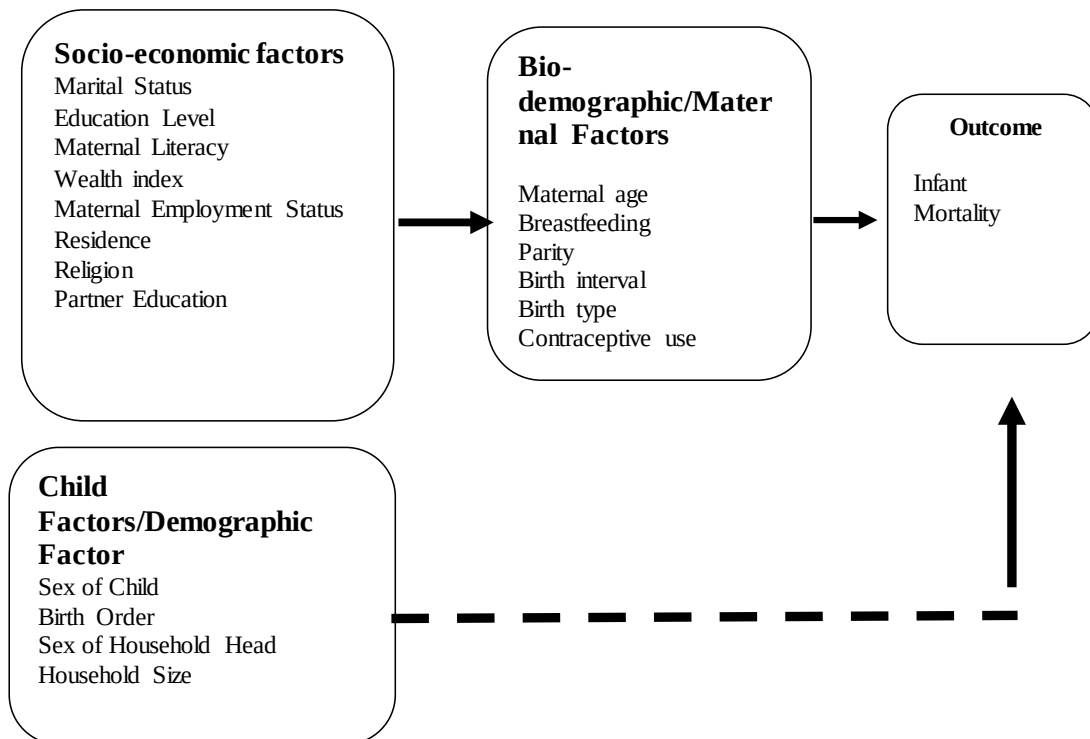
The socio-economic characteristics of women such as residence, education level, wealth index and maternal employment status will work through parity. Women with higher education level are likely to have a lower parity compared to those with lower education level. Women with educated partners adopt simple health knowledge contrary to fatalistic acceptance of health outcomes, they adopt alternatives in child care and recent treatments because their partners take keen interest in their health and child care (Mosley and Chen, 1984).

Women residing in rural areas usually tend to be poor which may determine contraceptive use and result in higher risk birth of a short preceding birth interval of less than 24 months and ultimately affecting infant mortality. Attitudes of women towards religion will influence child survival. If women rely on traditional or spiritual intervention when a child is sick instead of visiting the health facility. During pregnancy, religious women may resort to traditional medicine and prayers instead of going to a health facility when they are not well.

The framework outlined by Mosley and Chen does not incorporate child level factors. The framework in this study has been modified to include child level factors and demographic characteristics in the conceptual framework such as sex, birth order, sex of household head and household size which will have a direct relationship with infant mortality. The other proximate determinants such as personal illness, injury, nutrition deficiency and environmental contamination were not included due to unavailability of the variables in the dataset.

Figure 2.2: Conceptual Model adapted for the study of the determinants of infant mortality in Luapula, Zambia (Mosley and Chen 1984).

Socio-economic/Demographic Proximate Determinants Outcome



2.8 Research hypotheses

Hypothesis 1

H₀ (Null): There is no relationship between mother's age and infant mortality

H₁ (Research): Children born to younger mothers have higher risks of dying than children born to older mothers.

Hypothesis 2

H₀: (Null) There is no relationship between child's sex and infant mortality

H₁: (Research) Male children are more likely to die than female children.

Hypothesis 3

H₀: (Null) There is no relationship between birth type and infant mortality

H₁: (Research) Children born in multiple birth have higher risks of dying than children from single birth.

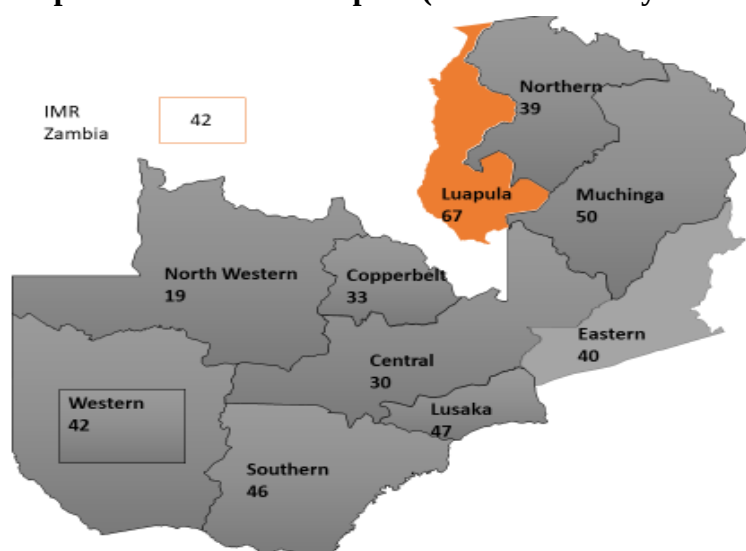
Significance Level: **0.05**

CHAPTER 3: STUDY METHODOLOGY

3.1 Introduction

This chapter presents the methodology of the study. Section 3.2 describes the study setting. Section 3.3 provides information about the study design. Section 3.4 and 3.5 describe the data source and population and sample size respectively. Variable identification, definition and measurement are described in section 3.6. Data quality assessment is described in section 3.7. Statistical analysis is described in section 3.8. Model building strategy and Goodness of fit, are described in 3.9 and 3.10 respectively. Ethical considerations and limitations are described in 3.11 and 3.12 respectively.

Figure 3.1 Map of Zambia with Luapula (Infant Mortality Rate*ZDHS 2018)



Source: Authors editing of a free SVG file in PowerPoint with levels from 2018 ZDHS

3.2 Study Setting

This study focused on Luapula province, one of the ten provinces in Zambia. Luapula is located in the northern part of Zambia. Luapula is named after the Luapula River and its capital is Mansa. According to Central Statistical Office (2014), the province had a population of 991,927 (third least) which accounted for eight per cent of the total Zambian population. The province is administratively divided into 12 districts, namely: Chiengwe, Kawambwa, Mansa, Milenge, Mwense, Nchelenge, Chipili, Chembe, Chifunabuli, Lunga, Mwasabombwe and Samfya. The province has international borders along with Democratic Republic of Congo (DR Congo) and domestically extends along the northern and eastern banks of the Luapula river

from Lake Bangweulu to Lake Mweru. The province is inhabited by Bemba speaking people, which is also a major tribe in the country. Bemba is the most spoken language in the province.

The major economic activities in the province are agriculture and fishing, with cassava being the major crop. Mutomboko ceremony is the most important festival that is celebrated. About 81 per cent of the population of Luapula is accounted as poor (Central Statistical Office, 2014) making it one of the poorest province in Zambia. Slightly, more than 80 per cent of the population resides in rural areas. It has eight major attractions of the country among its waterfalls, wildlife and cultural heritage. Major mineral deposits found in the province are manganese, lime, copper and precious metals (Central Statistical Office, 2014).

Luapula province has a total number of 697 learning institutions, broken down as follows: 15 Interactive Radio Instruction Centres, two Nursing Schools, 214 Community schools, 423 Basic schools, 14 Private schools, 26 High Schools, two Skills Centre's, two special Schools and one College of Education. Luapula Province had the lowest literacy rate (71 per cent) and lowest net attendance rate Luapula (65 per cent) (Central Statistical Office, 2015).

Luapula province has 148 health facilities. The health system consists of one General Hospital, six District Hospitals, 133 health centres and eight health posts. Basic vaccination coverage was lowest in Luapula (67 per cent). Generally, Luapula has been experiencing high fertility. Immunization is a widely accepted public health strategy for the prevention of infectious disease for children. To be considered fully vaccinated, a child should have received one dose of BCG, three doses of DPT, three doses of polio and one dose of measles vaccine. Luapula province had the second lowest full immunization coverage in 2015. Only 8 out of 10 children received full vaccination (Zambia Statistics Agency, *et al.*, 2018).

Western Province has had the highest proportion of the poor population at 82.2 per cent compared to 81.1 per cent for Luapula. Luapula is the second province affected by extreme poverty having 7 out of 10 people considered to be extremely poor. (Central Statistical Office, 2015).

3.3 Study Design

This study is a cross sectional study because it used already existing data from the 2018 ZDHS. The epitome of using secondary data is that it can save time that would otherwise be spent collecting data and particularly in the case of quantitative data, can provide larger and higher quality databases like the ZDHS database that would be unfeasible for any individual

researcher to collect on their own. Also, analysts consider secondary data important since it is impossible to conduct a new survey that can adequately capture past change and/or developments. Another clear benefit of using secondary data is that it is available from other sources and may already have been used in previous research making it easier to carry out further research. Further, it would be impossible for a researcher to have a representative sample because death is a rare event if they collected mortality data as an individual.

3.4 Data Source

The ZDHS was used. This is a national representative survey of women aged 15-49 and men aged 15-59. A representative of 18,052 households was drawn from the 2018 ZDHS. The survey was used as a two-stage stratified cluster sample design, with EAs (or clusters) selected during the first stage and households selected during the second stage. In the first stage, 545 Enumeration areas (EAs) were selected with probability proportional to size. An average of 25 households were selected in each EA.

The ZDHS collected information on children below the age of five in all the 10 provinces of Zambia. The information is part of a retrospective birth history in which female respondents are asked to list all the children to whom they had given birth in the last five years, along with each child's date of birth, survivorship status, and current age or age at death. The dataset also contains mother and child characteristics that are very useful for the analysis. With regards to women, the ZDHS also collects information on (residence, age, education, marital status). With regards to children, ZDHS also collects information such as (sex, birth type, age).

