Modelling Covariates of Infant and Child Mortality in Malawi

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PLAGIARISM DECLARATION

I understand plagiarism is wrong. This research is my work produced with assistance from my supervisor. The work of other people has been recognised using citations and references.

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Clara Lemani Date

ABSTRACT

Mortality of children under the age of five has been the main target of public health policies (Gakusi and Garenne 2006). There has been a significant decline in under-five mortality in the twentieth century in almost all countries regardless of initial levels and socio-economic factors, although the rate of decline has been different in different regions (UNIGME 2012). Malawi, a country in the sub-Saharan region, is characterised by high infant and child mortality. Using data from 2010 Malawi Demographic and Health Survey, infant mortality in Malawi was estimated at 66 deaths per 1000 births while child mortality was at 50 deaths per 1000 births (NSO and ORC Macro 2011).

Studies have been conducted to identify covariates of infant and child mortality in Malawi but none of these used recent data and none has included HIV/AIDS as a risk factor (Baker 1999; Bolstad and Manda 2001; Kalipeni 1992; Manda 1999). This study aims at examining bio-demographic, socio-economic and environmental factors associated with infant and child mortality in Malawi. Malawi Demographic and Health Survey (DHS) data for 2004 and 2010 are used. Two methods of analysis are applied to both 2004 DHS and 2010 DHS .These are the logistic regression method and survival analysis method.

The results of the study show that HIV status of the mother and length of the preceding birth interval were significantly associated with both infant and child mortality during both time periods. Other significant covariates include birth order, age of the mother at birth of the child, sex of the child, education of the mother and father, and wealth index. The risk of death among infants born to HIV positive mothers declined during the inter-survey period but increased for children aged 1 to 5. Scaling of Prevention of Mother to Child Transmission (PMTCT) programmes, raising awareness on the importance of long preceding birth interval and advocating parents' education will therefore help in reducing childhood deaths among others.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
CMC	Century Month Code
DHS	Demographic and Health Survey
HIV	Human Immunodeficiency Virus
HRCSI	Health Research Capacity Strengthening Initiative
IMR	Infant Mortality Rate
IHME	Institute for Health Metrics and Evaluation
ITN	Insecticides Treated Nets
MDG	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
NSO	National Statistical Office
PMTCT	Prevention of Mother to Child Transmission
UN	United Nations
UNAIDS	United Nations Programme on HIV/ Acquired Immune Deficiency Syndrome
UNICEF	United Nations Children's Fund
UNIGME	United Nations Inter-agency Group on Child mortality Estimation
UNSD	United Nations Statistics Division
USCB	Unites States Census Bureau

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1 INTRODUCTION

1.1 Background

Mortality of children under the age of five has been the main target of public health policies and is a common indicator of mortality levels, especially in developing countries (Gakusi and Garenne 2006). It is also viewed as an indicator of the level of development, health and socioeconomic status of the population. Improving child survival has been a priority for both policy makers and health advocates worldwide. One of these priorities is the development of the United Nations Millennium Development Goals (UN MDGs) of which one of them calls for a reduction in under-five deaths by two thirds by 2015.

There has been a significant decline in under-five mortality in the twentieth century in almost all countries regardless of initial levels and socio-economic factors although the rate of decline differs across regions (UNIGME 2012). A health transition observed globally indicates that under-five mortality had declined by 1.8 per cent per year between 1990 and 2000 (UNICEF 2012). This improvement increased to 3.2 per cent between 2000 and 2011 signifying a significant progress in child survival. However, under-five deaths remain high in the sub-Saharan Africa region where 1 in 9 children dies before the age of five (UNIGME 2012).

Malawi, a country in the sub-Saharan region, is characterised by high infant and child mortality. Using data from the 2000 Malawi Demographic and Health Survey, infant mortality in Malawi was estimated at 104 deaths per 1000 births while child mortality was 95 deaths per 1000 births (NSO and Macro 2001). The country has, however, seen a considerable decline in both infant and child mortality as they were estimated at 66 deaths per 1000 births and 50 deaths per 1000 births respectively in 2010 (NSO and ORC Macro 2011). Between 1990 and 2011, Malawi has reduced its under-five mortality by more than 60 per cent (UNICEF 2012).

Child deaths are commonly a result of several risk factors (Black, Morris and Bryce 2003). The relative importance of these factors in relation to infant and child mortality risks varies with the level of social and economic well-being of a society. UNICEF (2012) reported that children are at greater risk of dying before age five if they are born in rural areas, among the poor or to a mother denied basic education. It is therefore important to investigate the factors associated with infant and child mortality in Malawi.