3.5 Population and Sample Size

The Birth Recode dataset (ZMBR61FL) was used in relation to infant mortality in Luapula, Zambia. The target in this dataset were male and female children below the age of one. Death to children below the age of one is regarded as infant mortality (OECD, 2019). Subpopulation analysis was used to predict the determinants of infant mortality in Luapula since the study only focused on one province. The ZDHS collected information on 2804 infants of which 346 died before reaching their first birthday in Luapula. Of the 2804 (un-weighted) infants 50.1 per cent were female. The sex ratio was 100.6 entailing that there were more male children below the age of one in Luapula. ²

² 2804 **un-weighted** live births/ 21755 **weighted** | 346 **un-weighted** deaths; **weighted** deaths =2684

3.6 Variable identification, definition and measurement

Outcome		Definition	Coding/Measurement
Infant Mortality	b5 0 Dead 1 Alive	To measure this the mother was asked whether Child was Still Alive (11 months) STATUS VARIABLE	0.Alive 1.Dead
Age at death	B7 0,1,2,3,.....11	Age of child (b19) is calculated from the reported date of birth and/or age of the child from the birth history.	0,1,2,3,.....11
Current age of surviving child	B8 0,1,2,3,.....11	Age of child (b19) is calculated from the reported date of birth and/or age of the child from the birth history.	0,1,2,3,.....11
Socio-economic factors			
Marital Status	V501 0.None 1. Never in union 2. Living with partner 3.Widowed 4. Divorced 5. Separated	Respondents are asked "Are you currently married or living together with a man as if married?" and if the answer is no, not in union, they are asked "Have you ever been married or lived together with a man?" Women that respond yes to the latter question are asked "What is your marital status now: widowed, divorced, or separated?"	1.Single 2.Married 3. Widowed/Divorced/Separated
Maternal Education	V106 1. None 2.Primary 3.Secondary 4. Higher	Level of education of the respondent (v106), as for age, interviewed women are asked for the highest level of school they attended, and the highest grade they completed at that level.	1.No education 2.Primary 3.Secondary/Higher
Maternal Literacy	V155 0. cannot read at all 1.able to read only parts of sentence 2.able to read whole sentence	To measure literacy the respondent are showed a card and asked to read to read what's on the card	1.No 2.Yes
Wealth quintile	V190 1.Poorest 2.Poorer 3.Middle 4.Richer 5.Richest	The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using data on a household's ownership of selected assets.	1 Poor 2. Middle 3.Rich
Maternal Employment Status	V714 1. Yes 2. NO	Whether the respondent is currently employed (v714) (having worked in the past 7 days, including women who did not work in the past 7 days but who are regularly employed and were absent from work for leave, illness,).	1.Working 2.Not working
Residence	V025 1 Urban 2 Rural	Type of place of residence is established for the cluster as part of the sample design for the survey	1.Urban 2.Rural
Religion	V130 1. Catholic 2.Protestant 3. Muslim 96	Survey specific classification of the religious group to which the respondent associates himself or herself	1.Catholic 2.Protestant 3.Muslim
Parternal Education	V701 0 No education 1 Primary 2 Secondary 3 Higher 8.Dont Know	Level of education of the respondent (v106), as for age, interviewed women are asked for the highest level of school they attended, and the highest grade they completed at that level..	1.No education 2 Primary 3.Secondary/Higher
Demographic/Child factors			
Sex of Child	b4 1 Male 2 Female	Sex of each child is collected birth history "Is (NAME) male or female?"	1. Male 2. Female
Birth Order	bord 1,2,3,4,5,.....13	Birth order (bord) or parity is the order number of the births from first to last	1, 2,3, 5+
Sex of Household head	V151 1 Male 2 Female	Sex of each household member is collected in the Household Questionnaire with the question: "Is (NAME) male or female?"	1.Male 2. Female
Household size	V136 1,2,3,4,5,....17	To measure household mothers were asked the number of people in a household	1.<6 members 2.6+members
Proximate determinants			
Maternal age at birth	V012 15,16,17,.....49	Women are asked their date of birth and age as part of their interview. Age (v012) is recorded in completed years, and is typically reported in 5-year groups (v013).	1.<20 years 2.20-29, 30+
Currently Breastfeeding	V404 0 No 1 Yes	Whether the child was currently breastfeeding at the time of the survey	1.No 2.Yes
Parity	V201 1,2,3,4,5,.....14	Birth order (bord) or parity is the order number of the births from first to last.	1.<6 children 2. 6+ children
Previous Birth Interval	B11 8,9,10,11,.....100	The difference calculated in months between the date of birth of the child of interest and the date of birth of the preceding child. Not applicable for first-order births.	1.<24 months 2. 24-47 months 3. 48+ months
Birth type	b0 1.Single 2 First multiple 3 Second Multiple	To measure this the mothers were asked whether any of the births were multiple.	1.Single 2 Multiple
Current Contraceptive	V364 1. Using method 2.Using traditional method	To measure contraceptive mothers were asked if they were using contraceptives	1.No 2.Yes

3.6.1 Rationale for Categorization of selected Explanatory variables

Birth order: The categorisation for birth was based on previous studies (Adedini *et al.*, 2015; Ogbo *et al.*, 2019; Weldearegawi *et al.*, 2015)

Parity: This was based on Literature (Kananura *et al.*, 2016)

Household size: This was based on Literature and the average household size in Zambia. (Dwomoh *et al.*, 2019; Zambia Statistics Agency, *et al.*, 2019)

Wealth Index: The categorisation was based literature, most of the studies consider poor/poorer and richer and rich to be in the same category (Wegbom *et al.*, 2018; Ogbo *et al.*, 2019; Vijay and Patel, 2020).

Education: This also based on studies reviewed, most of the studies reviewed combined secondary and higher education due to low proportion of respondents with higher education (Bhandari *et al.*, 2019; I. Wegbom *et al.*, 2018; Kembo and van Ginneken, 2009).

Maternal age: Most studies reviewed use 10 year age interval with the exception for age 15-19 which has a different dimension with regards to child mortality (Adedini *et al.*, 2015; Bhandari *et al.*, 2019; Ezech *et al.*, 2015; Ogbo *et al.*, 2019).

Birth order is highly correlated with parity therefore it will not be included in multivariate analysis.

Paternal education will not be included in model building due to estimation complexities caused by a larger number of missing cases as observed in univariate analysis.

3.6.2 Definitions of terms

Infant mortality rate is the death of a child before celebrating first year of life per 1000 live births (OECD, 2019).

Hazard function is the short time event rate for subjects who have not yet experienced the outcome (Cox, 1972).

Hazard ratio is an estimate of the ratio of the occurrence of an event in the intervention versus the control group (Spruance *et al.*, 2004).

Proportional Hazard entails that the ratio of the hazards for two subjects' j and k at time t is the same for all values (Cox, 1972).

The Kaplan-Meier Curves is a graphical method of depicting survival times between two or more groups (Cox, 1972)

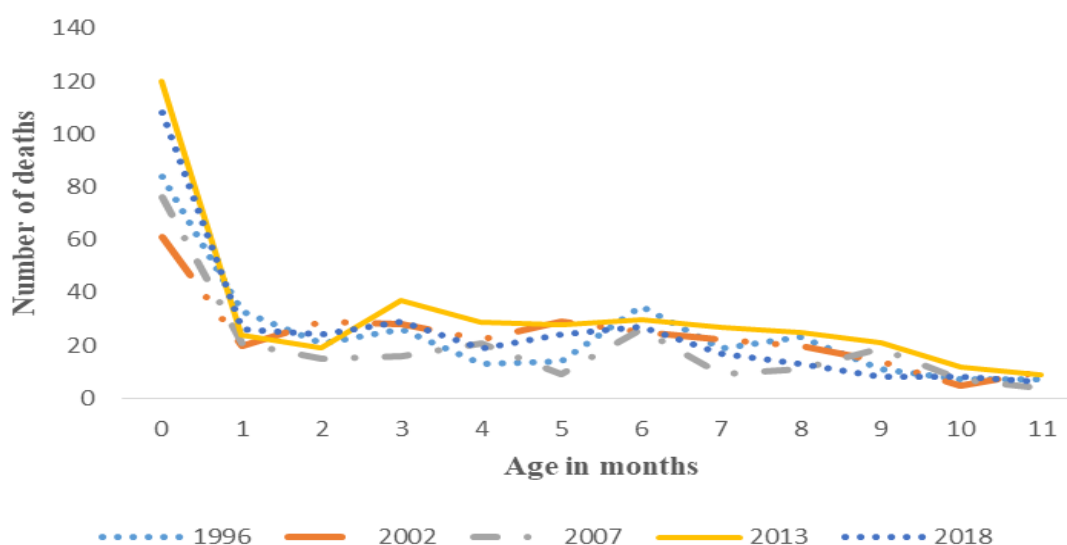
The Logrank test is a statistical test used for comparing the survival experience of two or more groups in survival analysis (Cox, 1972).

3.7 Data quality assessment and measurement

There is no survey anywhere in the world which is free from errors no matter how big and comprehensive the survey is. There is misreporting of age by the respondent, omission of births, deaths as well as the missing data which may affect the estimation of infant mortality. Therefore, to ensure data quality, the data will be checked for uniformity, accuracy and completeness. The age distributions of age at death will be examined.

Figure 3.1 shows that data quality for Luapula province was generally good as there are no notable signs of age heaping in the 2018 ZDHS. However, for the 1996 and 2007 ZDHS there was age heaping on six months. This is because it's notable month, it is the time a child is introduced to solid food and mostly marks the end of breastfeeding. The 2002 and 2013 survey look generally good as well.

Figure 3.1: Data quality assessment using age at Death



Source: 1996, 2002, 2007, 2013 and 2018 ZDHS data files author's computations

3.8 Statistical analysis methods

Stata version 14 was used for data analysis in this study, it was done at three levels. This was univariate, bivariate and multivariate. At the univariate level, descriptive analysis was done for selected variables. The levels of infant mortality were estimated using the direct methods. At the bivariate level, Log-rank test was used to examine the relationship between the

dependent variable (infant mortality) and the selected explanatory variables. At the multivariate level of analysis, Cox proportional regression analysis was performed to examine the association between explanatory variables and infant mortality.

The first objective to establish the levels of infant mortality by demographic and socio-economic was achieved by estimating the levels of infant mortality in Luapula by mother and child characteristics. Direct methods of calculation were used which require data on the date of birth of children, their survival status, and the dates of death or ages at death of the deceased children. The direct methods require data that are usually obtained only in specifically designed surveys with birth histories.

The second objective to determine the association between demographic and socio-economic characteristics and infant mortality was achieved by applying the Cox proportional regression model. The Cox proportional regression model was used because the outcome variable is time until an event occurred (Kleinbaum and Klein, 2005). An event in this case means infant mortality; when a child dies that means that an event has occurred. Other studies that also looked at infant mortality used Cox regression to study the predictors of infant mortality (Adedini *et al.*, 2015; Becher *et al.*, 2004; Ezeh *et al.*, 2015; Muriithi and Muriithi, 2015; Vijay and Patel, 2020; Weldearegawi *et al.*, 2015). The censored observation from the cross sectional study which is time to event can be handled by Cox regression model (Cox, 1972).

The major assumption of Cox proportional regression model is the proportional hazard assumption. Proportional hazard simply means that the ratio of the hazards for two subjects' j and k at time t is the same for all values of t , i.e. $h_j(t)/h_k(t) = \phi$. Also, if the assumption of proportional hazards is true for two groups of survival times, say Group one and Group two then the true survivor functions for the two groups do not cross each other. In the modelling with explanatory variables, the assumption of proportional hazards means that the effects of a variable on survival is constant over time (Cox, 1972).

The testing of model assumptions was done before fitting the model to ensure the non-violation of the assumption. This was done by inspecting the plot of Kaplan-Meier survival curves for independent variables. The graph should yield parallel lines of survival curves or proportional to each other and not cross (Cox 1972). Another method of testing the proportionality assumption is Schoenfeld and scaled Schoenfeld residuals which must first be saved through the **stcox** command. If the global test is less than .05 then the assumption is violated. The global test for proportional hazards is in table A.4.1.

The hazards ratios can be computed by exponentiating the regression coefficients for the independent variables. A hazard ratio equal to 1 indicates that the risk is the same as that of the baseline hazard. A hazard value that is greater than 1 indicates an increased hazard (risk) relative to the baseline hazard. A hazard ratio value that is less than 1 indicates a reduced risk relative to the baseline hazard (Cox, 1972).

When an infant dies before 12 months, this means that an event has occurred (1) and when the child survives this means that the event has not occurred and it was coded (0). This was done because survival analysis is suitable for handling censored observation (Kim, 2012). In social science research, censoring occurs when the value of an observation is not fully known. Therefore survival analysis will allow for the inclusion of censored data and it models censored time-until-event data as a dependent variable (infant mortality) where it can be assumed that the covariates have a multiplying effect on hazard rates (Nyinawajambo, 2018). Using Cox proportional hazards regression analysis, both the occurrence of infant mortality and the time when the child died was combined to generate the dependent variable. Using the multivariate Cox proportional hazards model, the probability of infant death was regarded as the hazard. The hazard will be modelled using the following equations:

$$\log h(t/x)/h_0(t) = B_1 X_1 + \dots + B_K X_K \quad \text{Equation 1}$$

Where $h(t/x)$ is the hazard at time t for an observation with covariate value x and $h_0(t)$ is the baseline hazard function, defined as the hazard at time t for observations with all predictors equal to zero. $X_1 \dots X_K$ are a collection of explanatory variables and $H_0(t)$ is the baseline hazard at time t , representing the hazard for an infant with the value 0 for all the explanatory variables. By dividing both sides of equation (1) by $H_0(t)$ and taking logarithms, equation (1) becomes:

$$h(t/x) = h_0(t) \exp(B_1 X_1 + \dots + B_K X_K) \quad \text{Equation 2}$$

$$h(t/x) = h_0(t) \exp(HR_x)$$

Where HR_x is regarded as the hazard ratio with covariate x (Kleinbaum and Klein, 2005).

3.9 Model building strategy

Three models were generated for the determinants of infant mortality in Luapula at 5 per cent level of significance. The first model comprised socio-economic variables:

Model 1: $\log h$ (infant mortality)/ $h_{ot} = \beta_1$ Maternal literacy + β_2 Wealth quintile + β_3 Maternal employment status

The second model included demographic and child factors to determine how child factors affect infant mortality:

Model 2: $\log h$ (infant mortality)/ $h_{ot} = \beta_1$ Maternal literacy + β_2 Wealth quintile + β_3 Maternal employment status + β_4 Sex of child + β_5 Sex of household head + β_6 Household size

The third model included proximate determinants through which the socio-economic and demographic and child factors operate to influence infant mortality:

Model 3: $\log h$ (infant mortality)/ $h_{ot} = \beta_1$ Maternal literacy + β_2 Wealth quintile + β_3 Maternal employment status + β_4 Sex of child + β_5 Sex of household head + β_6 Household size + β_7 Mothers age at birth + β_8 Breastfeeding + β_9 Parity + β_{10} previous birth interval + β_{11} Birth type + β_{12} Contraceptive use

Weights were used in the analysis, sample weights were generated to generate sample weights by dividing by 100000 (gen samplewt=v005/100000) which is also applicable to the Birth recode dataset. Then the primary sampling unit (v021) and sample strata for sampling errors (v022) were used to set the data for using weight [svyset v021 [pweight = samplewt], strata(v022)]. Sample weights are adjustment factors applied to each case in tabulations to adjust for differences in probability of selection and interview between cases in a sample, due to either design or happenstance.

3.10 Test of Goodness Fit of the Cox Proportional Model.

To test the goodness of fit of the final Cox regression model, Cox-Snell residuals was used to determine how good a model is. If the model fits the data well, then the Cox-Snell residuals should have a standard exponential distribution with hazard function equal to one, and thus the plot of cumulative hazard of the Cox-Snell residuals against Cox-Snell residuals should be in a straight line passing through the origin with a slope of unity. The hazard function should follow the 45-degree line very closely except for very large values of time. It is very common for models with censored data to have some wiggling at large values of time and it is not

something which should cause much concern. Overall, we would conclude that the final model fits the data very well.

This translates into fitting the model using the **stcox** command and specifying the **mgale** option which will generate the martingale residuals. Then we use the **predict** command with the **csnell** option to generate the Cox-Snell residuals for the model. We reset the data using the **stset** command specifying the variable **cs**, the variable containing the Cox-Snell residuals, as the time variable. We then use the **sts generate** command to create the Nelson-Aalen cumulative hazard function. Finally, we graph the Nelson-Aalen cumulative hazard function and the **cs** variable so that we can compare the hazard function to the diagonal line. If the hazard function follows the 45-degree line then we know that it approximately has an exponential distribution with a hazard rate of one and that the model fits the data well. The Cox-Snell is in Annex A.5.1

3.11 Ethical Consideration

The ZDHS survey obtained ethical approval from Tropical Disease and Research Centre (TDRC) in Ndola, Zambia and the US Centre for Disease Control and Prevention (CDC) and voluntary consent. Participants were informed about this in accordance with ethical requirements. The analysis of this data will not infringe on participants privacy. The ZHDS dataset was accessed at <https://dpsprogram.com/data/available-dataset.cfm>. The dataset was accessed by applying to DHS programme requesting for the Birth recode and writing a short abstract on the intended use. Thereafter, permission was granted and the DHS program stipulates that the dataset should be only used for the intended purpose it was requested for. The letter is attached at the Annex.

3.12 Study limitations

Infant mortality data is not free from errors. This is because direct mortality estimates from the ZDHS relies on the retrospective birth history of the mother. This highly depends on the mother's ability to recall all live births she had, as well as birth dates and age at death, it is possible to have recall bias which affects the quality of the estimates. The possibility of misreporting of important information like infant mortality by the (mothers) could be higher. To reduce recall bias on birth history, this study was limited to birth and deaths that occurred five years preceding the survey. This enabled the reduction of recall bias because of a shorter period. Qualitative data were not collected to validate the secondary data from ZDHS due to financial constraint.

The omission of deceased children by the mothers may result in the underestimation of the infant mortality indicator. Estimation of infant mortality, using direct methods, depends on the correct reporting of age at death as under or over one year. The heaping of deaths at age 6 months is common, and to the extent that it causes a transfer of deaths across the one-year boundary, infant mortality rates may be somewhat underestimated. The misreporting of birth dates can also affect direct estimates, but unless the misreporting occurs much more for deceased children, mortality rates are little affected. Furthermore, with cross sectional data causality cannot be established.

CHAPTER 4: STUDY FINDINGS

4.0 Introduction

This chapter presents the characteristics of the study population, levels of infant mortality, bivariate analysis and multivariate analysis by demographic and socio-economic characteristics of mother and child. The chapter is divided into five parts. The first part shows the characteristics of the study population, the second part shows levels of infant mortality, the third part shows the bivariate analysis while the last two parts show the unadjusted and adjusted Cox proportional regression model.

4.1 Characteristics of the study population

Table 4.1 presents the characteristics of the study population in Luapula by mother and child. There were 21755 infants considered in this study, of which 2684 of them died before age 1 representing 12 per cent. The study also showed that three quarters (78 per cent) of the women were married/living with partner. The study reveals that the majority of the mothers had attained primary education (63 per cent). Results further indicate that 60 per cent of the women were literate.

Table 4.1 shows that 71 per cent of the mothers were classified as poor and 67 per cent of the women were not working. The study reveals that a large number, (82 per cent), of the participants resided in rural areas. Almost three quarters (74 per cent) were protestants. Results show that 45 per cent of the infants belonged to the second and fourth birth order. More than half (66 per cent) of the households in Luapula had 6 or more household members.

Slightly more than half (51 per cent) of the mothers were aged 20-29 years. More than half (57 per cent), of the infants were not breastfed. The study also shows that more than half (57 per cent) of the mothers in Luapula had less than 6 children. Table 4.1 shows that 55 per cent of the births occurred between 24-47 months before the last birth. Most (96 per cent) of the births were singleton. Sixty one per cent of the mothers were using contraceptives.

Tab 4.1 Demographic and socio-economic characteristics of mother and child, Luapula Province ZDHS 2018

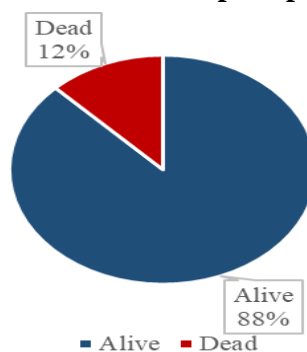
Characteristics	Weighted		Unweighted	
	Number	Percent	Number	Percent
Socio-economic factors				
Marital Status				
Single	1266	5.8	161	5.7
Married	16866	77.5	2 182	77.8
Formerly	3623	16.7	461	16.4
Maternal Education				
None	3278	15.1	403	14.4
Primary	13651	62.7	1 713	61.1
Secondary/Higher	4827	22.2	688	24.5
Maternal Literacy				
No	13014	59.8	1 631	58.2
Yes	8741	40.2	1 173	41.8
Wealth Quintile				
Poor	15351	70.6	1 863	66.4
Middle	3863	17.8	536	19.1
Rich	2541	11.7	405	14.4
Maternal Employment				
Yes	14724	67.7	1 855	66.2
No	7031	32.3	949	33.8
Residence				
Urban	3852	17.7	684	24.4
Rural	17903	82.3	2 120	75.6
Religion				
Catholics	5608	25.9	707	25.4
Protestants	15963	74.0	2 082	74.7
Partenal Education				
None	953	50.6	7617	52.5
Primary	820	43.5	6113	42.2
Secondary /Higher	111	5.9	772	5.3
Demographic/Child Factors				
Sex of Child				
Male	11080	50.9	1 406	50.1
Female	10675	49.1	1 398	49.9
Birth Order				
1	586	20.9	4473	20.6
2_4	1 255	44.8	9740	44.8
5+	963	34.3	7542	34.7
Sex of Household Head				
Male	16992	78.1	2 199	78.4
Female	4763	21.9	605	21.6
Household size				
<6 members	7514	34.5	957	34.1
6+ members	14241	65.5	1 847	65.9
Proximate determinants				
Maternal Age at Birth				
20-29	11197	51.5	1 446	51.6
<20	4083	18.8	532	19.0
30+	6475	29.8	826	29.5
Currently Breastfeeding				
Yes	9270	42.6	1 168	41.7
No	12485	57.4	1 636	58.4
Parity				
< 6 children	12329	56.7	1 602	57.1
> 6 Children	9426	43.3	1 202	42.9
Previous Birth Interval				
<24 months	9526	55.2	1 243	56.2
24-47 months	4542	26.3	565	25.5
48+ months	3176	18.4	405	18.3
Birth type				
Single	20950	96.3	2 700	96.3
Mulitple	805	3.7	104	3.7
Contraceptive use				
Yes	8413	38.7	1 143	40.8
No	13342	61.3	1 661	59.2

Source: 2018 ZDHS Data files author's computations

4.1.1 Child survival status, Luapula province Zambia

Figure 4.1.1 shows that out the 21755 live births, 12 per cent of the children in Luapula province died before celebrating their first birthday

Figure 4.1.1 : Child survival status, Luapula province ZDHS 2018

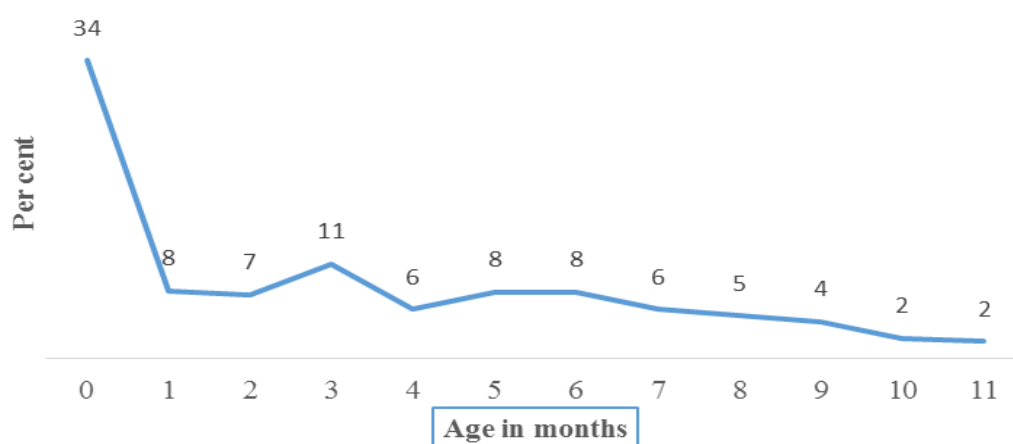


Source: 2018 ZDHS Data files author's computations
(n:un-weighted=2804; weighted=21755)

4.1.2 Age at death of child Luapula

The age at which a child dies is a very important indicator as it is closely linked to mortality. The study shows that a large proportion (34 per cent) of children died in the first month, followed by the third month (11 per cent) while the least proportion (2 per cent) of deaths occurred in the 11 months as indicated in figure 4.1.2.

Figure 4.1.2: Age at death of child Luapula, ZDHS 2018



Source: 2018 ZDHS Data files author's computations
(n: un-weighted=346; weighted=2684)

4.2 Levels of infant mortality in Luapula province, Zambia.

Table 4.2 presents infant mortality rates by demographic and socio-economic characteristics for Luapula, Zambia. Demographic and socio-economic characteristics of both the mother and child play an important role in the survival of children. Infant mortality in 2018 was 67 deaths per 1000 live births. This means that 1 in every 15 children in Luapula dies before reaching age 1.

Furthermore, results show that children born to single mothers had the highest risk of dying before turning 1 (100 per 1000 live births). Table 4.2 also shows that the risk of dying was high in mothers with primary education (68 deaths per 1000 live births) and lowest in mothers with secondary or higher education (24 deaths per 1000 live births). Infant mortality in rural areas was 59 deaths per 1,000 live births, compared to 57 deaths per 1,000 live births in urban areas. One in fourteen male children dies before age 1 (71 deaths per 1000 live births) compared to 1 in 22 female children (45 deaths per 1000 live births) in Luapula. The relationship between infant mortality and the number of household members is negatively correlated. Children born in a household with less than 6 members had higher risks of dying (95 deaths per 1000 live births) compared to children born in a house with 6 or more members (51 deaths per 1000 live births).