1.2 Objectives of the study

The objective of this study is to identify socioeconomic, demographic and environmental factors associated with infant and child mortality in Malawi. It also intends to identify changes in the factors during the period between the two surveys used, that is, 2004 and 2010 surveys.

Based on the general literature on the correlates of infant and child mortality, the hypothesis underpinning this study is that demographic factors are strongly associated with infant mortality while demographic, socioeconomic and environmental factors are significant in influencing child mortality.

1.3 Problem statement and justification of the study

Infant and child mortality remains a great concern not only to Malawi but also to many countries in the sub Saharan region. As a signatory to the Millennium Development Goals, Malawi made a commitment to reduce under-five mortality by two thirds by 2015. Although the country has seen a significant decline in mortality in the last decade, infant and child mortality are still high. The 2010 Malawi Demographic and Health Survey estimate of under-five mortality is 112 and infant and child mortality are estimated to be at 66 and 50 respectively.

Infant and child mortality are associated with the well-being of the population. Identifying determinants of infant and child mortality is essential for formulating appropriate health programmes and policies. A significant pace of decline in infant and child mortality can only be achieved if the strategies and policies against mortality are directed towards those factors associated with high mortality rates (Mustafa and Odimegwu 2008). Studies have been conducted to identify covariates of infant and child mortality in Malawi but none of these have used recent data and none has included HIV/AIDS as a risk factor (Baker 1999; Bolstad and Manda 2001; Kalipeni 1992; Manda 1999). This study will help the Malawi Government, non-governmental organisations and other partners in the health sector to know and understand the important areas they need to focus on in order to develop policies, programmes and projects to reduce infant and child mortality rates. It will add to the existing literature on infant and child mortality in Malawi.

1.4 Dissertation outline

This dissertation is organised into five chapters. Chapter 2 gives a review of literature on trends of infant and child mortality in Africa and Malawi. It includes summary findings of studies on factors associated with infant and child mortality. Chapter 3 describes the data used in the study and methods used in analysing the data. Results and discussion of the results are presented in Chapter 4, and Chapter 5 presents recommendations, limitations of the study and conclusion.

2 LITERATURE REVIEW

This chapter summarises the literature on infant and child mortality. Section 2.1 gives an overview of the trends in infant and child mortality in sub-Saharan Africa and in Malawi. Section 2.2 presents the conceptual framework used in the analysis. A review of the literature on factors associated with infant and child mortality is covered in section 2.3. The last section, Section 2.4, discusses the biases in HIV data.

2.1 Trends in Infant and child mortality

This study focuses on factors associated with infant and child mortality in Malawi. However, it is important to have a general overview of the trend in these mortality rates. This section summarises the trends in infant and child mortality since 1970. Section 2.1.1 gives a summary of under-five mortality for sub-Saharan Africa compared to some regions of the world. Section 2.1.2 reviews infant and child mortality specifically for Malawi, which is our focus.