Infant mortality among children not breastfed was almost twice (84 deaths per 1000 live births) as high as mortality among children who were breastfed (45 deaths per 1000 live births). Findings reveal that there were 59 singleton deaths per 1000 live births compared to 259 multiple deaths per 1000 live births. In terms of contraceptive use, children born to mothers not using contraceptive were more likely to die (87 deaths per 1000 live births) compared to children born to mothers using contraceptive (37 deaths per 1000 live births).

Table 4.2 Infant mortality rates by demographic and socio-economic characteristics Luapula ZDHS 2018

Characteristics	IMR/1000	95% [C I]
Luapula	67	[60.3-74.4]
Socio-economic Factors		
Maternal Factors		
Marital Status		
Single	100	[59.2-168.8]
Married/Living with partner	60	[53.1-67.8]
Widowed/Divorced/Separated	87	[69.6-108]
Maternal Education		
None	68	[51.2-90.2]
Primary	62	[54.4-70.7]
Secondary/Higher	24	[19.1-30.2]
Maternal Literacy		
No	74	[64.7-84.7]
Yes	56	[47.3-66.3]
Wealth Quintile		
Poor	70	[61.6-79.5]
Middle	55	[43.1-70.1]
Rich	65	[48.5-87.1]
Maternal Employment		
Not Working	99	[82.9-118.2]
Working	54	[47.4-61.6]
Residence		
Urban	57	[46.4-70.1]
Rural	59	[52.2-66.7]
Religion		
Catholic	70	[56.7-86.5]
Protestant	66	[58.4-74.6]
Paternal Education		
None	68	[56.8-81.4]
Primary	62	[50.7-75.8]
Secondary/Higher	37	[17.6-77.6]
Demographic/Child Factors		
Sex of child		
Male	71	[61.5-82.0]
Female	45	[38.6-52.5]
Birth Order		
1	98	[80.8-118.8]
2_4	63	[53.7-118.8]
5+	55	[44.8-67.5]
Sex of Household Head		
Male	63	[55.6-71.3]
Female	83	[68.0-101.3]
Household Size		
<6 members	95	[80.8-111.7]
6+ members	51	[44.4-58.6]
Proximate Determinants		
Maternal age		
<20	102	[85.0-122.4]
20-29	64	[55.2-74.2]
30+	51	[39.2-66.4]
Currently Breastfeeding		
No	84	[74.2-95.1]
Yes	45	[36.9-54.9]
Parity		
<6 Children	68	[57.4-80.5]
6+ Children	65	[56.8-74.4]
Previous Birth Interval		
<24 months	142	[139.0-167.8]
24-47 months	36	[44.4-87.0]
48+ months	26	[16.0-42.4]
Birth type		
Single	59	[52.8-66.0]
Multiple	296	[216.3-405.1]
Contraceptive Use		
No	87	[76.8-98.5]
Yes	37	[30.3-45.1]

Source: 2018 ZDHS Data files author's computations

4.3 Determinants of infant mortality by selected background characteristics

4.3.1 Bivariate Cox relationships (Log-rank test)

The Log-rank test is a statistical test used for comparing the survival experience of two or more groups in survival analysis (Cox, 1972). The higher the relative hazard, the higher the likelihood of experiencing the event. This is similar to the chi-square test. Table 4.3.1 presents the log-rank tests results by selected background characteristics in Luapula, Zambia.

Among the socio-economic factors considered, only maternal literacy, wealth quintile, maternal employment status and paternal education were significant. Maternal literacy was significantly associated with infant mortality (Log-rank test $p=0.0565$). By wealth quintile, the study revealed that there were significant differences in survival times in the three groups (Log-rank test, $p=0.0551$). With regards to maternal employment status, the results show that there were significant differences in the survival of children for mothers working and not working (Log-rank test $=4.7$, $p=0.0302$). The study reveals that there were significant differences among the three survival curves for paternal education (Log-rank test $=6.3$, $p=0.0438$).

Table 4.3.1 shows that among the demographic/child factors considered, birth order, sex of household head and household size were significantly related to infant mortality. In terms of birth order, there were highly significant differences among the first, second to fourth and fifth and over birth order (Log-rank test $=12.59$, $p=0.0018$). In terms of sex of household head, the results reveal that there were significant differences in child survival for the male and female headed households (Log-rank Test, $p=0.0575$). With regards to household size, the study revealed that there were significant differences in the survival times for children in a household with less than 6 and over 6 members (Log-rank test $=19.6$, $p=0.0000$).

The results show that among proximate determinant considered mothers age at birth, breastfeeding, parity, previous birth interval birth type and contraceptive use were significantly associated with infant mortality in Luapula province. The results show that maternal age at birth was significantly associated with infant mortality. This entails that the survival curves were significantly different (Log-rank test $=29$, $p=0.000$). The survival curves for mothers who breastfed and those who did not breastfeed their children were significantly different (Log-rank test $=5.21$, $p=0.0225$). In terms of parity, there were highly significant differences in the survival prospects for children born to mothers with less than 6 children and those with more than 6 children (Log-rank test $=14.2$, $p=0.0000$). There were statistically significant differences in the survival times of the 3 groups of previous birth interval (Log-rank test $=61.1$, $p=0.0000$).

The results show that there were highly significant differences in the survival curves for multiple and single births (Log-rank test=9.76 $p=0.0018$). By contraceptive use, the results show that there were statistically significant differences in the survival times for children born to mothers using and not using contraceptives (Log-rank test=16 $p=0.000$).

Table 4.3.1 : Bivariate Cox relationships between Infant mortality and selected background characteristics of mother and child in Luapula, Zambia

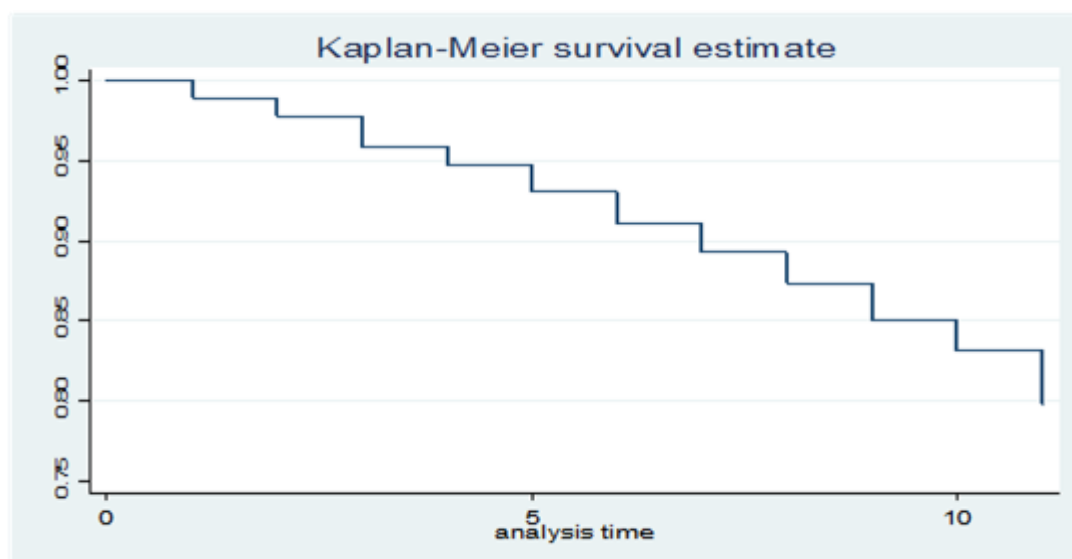
Characteristics	Observed Events	Relative Hazard	Log rank test	P value
Socio-economic Facotrs				
Marital Status				
Single	61	1.10	2.5	0.290
Married/Living with partner	1323	0.95		
Formerly Married	386	1.24		
Maternal Education				
None	288	1.02	4,3	0.118
Primary	1221	1.09		
Secondary/Higher	262	0.74		
Maternal Literacy				
No	1174	1.12	3.6	0.057
Yes	596	0.84		
Wealth Quintile				
Poor	1326	1.11	5.8*	0.055
Middle	301	0.89		
Richer	143	0.67		
Maternal Employment				
Not Working	1095	0.90	6.3**	0.012
Working	676	0.30		
Residence				
Rural	1472	1.02	0.5	0.488
Urban	299	0.91		
Religion				
Catholic	432	0.96	0.1	0.720
Protestant	1290	1.02		
Paternal Education				
None	694	1.20	6.3**	0.044
Primary	374	0.90		
Secondary/Higher	19	0.34		
Demographic/Child factors				
Child Sex				
Male	859	1.01	0.0	0.944
Female	912	1.00		
Birth Order				
1	488	1.48	12.6***	0.002
2_4	847	1.04		
5+	436	0.75		
Sex of Household Head				
Male	1276	0.94	3.6*	0.058
Female	495	1.26		
Household Size				
<6 members	779	1.56	19.6***	0.000
6+ members	991	0.83		
Proximate Determinants				
Mothers age at Birth				
<20 years	533	1.88	29.8***	0.000
20-29 Years	998	1.13		
30+ Years	240	0.53		
Currently Breastfeeding				
No	481	0.79	5.2**	0.003
Yes	1290	1.14		
Parity				
<6 Children	596	0.74	14.2***	0.000
6+ Children	1175	1.32		
Previous Birth Interval				
<24 months	754	2.66	61.1***	0.000
24-47 months	456	0.80		
48+ months	66	0.40		
Birth type				
Single	1648	0.97	9.8***	0.002
Multiple	123	2.25		
Contraceptive Use				
No	458	0.68	16.0***	0.000
Yes	1312	1.29		

Source: 2018 ZDHS Data files author's computations

*** p<0.01, ** p<0.05, * p<0.1, X2 : log rank test value

Figure 4.3 shows the Kaplan Meier curve showing the duration of survival since birth for all the children that died before age 1.

Figure 4.3 : survival since birth for all the children that died before age 1



4.3.2 Unadjusted Cox Proportional Regression Model

Table 4.3.2 presents the unadjusted hazard ratios for determinants of infant mortality in Luapula, Zambia. The results show that marital status, maternal education, residence and religion were not significantly associated with infant mortality in Luapula. Therefore, will be debarred from the Cox regression model building.

Socio-economi factors

Considering socio-economic factors, the results show that children born to literate women had 25 per cent lower risks of dying compared to children born to illiterate mothers [UHR: 0.75; 95% CI:0.556-1.020]. Further, the study shows that children born to mothers in rich wealth quintile were 40 per cent less likely to die compared to children born to mothers in poor wealth quintile [UHR: 0.60; 95% CI:0.359-1.007]. By maternal employment status, the results show that children born to unemployed mothers were 45 per cent more likely to die compared to children born to employed mothers [UHR: 1.45; 95% CI:0.971-2.159]. By paternal education, the study revealed that children born to mothers with a partner who had secondary and over education had lower chances of dying compared to children born to mothers with a partner who had no education [UHR: 0.28; 95% CI:0.084-0.928].

Demographic/Child Factors

As far as demographic/child factors are considered, the study shows that children born in second to fourth and fifth birth order had 29 and 49 per cent lower risks of infant mortality compared to children born in the first order respectively [UHR: 0.71; 95% CI: 0.518-0.961] and UHR: 0.51; 95% CI:0.371-0.703]. Further, the results show that children born in female-headed households had significantly 1.35 higher hazards of dying compared to children born in a male-headed household [UHR: 1.35; 95% CI:0.955-1.915]. Further, the results show that children born in a household with 6 or more members had 47 per cent reduced risk of dying compared to children in a household with less than 6 members [UHR: 0.53; 95% CI: 0.362-0.778].

Proximate determinants

Pertaining to the proximate determinants, mother's age at birth was a strong significant predictor of infant mortality in Luapula, Zambia. The study revealed that children born to mothers below 20 years had significantly increased hazards of dying compared to those born to mothers aged 20-29 [UHR: 1.66; 95% CI:1.203-2.284]. Children born to mothers aged 30+ had significantly lower chances of dying compared to children born to mothers aged 20-29 years [UHR: 0.47; 95% CI:0.292-0.784]. Children who were not breastfed by their mothers had 45 per cent higher risks of dying compared to children breastfed [UHR: 1.45; 95% CI: 1.009-2.077]. Children born to mothers with 6 children or more children had 1.79 higher hazards of dying compared to children born to mothers with less than 6 children [UHR: 1.79; 95% CI: 1.266-2.531.961].

The study revealed that children born to mothers with a preceding birth interval of less than 24 months were three times more likely to die compared to women with a preceding birth interval of 24-47 months [UHR: 0.3.33; 95% CI: 2.441-4.534. Additionally, the study revealed that children born to mothers with a preceding birth interval of 48+ months had 50 per cent lower chances of dying [UHR: 0.50; 95% CI: 0.221-1.145]. The results show that the risk of infant mortality among multiple births was 2.31 higher compared to single births [UHR: 2.31; 95% CI: 1.314-4.061]. Table 4.3.2 shows that children born to mothers not using contraceptives were significantly two times more likely to die compared to children born to mother's using contraceptives [UHR: 1.91; 95% CI: 1.360-2.675].

Table 4.3.2 : Univariate Cox Regression: Unadjusted Hazard Ratios (UHR) of the association between infant and selected background characteristics of mother and Child

Characteristics	Hazard Ratios	P-value	95 % C I
Socio-economic factors			
Marital Status			
Single Ref	1.00		
Married/Living with partner	0.87	0.708	[0.403-1.861]
Widowed/Divorced/Separated	1.13	0.785	[0.471-2.696]
Maternal Education			
No Education Ref	1.00		
Primary	1.07	0.801	[0.627-1.826]
Secondary/Higher	0.72	0.217	[0.432-1.216]
Maternal Literacy			
No Ref	1.00		
Yes	0.75*	0.067	[0.556-1.020]
Wealth Quintile			
Poor Ref	1.00		
Middle	0.8	0.258	[0.549-1.178]
Rich	0.60*	0.053	[0.359-1.007]
Maternal Employment			
Working Ref	1		
Not working	1.45*	0.068	[0.971-2.159]
Residence			
Urban Ref	1.00		
Rural	1.12	0.408	[0.854-1.465]
Religion			
Catholic Ref	1.00		
Protestants	1.06	0.747	[0.737-1.526]
Partenal education			
No Education Ref	1.00		
Primary	0.75	0.121	[0.517-1.082]
Secondary/Higher	0.28**	0.038	[0.084-0.928]
Demographic/Child factors			
Sex of child			
Male Ref	1		
Female	1.01	0.955	[0.712-1.433]
Birth order			
1 Ref	1		
2_4	0.71	0.028	[0.518-0.961]
5+	0.51***	0.000	[0.371-0.703]
Sex of Household head			
Male Ref	1.00		
Female	1.35*	0.088	[0.955-1.915]
Household size			
< 6 members Ref	1		
6+ members	0.53***	0.002	[0.362-0.778]
Proximate determinants			
Maternal age at birth			
<20 years	1.66***	0.003	[1.203-2.284]
20-29 years Ref	1.00		
30+ years	0.47***	0.002	[0.292-0.784]
Currently Breastfeeding			
Yes Ref	1		
No	1.45**	0.045	[1.009-2.077]
Parity			
<6 Ref	1.00		
6+	1.79***	0.001	[1.266-2.531]
Previous birth interval			
< 24 months	3.33***	0.000	[2.4414.534]
24-47 months Ref	1		
48 months	0.50*	0.100	[0.221-1.145]
Birth type			
Single Ref	1		
Multiple	2.31***	0.004	[1.314-406]
Contraceptive Use			
Yes Ref	1		
No	1.91***	0.000	[1.360-2.675]

Source: 2018 ZDHS Data files author's computations

*** p<0.01, ** p<0.05, * p<0.1 UHR (Unadjusted Hazard Ratios) Ref (Reference Category)

3

³ Hazard ratios interpretation | **HR = 1**: No effect ; **HR < 1**: Reduction in the hazard; **HR > 1**: Increase in Hazard

4.3.3 Multivariate regression analysis

Table 4.3.3 shows the Adjusted Hazard Ratios (AHRs) of the association between infant mortality and selected explanatory factors of mother and child. Three models were generated to identify the predictors of infant mortality in Luapula. In model 1 socio-economic factors were included, model 2 demographic/child factors were included and in model 3 (full model) the proximate determinants selected from the mother and child factors were added. In the final model, only variables that were significant in model 3 were included to come up with the best model as shown by the Cox-Snell residue in Annex A.5.1

Model 1 : Socio-economic factors

Model 1 shows that children born in rich wealth quintile in Luapula province had 0.63 lower hazards of dying compared to children born in poor wealth quintile [AHR: 0.63; 95% CI:0.378-1.061]. The results also show that children born to mothers who were not employed were 44 per cent more likely to die in infancy compared to children born to mothers who were employed [AHR: 1.44; 95% CI:0.949-2.178].

Model 2: Demographic/Child factors included

The results in model 2 show that after adjusting for demographic/child factors, wealth quintile and employment status were not significant determinants of infant mortality. Further the results in model 2 reveal that children born in household with 6 or more members were 44 percent less likely to die compared to children born in households with less than 6 members [AHR: 0.56; 95% CI: 0.384-0.826].

Model 3: Proximate determinants included

Furthermore, the inclusion of proximate determinants to the model resulted in the reduction of the risk of dying for children born in households with 6 or more members. Additionally, results show that children born to mothers below 20 were two times more likely to die compared to children born to mothers aged 20-29 [AHR: 2.06; 95% CI:1.293-3.277]. Further the results show that children born to mothers aged 30+ years had significantly reduced risks of dying compared to children born to mothers aged 20-29 years [AHR: 0.36; 95% CI:0.204-0.621].

Model 3 also shows that children who were not breastfed had significantly increased risks of dying compared to children breastfed by their mothers [AHR: 1.76; 95% CI: 1.187-2.605]. Children born to mothers with more than 6 children were three times more likely to die compared to children born to mothers with less than 6 children [AHR: 2.84; 95% CI: 1.638-4.940]. The children born in less than 24 months previous birth interval had significantly

increased hazards of dying compared to children born in a 24-47 months before the previous birth [AHR: 2.88; 95% CI: 2.032-4.069]. The risks of dying for children born in multiple births was high compared to children born in singleton births [AHR: 2.85; 95% CI: 1.673-4.964]. The findings also reveal that children born to mothers not using contraceptives had significantly increased chances of dying in infancy compared to children born to mothers using contraceptives [AHR: 1.56; 95% CI: 1.106-2.199].

Table 4.3.3 : Multivariate Cox Proportional Regression: Adjusted Hazard Ratios (AHRs) of the association between infant mortality selected explanatory factors of mother and child

Characteristics	Model I			Model II			Model III Full		
	Hazard ratio	P-value	[95% CI]	Hazard ratio	P-value	[95% CI]	Hazard ratio	P-value	[95% CI]
Socio-economic factors									
Maternal Literacy									
No Ref	1.00			1.00			1.00		
Yes	0.87	0.380	[0.633-1.193]	0.86	0.393	[0.595-1.169]	0.85	0.373	[0.660-1.215]
Wealth Quintile									
Poor Ref	1.00			1.00			1.00		
Middle	0.88	0.532	[0.594-1.313]	0.89	0.531	[0.607-1.377]	1.17	0.436	[0.782-1.755]
Richer	0.63*	0.082	[0.378-1.313]	0.66	0.133	[0.360-1.117]	0.82	0.622	[0.371-1.821]
Maternal Employment									
Working Ref	1.00			1.00			1.00		
Not Working	1.44*	0.086	[0.949-2.178]	1.45*	0.082	[0.912-2.193]	1.34	0.191	[0.841-2.322]
Demographic/Child Factors									
Sex of child									
Male Ref				1.00			1.00		
Female				1.02	0.892	[0.697-1.401]	1.02	0.932	[0.692-1.493]
Sex of Household Head									
Male Ref				1.00			1.00		
Female				1.23	0.226	[0.977-2.062]	1.31	0.142	[0.911-1.883]
Household Size									
<6 members Ref				1.00			1.00		
6+ members				0.56***	0.004		0.48***	0.001	[0.322-0.773]
Proximate Determinants									
Mothers age at Birth									
<20 years							2.06***	0.003	[1.293-3.277]
20-29years Ref							1.00		
30+ years							0.36***	0.000	[0.204-0.621]
Currently Breastfeeding									
Yes Ref							1.00		
No							1.76***	0.006	[1.187-2.605]
Parity									
<6 Children Ref							1.00		
6+ Children							2.84***	0.000	[1.638-4.940]
Previous Birth Interval									
<24 months							2.88***	0.000	[2.032-4.069]
24-47 months Ref							1.00		
48+ months							0.56	0.175	[0.241-1.304]
Birth type									
Single Ref							1.00		
Multiple							2.85***	0.000	[1.673-4.964]
Contraceptive Use									
Yes Ref							1.00		
No							1.56**	0.012	[1.106-2.199]

Source: 2018 ZDHS Data files author's computations

*** p<0.01, ** p<0.05, * p<0.1 AHR (Adjusted Hazard Ratio) Ref (Reference category)

4.3.4 Final Cox regression model

The final model is presented in table 4.3.4. In this model variables found to be less insightful were dropped. The results in the final model show that household size, mothers' age at birth breastfeeding, parity, previous birth interval, birth type and contraceptive use are important determinants of infant mortality in Luapula, Zambia. The model was the best model as it had the highest chi-square value and it was also affirmed by the Cox and Snell residue which showed that the hazard function closely followed the 45 degrees line.

The study indicated in the final model that children born in a household with 6 or more members [AHR: 0.45; 95% CI: 0.298-0.691] had significantly lower hazards of dying compared to children born in households with less 6 members.

Findings in the final model revealed that the risks of death to children born to mothers below 20 years remained significantly high [AHR: 2.09; 95% CI: 1.354-3.224]. The risks of dying for children to mothers aged 30+ years reduced further [AHR: 0.33; 95% CI: 0.190-0.573]. Though a slight reduction was observed, the risks of infant mortality among multiple births remained significantly higher [AHR: 2.55; 95% CI: 1.381-4.710] compared to children born among single births. Similarly, children who were not breastfed [AHR: 1.72; 95% CI: 1.185-2.504] had significantly higher risks of dying compared to children not breastfed. The results also reveal that children born to mothers with 6 or more children [AHR: 3.00; 95% CI: 1.754-5.117] were three times more likely to die compared to children born to mothers with less than 6 children.

Results also show that children born in a preceding birth interval less than 24 months had significantly reduced risks of dying compared to children born to mothers with a preceding birth interval of 24-47 months [AHR: 2.88; 95% CI: 2.005-4.146]. Mother's not using contraceptives [AHR: 1.66; 95% CI: 1.157-2.386] their children had 1.66 increased hazards of dying compared to children born to mothers using contraceptives.

Table 4.3.4: Final Cox proportional regression model: Adjusted Hazard Ratios of the association between mother and child characteristics.

Characteristic	Hazard Ratio	P-value	95 % C I
Demographic/Child factors			
Household size			
<6 members Ref	1,00		
6+ members	0.45***	0,000	[0.298-0.691]
Proximate determinants			
Mothers age at birth			
<20 years	2.09***	0,001	[1.354-3.334]
20-29 years Ref	1,00		
30+ years	0.33***	0,000	[0.190-0.573]
Currently breastfeeding			
Yes Ref	1,00		
No	1.72***	0,005	[1.185-2.504]
Parity			
<6 Ref	1,00		
6+	3.00***	0,000	[1.754-5.117]
Previous birth interval			
< 2 months	2.88***	0,000	[2.005-4.146]
24-47 months Ref	1,00		
48+ months	0,58	0,187	[0.255-1.315]
Birth type			
Single Ref	1,00		
Multiple	2.55***	0,003	[1.381-4.710]
Contraceptive use			
Yes Ref	1,00		
No	1.66***	0,007	[1.157-2.386]

Source: 2018 ZDHS Data files author's computations

*** p<0.01, ** p<0.05, * p<0.1 AHR (Adjusted Hazard Ratio) Ref (Reference category)

CHAPTER 5: DISCUSSION OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

The study examined the determinants of infant mortality in Luapula, Zambia, using the 2018 ZDHS, levels, bivariate analysis (log-rank tests) and multivariate analysis (Cox proportional regression model). The study found that household size, mothers age at birth, breastfeeding, parity, previous birth interval, birth type and contraceptive use were significantly associated with infant mortality.