2.1.1 An overview of child mortality in the world

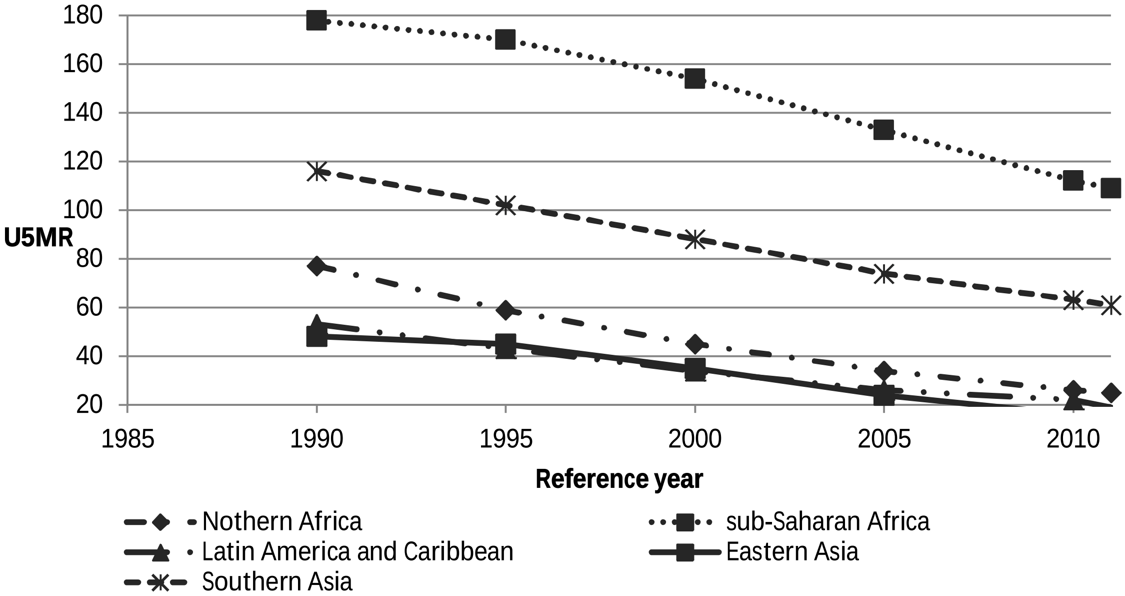
The world as a whole has seen a significant decline in the number of under-five deaths from nearly 12 million in 1990 to 6.9 million in 2011 with an annual decline of 1.8 per cent between 1990 and 2000, and 3.2 per cent between 2000 and 2011 (UNIGME 2012). This represents a global decline of about 41 per cent, from 87 deaths per 1000 live births in 1990 to 51 deaths per 1000 live births in 2011 (UNICEF 2012). These deaths are, however, not evenly distributed as childhood mortality rates are different in different parts of the world, with the sub-Saharan region having the highest rates. It has been observed that 49.6 per cent of deaths before the age of five worldwide occur in this region (Rajaratnam, Marcus, Flaxman *et al.* 2010). However, one of the major achievements in this region is the significant decline in mortality and subsequent increase in life expectancy. The region's under-five deaths have declined from 178 deaths per 1000 in 1990 to 109 deaths per 1000 in 2011 at an annual rate of 3.1 per cent (UNIGME 2012). This translates to a 39 per cent reduction between 1990 and 2011.

The efforts to reduce infant and child mortality in this region have suffered a major setback since the emergence of HIV/AIDS pandemic in the late 1980s. HIV/AIDS is now one of the leading causes of death in many African countries. Sub-Saharan Africa is the most severely affected as it is the home of nearly 69 per cent of people living with HIV worldwide (UNAIDS 2012). In 2011, 3.4 million children under 15 years old were living with HIV and 91 per cent of them were in sub-Saharan Africa (UNICEF 2012). The

HIV/AIDS pandemic in this region has led to slowed decline in improvements in infant and child mortality and even reversals of the trend in some of the countries in the late 1990s and early 2000s.

Figure 2.1 shows the trends in under-five mortality for selected regions of the world from 1990 to 2011. As observed, all regions show a declining trend in under-five mortality. However, the trend for sub-Saharan Africa indicates distinctively higher mortality compared to that of other regions. Among the regions considered, Eastern Asia and Latin America and Caribbean have lower mortality since 1990.

Figure 2.1 Trends in under-five mortality for some of the major regions of the world from 1990 to 2011



Source: UN IGME 2012

2.1.2 Infant and child mortality in Malawi

2.1.2.1 Data sources

The trends in infant and child mortality in Malawi can be assessed by comparing the estimates from different sources of data that collected information on childhood mortality and in different time periods. Malawi, as is the case in most developing countries, does not have a complete vital registration system. Information on child mortality is therefore collected through population and housing censuses, and national surveys. Malawi has been conducting population and housing censuses since the colonial era but the most comprehensive ones are the ones conducted since independence (NSO 2008). So far five comprehensive censuses have been conducted: 1966, 1977, 1987, 1998 and 2008 population censuses. However, the information from these censuses is less detailed as they try to keep the questionnaire as simple as possible since it enumerates the whole population.

Detailed information of the population in Malawi is collected through surveys. These collect information on a number of individuals in a population, which are considered to be representative of the whole population. The Demographic and Health Survey (DHS) is one of them and provides a rich source of data for infant and child mortality estimation in Malawi. The DHS is the world's largest survey implemented in more than 60 countries with support from ORC Macro (Rutstein 2000). Malawi has so far conducted four DHSs since 1992 at five year intervals. It also conducted a Multiple Indicator Cluster Survey (MICS) in 1996 with assistance from United Nations Children's Fund (UNICEF).

Other organisations, such as United Nations Children's fund (UNICEF), World Health Organisation (WHO) and Institute for Health Metrics and Evaluation (IHME) also publish estimates of infant and child mortality for different countries. The United Nations Inter-agency Group on Child Mortality Estimation (UN IGME) was formed in 2004, and its aims include sharing of child mortality data and statistics (UNIGME 2012).