5.2 Discussion of findings

The findings show that 34 per cent of the infant death occurred in the first month of life in Luapula, Zambia. The study found that infant mortality in Luapula was 67 deaths per 1000 live births which is higher than the national average (42 per 1000 live births). This entails that 1 in every 15 children dies before age 1 in Luapula province.

5.2.1 Socio-economic factors

The log rank test at bivariate level revealed that maternal literacy and wealth quintile had a weak association with infant mortality at 10 percent significance level. The test also revealed that maternal employment status and paternal education were significantly associated with infant mortality. However, in the multivariate analysis, the study revealed after adjusting for the demographic/child factors and the proximate determinants, there was no association between socio-economic factors with infant mortality in Luapula province contrary to the studies done in Zambia (Lukonga and Michelo, 2015; Madise *et al.*, 2003). This could be attributed to the homogeneous nature of the population of Luapula province in terms of socio-economic factors. According to the 2010 Census about 80 per cent of population in Luapula resides in rural areas and 73 percent of the women had done only upto primary education (Central Statistical Office, 2014).

5.2.2 Demographic/Child Factors

The findings reveal that children born in households with 6 or more members had significantly reduced risks of dying compared to those born in households with less than 5 members. This is consistent with a study done by Ibrahim *et al.*, (2019) in Nigeria which found that infants born in larger households had significantly reduced risks of dying compared to children born in smaller households. Similarly, a study done by Dwomoh *et al.*, (2019) in Ghana found that children born in larger households had significantly reduced risk of dying compared to children

born in smaller households. Dwomoh *et al.*, (2019) in Ghana concluded that the observed protective effect of household size may not necessarily be the size of the household but the benefit of having more educated and experienced household members to advice on critical child and maternal healthcare challenges.

5.2.3 Proximate determinants

The study also showed that children born to mothers aged 30+ years had significantly reduced hazards of dying. The study findings are consistent with the study done in the United States of America by He *et al.*, (2015) which found that infants born to old mothers had significantly lower risks of dying compared to infants born to young mothers (below 20) because normally young mothers tend to have biological, emotional, social, and economic problems that frustrate their entire childbearing process. Other studies done by (Ezeh *et al.*, 2015; Weldearegawi *et al.*, 2015) from Nigeria and Ethiopia found that infants born to mothers below 20 had significantly higher risks of dying compared to children of older mothers. Additionally, younger mothers are more likely to be poor, uneducated and unemployed, which may affect the health of their infants.

Further, in this study, the risk of infant death was significantly higher for children not breastfed by their mothers. This finding is consistent with a study conducted in the United States of America by Ware *et al.*, (2019) which found infants not breastfed had higher risks of dying compared to infants breastfed. Another study by Lamichhane *et al.*, (2017) in Nepal revealed that children not breastfed were more likely to die compared to children breastfed by their mothers. Equally, a cohort study conducted by Biks *et al.*, (2015) in Ethiopia found that infant not breastfed were eight times more likely to die than those breastfed. A conceivable explanation is that breastfeeding improves infant health because it is nutritious; it can provide all the nutritional requirements for an infant up to six months. It also improves the immunity of infants (Biks *et al.*, 2015; Brahm and Valdés, 2017).

With regards to parity, the findings show that women with more children are more likely to lose a child compared to women with few children. The study showed that children born to mothers with 6 or more children had significantly higher risks of dying compared to those born to mothers with 5 or less children. Another study done by Kananura *et al.*, (2016) in rural Eastern Uganda found women who were of parity 5 and above were three times more likely to lose their new-borns within 28 days compared to those who were of parity 4 and below. However, in a cohort study done by Santos *et al.* (2016) in Brazil found that parity was not

significantly associated with infant mortality. Similarly, a study done by Dev *et al.*, (2017) in Nepal found no significant associations. High parity births are associated with high mortality because when parity increases, a larger proportion of births belongs to these higher risk such as having a preceding birth interval of less than 24 months which is a strong predictor of mortality (Naoko *et al.*, 2014).

This study also demonstrated that the risk of death was significantly higher for the preceding birth interval of less than 24 months compared to 24-47 months. This is consistent when compared to findings from Nepal, in which infants born within 24 months preceding birth interval had higher risks of dying. Similarly, Madise *et al* (2003) in Zambia found that longer preceding birth interval is associated with low infant mortality. A cohort study conducted in Ethiopia found that infants with a preceding birth interval of less 24 months were four times more likely to die. The possible reason for this is that a short preceding birth interval affects the survival of the index child due to maternal depletion. This is because the mother has not had enough time to recover from the previous birth and so her next birth will be very weak with low birth weight (Madise *et al.*, 2003).

The study also established that the risk of death of an infant was significantly higher among multiple than singleton births. This finding is consistent with a study conducted by Uthman *et al.*, (2008) in Nigeria in which the risk of death for infants born in multiple births was significantly higher than singleton births. A study by (Bills *et al.*, 2018) showed that the risk of dying among multiple births was three times higher compared to single births in India in line with this study. Similarly, a study done by Abate *et al* (2020) found that infant mortality among multiple births was four times higher than singleton birth. Furthermore, a study done by (Dwomoh *et al.*, 2019) in Ghana found that infant mortality among multiple births was over three times higher than singleton. Births including twins and higher order multiples such as triplets and quadruplets are high-risk pregnancy and birth. These are accompanied by a number of associated foetal and neonatal complications that require special and expensive medical care.

The study found a higher risk of infant mortality with mothers not using contraceptives compared to mothers using contraceptives. This is consistent with a cohort study done in North-western Ethiopia which found that children born to mothers not using contraceptives were more likely to die (Biks *et al*, 2015). This is also in line with a study done in Bangladesh that found that children born to mothers using contraceptives had reduced odds of dying compared to

children born to mothers not using contraceptives (Abir *et al.*, 2015). Furthermore, a study done in Nepal found that women not using contraceptives were two times more likely to lose a child compared to mothers using contraceptives (Ghimire *et al.*, 2019). The plausible explanation is that no or low contraceptive use is associated with the highest rates of birth risk such as short birth intervals (<24 months) which is a strong predictor of infant mortality (Maïga *et al.*, 2015).

The research hypothesis that younger mothers are more likely to lose a child compared to older and that children in multiple births are more likely to die have been accepted. However, the hypothesis that male children are more likely to die compared to female children has been rejected.

This study has shown that proximate determinants are important predictors of infant mortality as outlined in the 1984 Mosley and Chen framework. The proximate determinants outlined in Mosley and Chen framework were significant in this study, which includes mother's age at birth, parity and previous birth interval. The socio-economic factors were not significant determinants of infant mortality in Luapula, Zambia.

This study has contributed to the literature on determinants of infant mortality at a provincial level in Zambia because most of the studies that have been conducted focused on national level factors. This will provide policymakers with insights that the national level factors of infant mortality are different from the provincial factors as evidenced by this study.

5.3 Conclusion

Infant mortality has been relatively high in Luapula province compared to other provinces in Zambia. The study found that 1 in every 15 children in Luapula dies before celebrating their first birthday. Findings reveal that only bio-demographic factors were significant predictors of infant mortality. The study found no socio-economic determinants associated to infant mortality.

The study found that children born in larger households were less likely to die. Findings further revealed that children born to young mothers were more at risk of death at infancy. This because young mothers are more likely to be poor, uneducated and unemployed, which may affect the health of their infants. The study also showed that women who did not breastfeed were more likely to lose a child. Women who had more children and who had a short previous birth interval were more likely to lose a child. Further, the study revealed that children born

among multiple births were more at risk due to the complications that pregnancy of twins, triplets or quadruplets are high risk pregnancy. There is need to investigate the dynamics of household size and its relative effect on child survival in Luapula, Zambia.

5.4 Recommendations

- i. The government through the Ministry of health should advocate for use of modern contraceptives among women in Luapula to prevent high risks birth (short preceding birth interval < 24 months). Findings reveal that children born to mother's not using contraceptives were more likely to die compared to their counterparts. Low contraceptive uptake is associated with high risks birth such as short preceding birth interval.
- ii. The study reveals that children who were not breastfed by their mothers had higher risks of dying compared to children that were breastfed. The government should sensitize women on the need to breastfeed their new-born children because of the nutrients it provides and its importance to the optimal growth of the infant.
- iii. Findings show that mothers with more children are more likely to lose a child compared to women with fewer children. The government should partner with Non-Governmental Organisations to advocate for girl child education which in turn raises the age at marriage, first birth and consequently reduces parity.
- iv. The study found that infants born in households with more members had a lower risk of dying. Qualitative research needs to be done to understand better the dynamics of household size and its relative effect on child survival in Zambia. The protective effect of household size may not necessarily be the size of the household but the benefit of having more educated and experience household members to advice on critical child and maternal healthcare challenges.

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CHAPTER 4 APPENDICES

Figure A.4.1: Test of a goodness of fit (Cox Snell Residual)

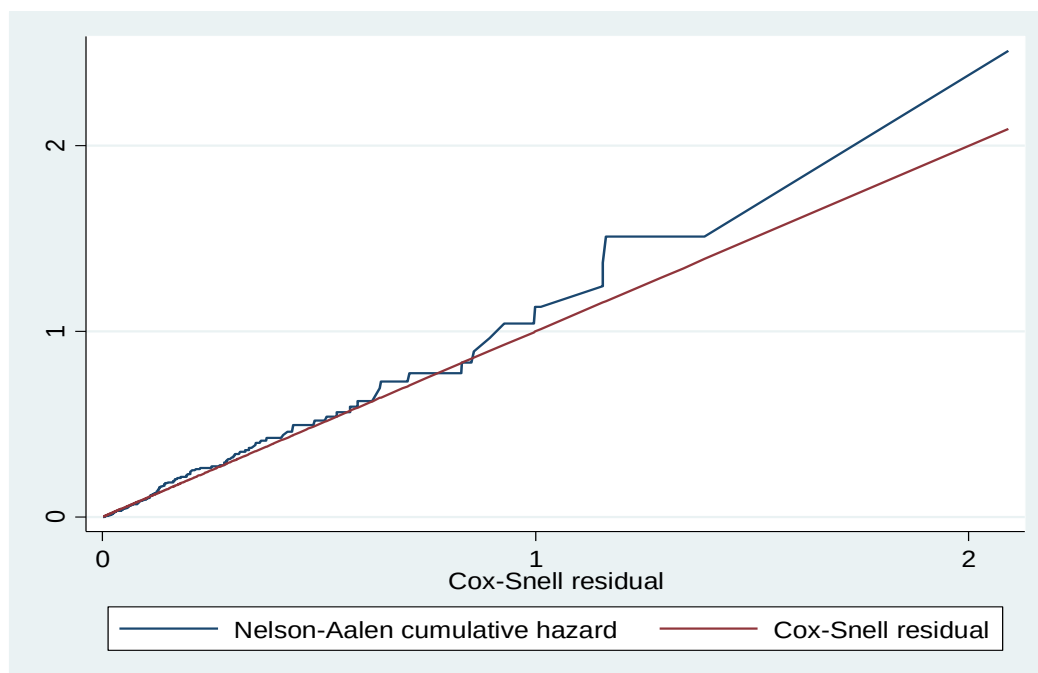


Figure A.4.2: Kaplan-Meier survival estimates by maternal employment of child in Luapula, Zambia 2018 ZDHS

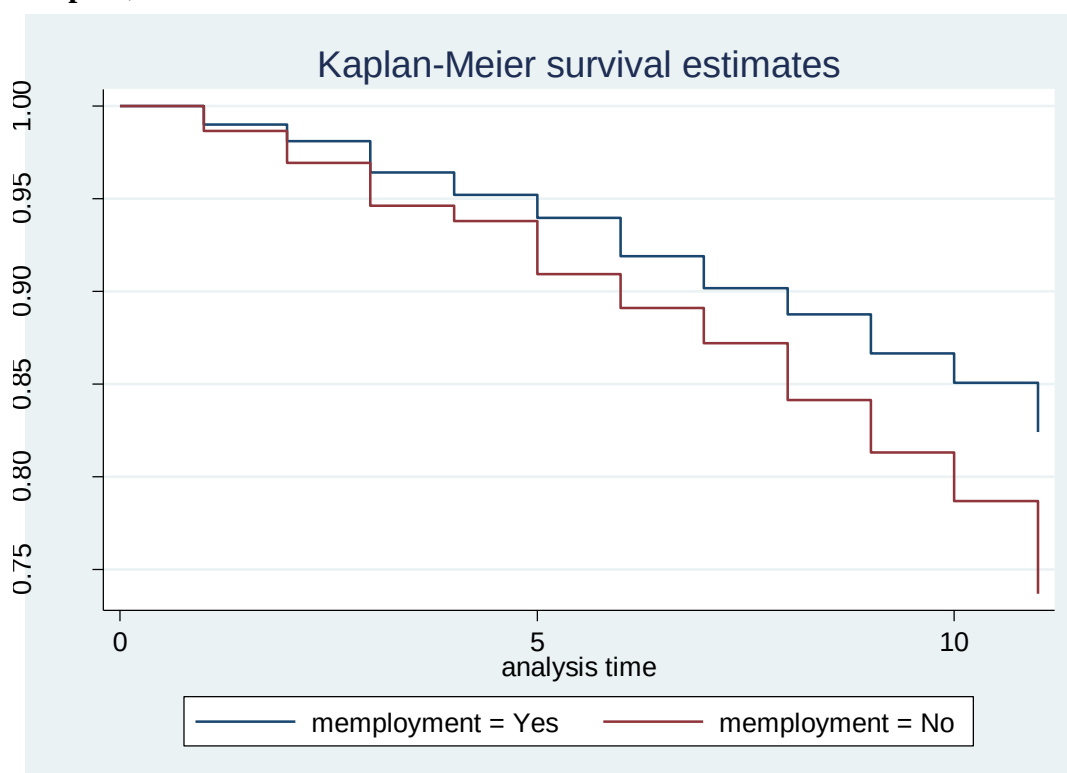


Figure A.4.3: Kaplan-Meier survival estimates by birth order of mother in Luapula, Zambia 2018 ZDHS

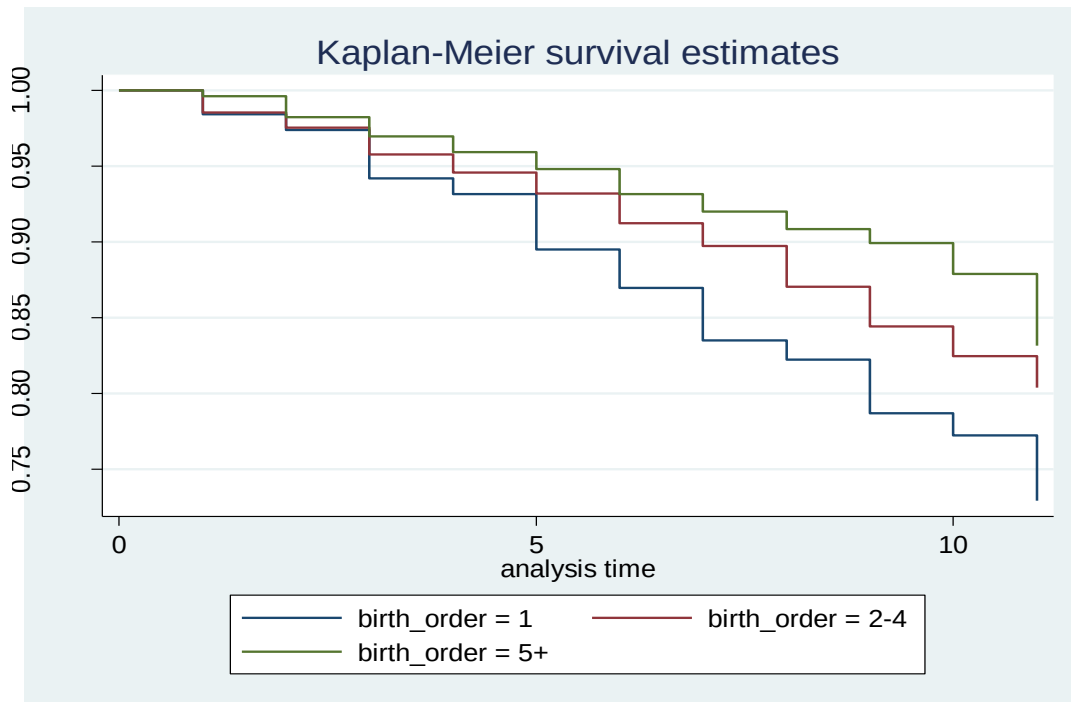


Figure A.4.4: Kaplan-Meier survival estimates by household size in Luapula, Zambia 2018 ZDHS

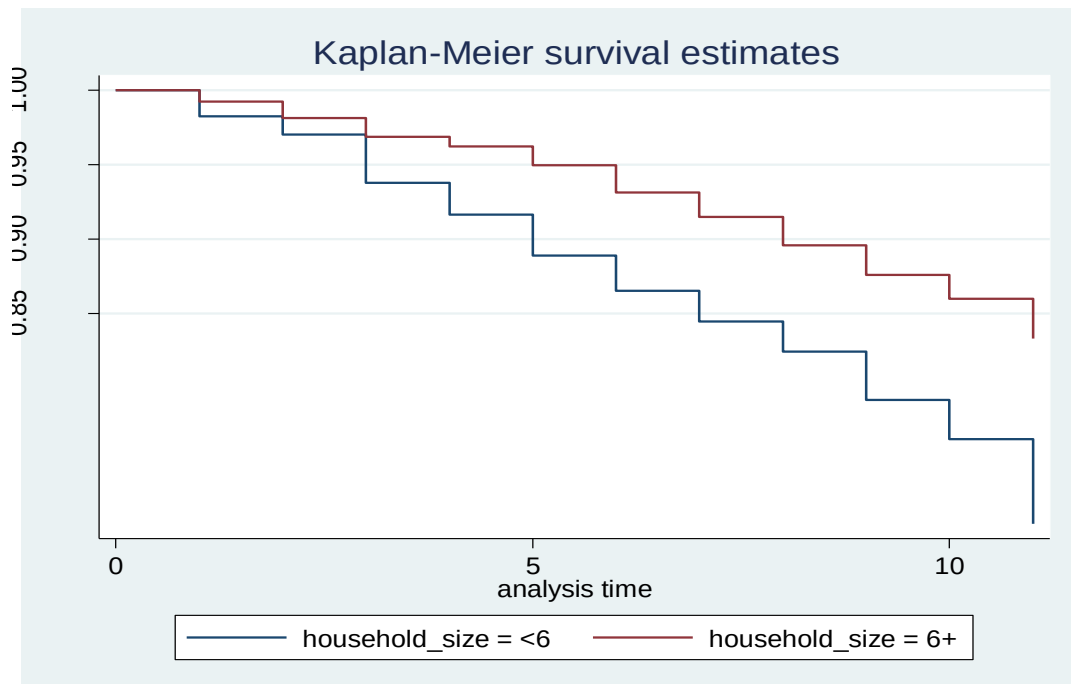


Figure A.4.5: Kaplan-Meier survival estimates by previous birth interval in Luapula, Zambia 2018 ZDHS

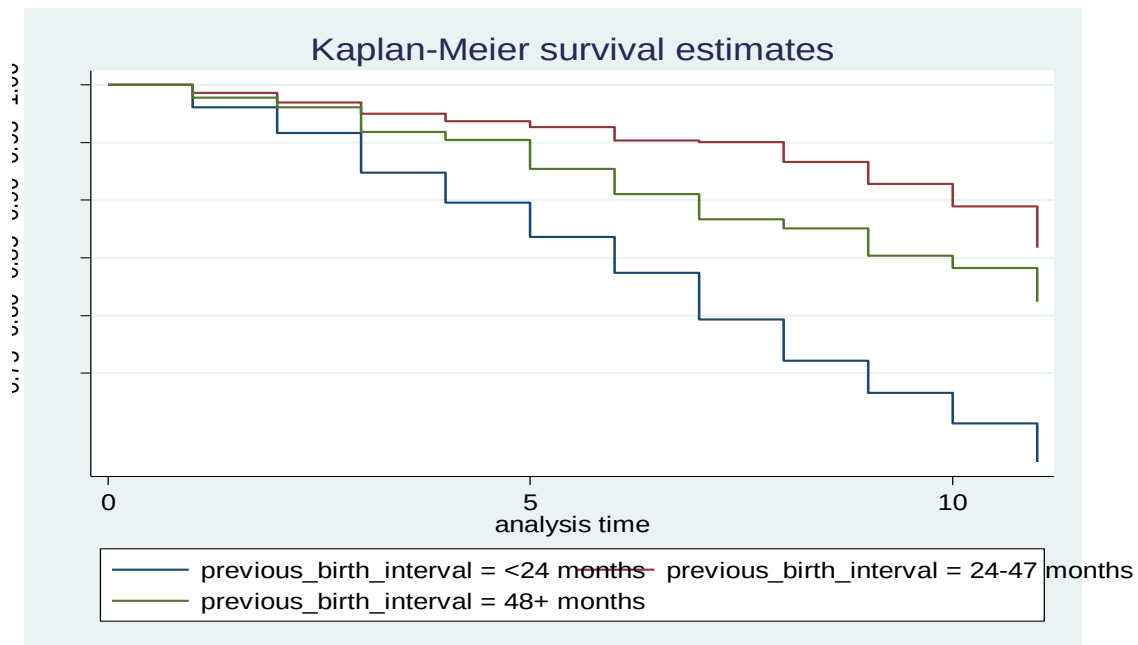


Figure A.4.6: Kaplan-Meier survival estimates by wealth quintile of mother in Luapula, Zambia 2018 ZDHS

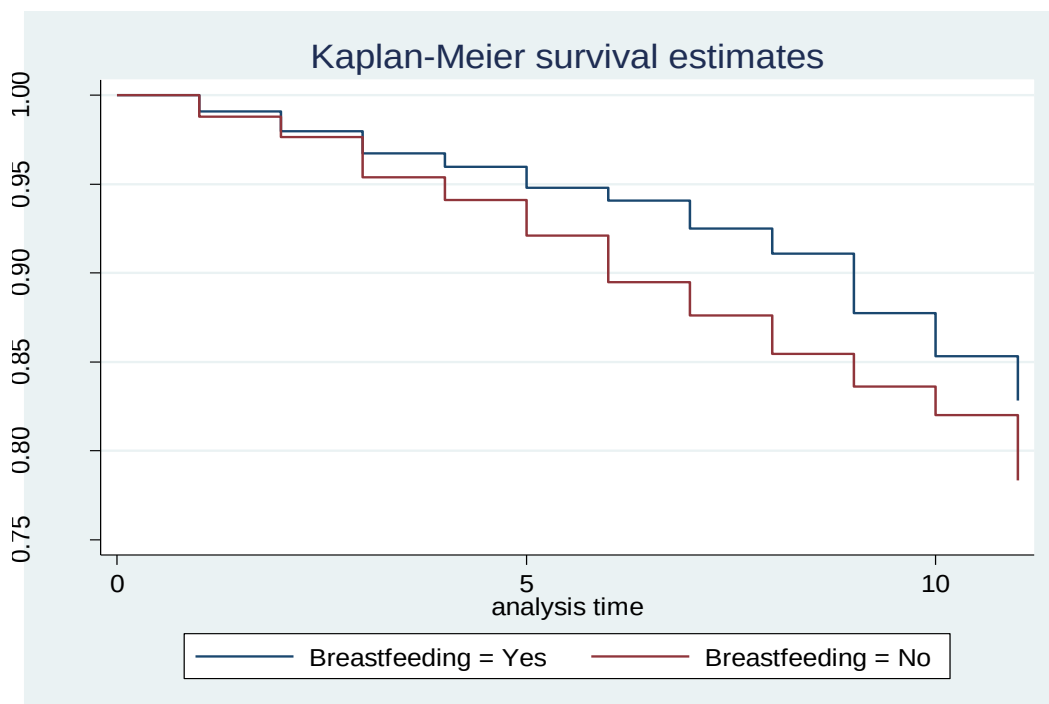


Figure A.4.7: Kaplan-Meier survival estimates by sex of household head in Luapula, Zambia 2018 ZDHS