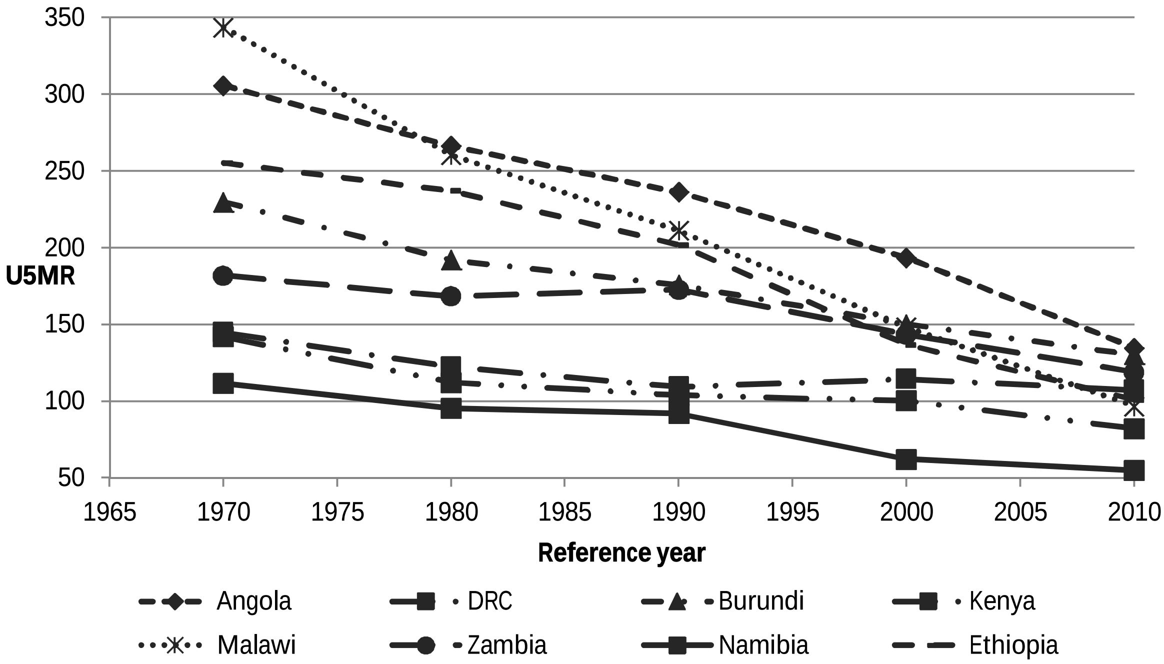
2.1.2.2 Trends and levels in infant and child mortality in Malawi

Malawi is characterised by high infant and child mortality compared to some African countries. Under-five mortality around 1970 was 344 deaths per 1000 and was among the highest in the sub-Saharan region (Rajaratnam, Marcus, Flaxman *et al.* 2010). This was almost twice that of Namibia, which was estimated at 111.5 in 1970. The country has, however, seen a significant decline in under-five mortality, from 343.9 deaths per 1000 in 1970 to 96.8 deaths per 1000 in 2010. This is almost three times the decline observed in Zambia which had a lower rate in 1970 compared to that of Malawi. Malawi, Ethiopia and Namibia have been singled out as countries which have seen a significant decline in the proportion of children dying (Kazembe, Clarke and Kandala 2012).

Like many countries in sub-Saharan Africa, HIV/AIDS is a great health challenge in Malawi. The national HIV prevalence rate is one of the highest in the world. The 2010 Malawi Demographic and Health Survey (MDHS) indicates that 11 per cent of the population aged 15-49 was living with HIV/AIDS (NSO and ORC Macro 2011). At least 910 000 people in Malawi were living with HIV/AIDS of which 170 000 were children aged 0 to 14 and most of them were infected through mother to child transmission at birth (UNAIDS 2011). HIV/AIDS is now one of the leading causes of child deaths in Malawi (Bowie 2011).