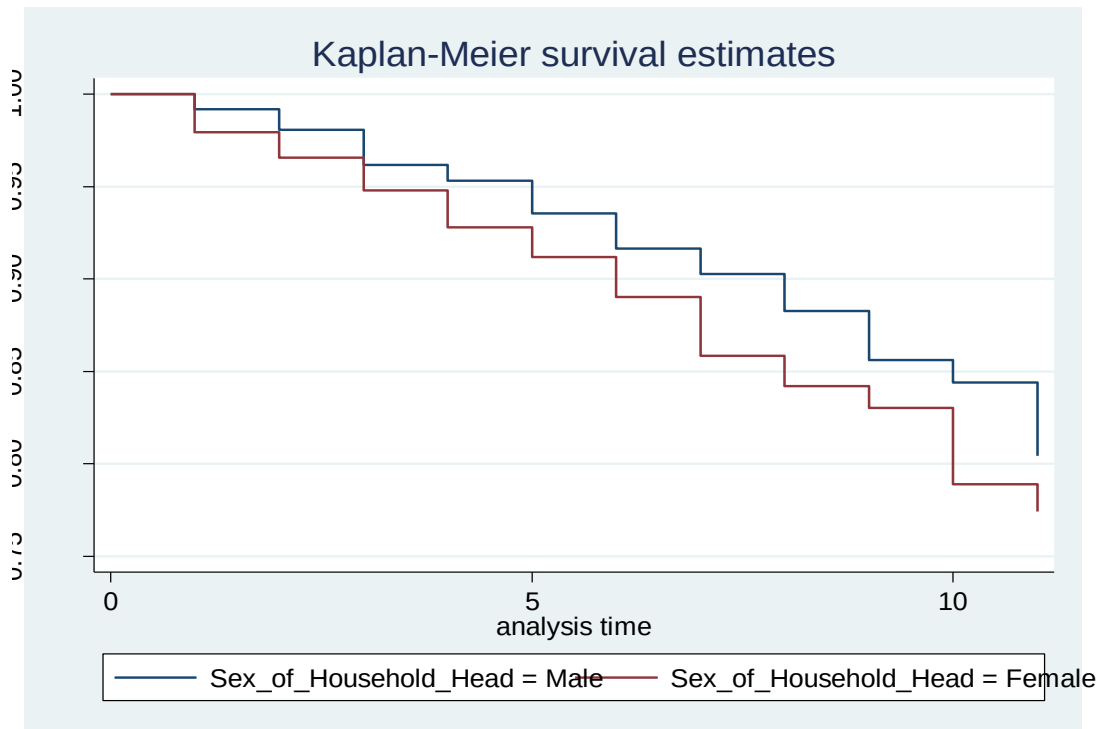


Figure A.4.8: Kaplan-Meier survival estimates by contraceptive use of mother in Luapula, Zambia 2018 ZDHS

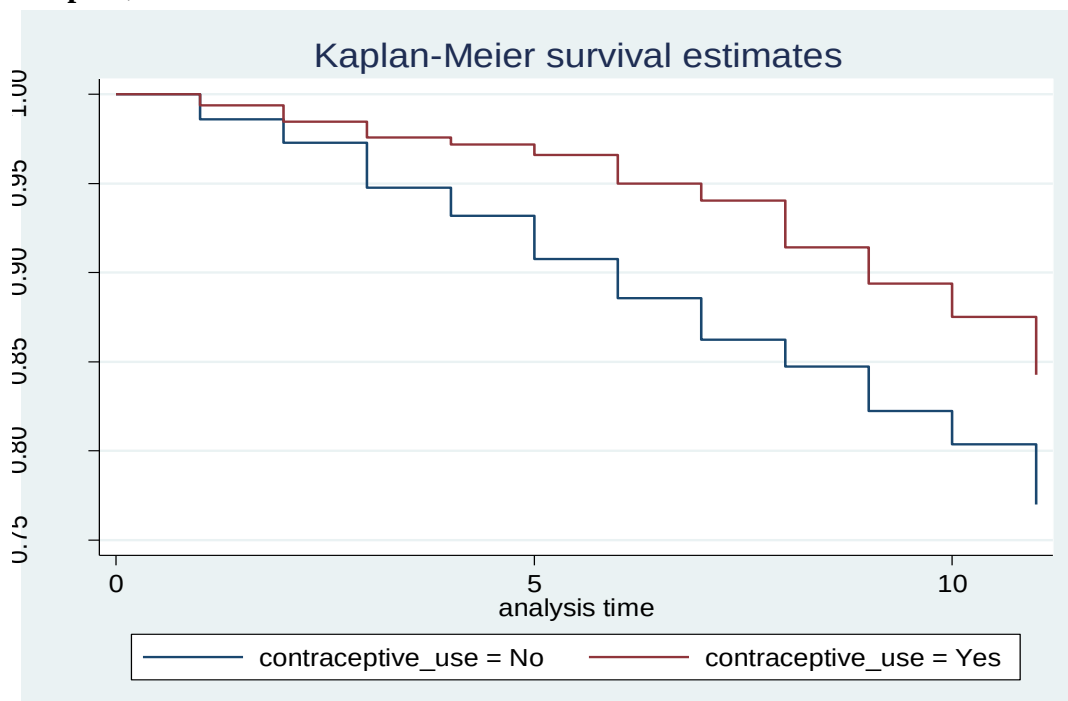


Figure A.4.9: Kaplan-Meier survival estimates by Literacy of mother in Luapula, Zambia 2018 ZDHS

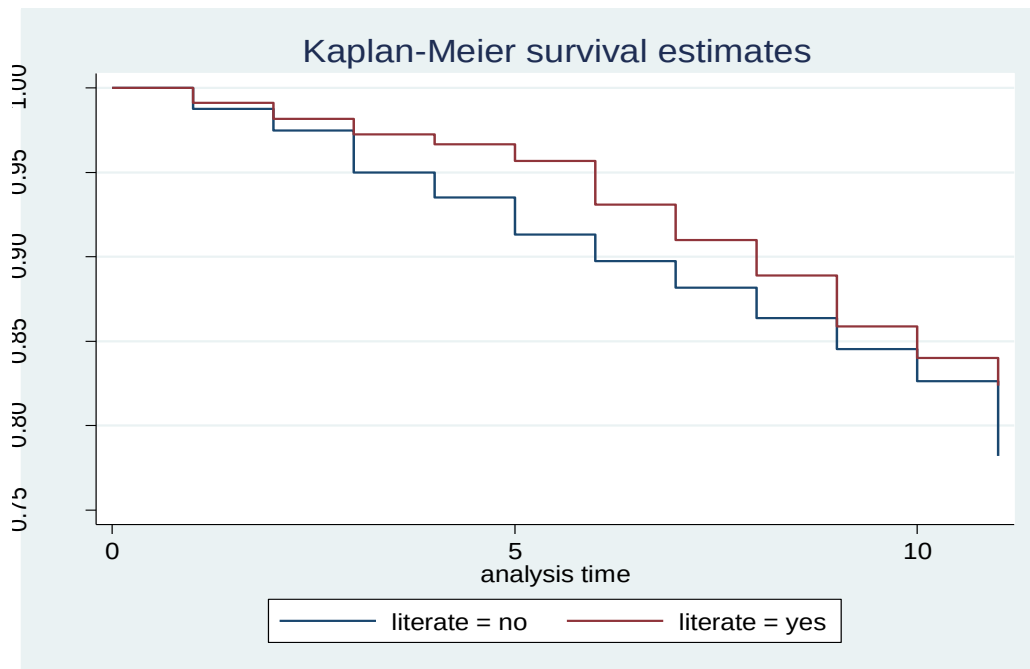


Figure A 4.10: Kaplan-Meier survival estimates by parity of mother in Luapula, Zambia 2018 ZDHS

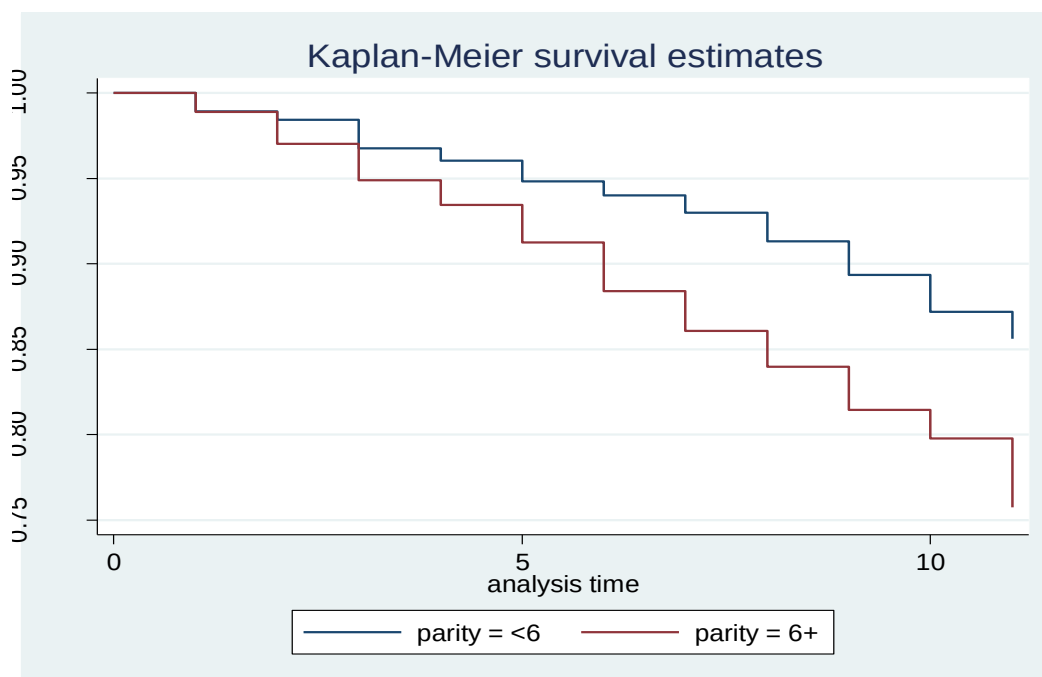


Table A 4.1 Test of Proportional Hazard Assumption

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Test of proportional-hazards assumption

Time: Time

	rho	chi2	df	Prob>chi2
mothers_ag~_	-0.05287	0.71	1	0.3997
Sex_househ~d	-0.00531	0.01	1	0.9326
maternal_l~y	0.05053	0.61	1	0.4357
wealth_qui~e	0.07359	1.23	1	0.2673
maternal_e~t	-0.03221	0.24	1	0.6238
birth_type	0.00013	0.00	1	0.9986
currently_~g	-0.00020	0.00	1	0.9974
parity	0.03437	0.30	1	0.5849
prev_bint	-0.02074	0.11	1	0.7361
contraceti~e	-0.12827	3.30	1	0.0691
household_~e	0.02162	0.11	1	0.7415
global test		7.78	11	0.7330

note: robust variance-covariance matrix used.



Jan 14, 2021

Peter Mumba
University of Zambia
Zambia
Phone: +260979445618
Email: petmumba50@gmail.com
Request Date: 01/14/2021

Dear Peter Mumba:

This is to confirm that you are approved to use the following Survey Datasets for your registered research paper titled: "Determinants of infant mortality in Luapula, Zambia":

Zambia

To access the datasets, please login at: https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The user name is the registered email address, and the password is the one selected during registration.

The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.

The DHS Data may be used only for the purpose of statistical reporting and analysis, and only for your registered research. To use the data for another purpose, a new research project must be registered. All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey. Please reference the complete terms of use at: <https://dhsprogram.com/Data/terms-of-use.cfm>.

The data must not be passed on to other researchers without the written consent of DHS. However, if you have coresearchers registered in your account for this research paper, you are authorized to share the data with them. All data users are required to submit an electronic copy (pdf) of any reports/publications resulting from using the DHS data files to: references@dhsprogram.com.

Sincerely,

Bridgette Wellington

Bridgette Wellington
Data Archivist
The Demographic and Health Surveys (DHS) Program