Figure 2.2 shows the trend in under-five mortality for Malawi and some countries in sub-Saharan Africa. As can be observed form the figure, Malawi's under-five mortality in 1970 was the highest among the eight countries considered. The rate has, however, declined and unlike other countries this decline has been consistent without any reversals between 1970 and 2010. UN IGME estimated a decline in under-five mortality in Malawi of 63.6 per cent between 1990 and 2011

Figure 2.2 Trends in under-five mortality in some countries in the sub-Saharan Africa region from 1970 to 2010

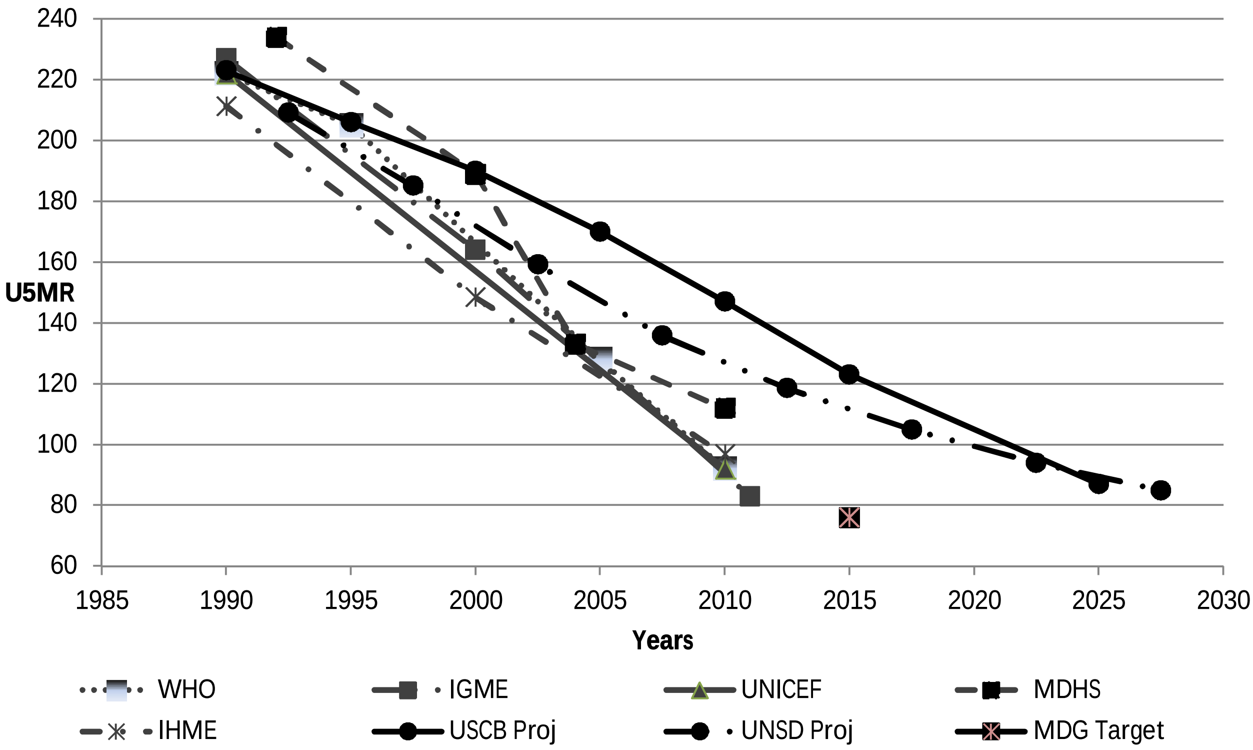


Source: Flaxman A.D, Rajaratman J.K, Marcus J.R, *etal* 2010

The trend observed in the estimates produced by Flaxman, Rajaratman, Marcus, (2010) is consistent with the estimates from other sources. The estimate of under-five mortality as reported in the 1992 Malawi DHS was 234 deaths per 1000 live births. This declined to 189 deaths per 1000 live births in 2004 and then declined further to 112 deaths per 1000 live births as estimated by the 2010 DHS. IHME produced an estimate of under-five mortality of 211.3 deaths per 1000 live births in 1990. This decreased to 148.4 in 2000 and then 96.8 deaths per 1000 live births in 2010. It is also important to note that the projected under-five mortality rates for both United States Census Bureau (USCB) and United Nations Statistics Division (UNSD) are higher compared to the other estimates. This implies that these projections did not capture the recent declines in under-five mortality in Malawi

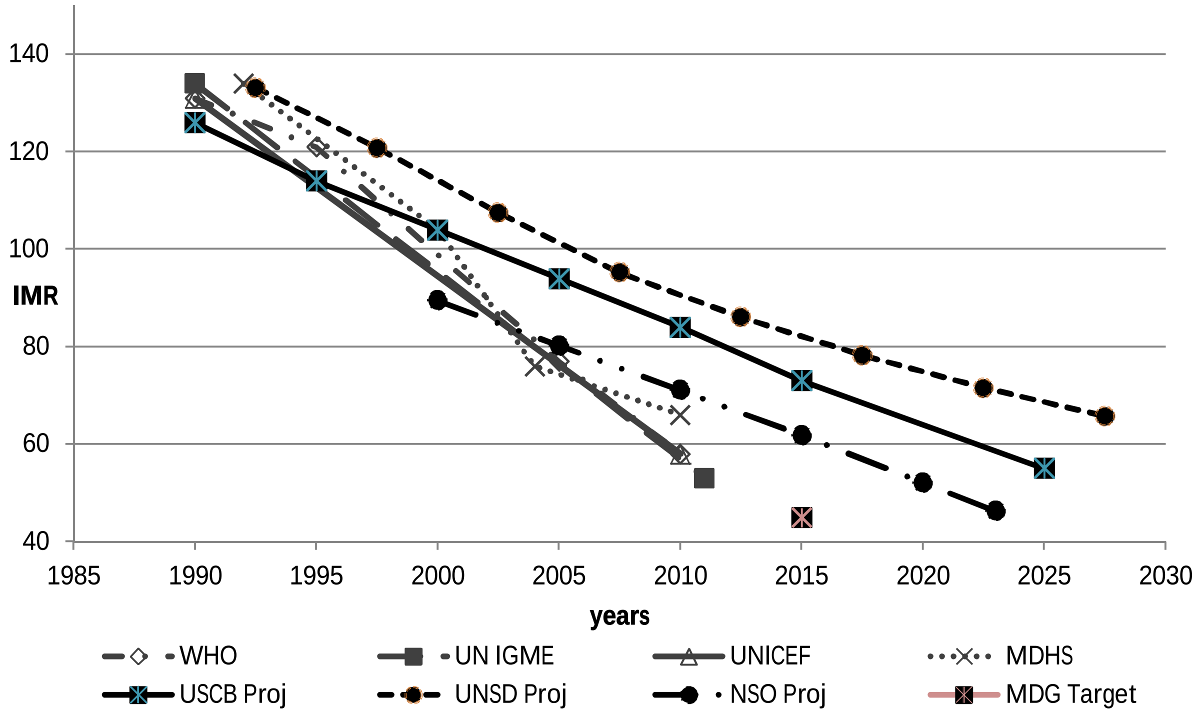
Figure 2.3 shows the trend in the under-five mortality rate in Malawi using estimates from different data sources and projections. The differences in the estimates in the same year may be due to the fact that different methods were used to produce them. For example, in 2000, DHS estimated under-five mortality at 189 deaths per 1000 live births compared to 164 as estimated by UN IGME and 148 as estimated by IHME. It is also important to note that estimates for IHME and UN IGME are produced by fitting a regression model to estimates from surveys, censuses, vital registration systems and other data sources (Alkema and You 2012). The UN IGME used locally weighted least squares regression while IHME used Gaussian process regression to derive trend estimates. All in all, as can be observed, they all show a declining trend since 1990.

Figure 2.3 Trends in under-five mortality rate (per 1000 live births) in Malawi



Trends in infant mortality also show a significant decline. 2004 DHS reported an IMR of 76 deaths per 1000 live birth a decline from 104 deaths per 1000 live births as reported by 2000 DHS. This dropped further to 66 deaths per 1000 live births as estimated by the 2010 DHS. In 2005 WHO produced an estimate of 77 deaths per 1000 live births and the 2006 MICS estimated infant mortality rate at 72 deaths per 1000 live births. As with under-five mortality, the trend is also consistent with negative gradients. As is the case with under-five mortality, the UNSD projected infant mortality rates are higher in all the reference years while that of USCB are higher from the year 2000. Figure 2.4 shows the trends in IMR in Malawi from different sources.

Figure 2.4 Trends in infant mortality rates (per 1000 live births) in Malawi



The decline in infant and childhood mortality rates attest to the efforts by government and non-governmental organisations to create a good environment for childhood survival. This has seen them developing strategies aimed at reducing childhood mortality rates. One of these strategies includes the recruitment of high school educated village health surveillance assistants, who stay and work in the villages (Chinyama 2012), and ensure that people receive basic health attention in their own village, which is often far from a health centre. There has also been an increase in vaccination coverage and malaria control programmes, which include the distribution of insecticide treated nets (ITN) to the community (NSO 2008). Prevention of mother to child transmission (PMTCT) has also helped reduce child deaths due to HIV/AIDS. Promotion of breastfeeding for the first six months of infancy has led to an improvement in child health thereby reducing deaths due to malnutrition.

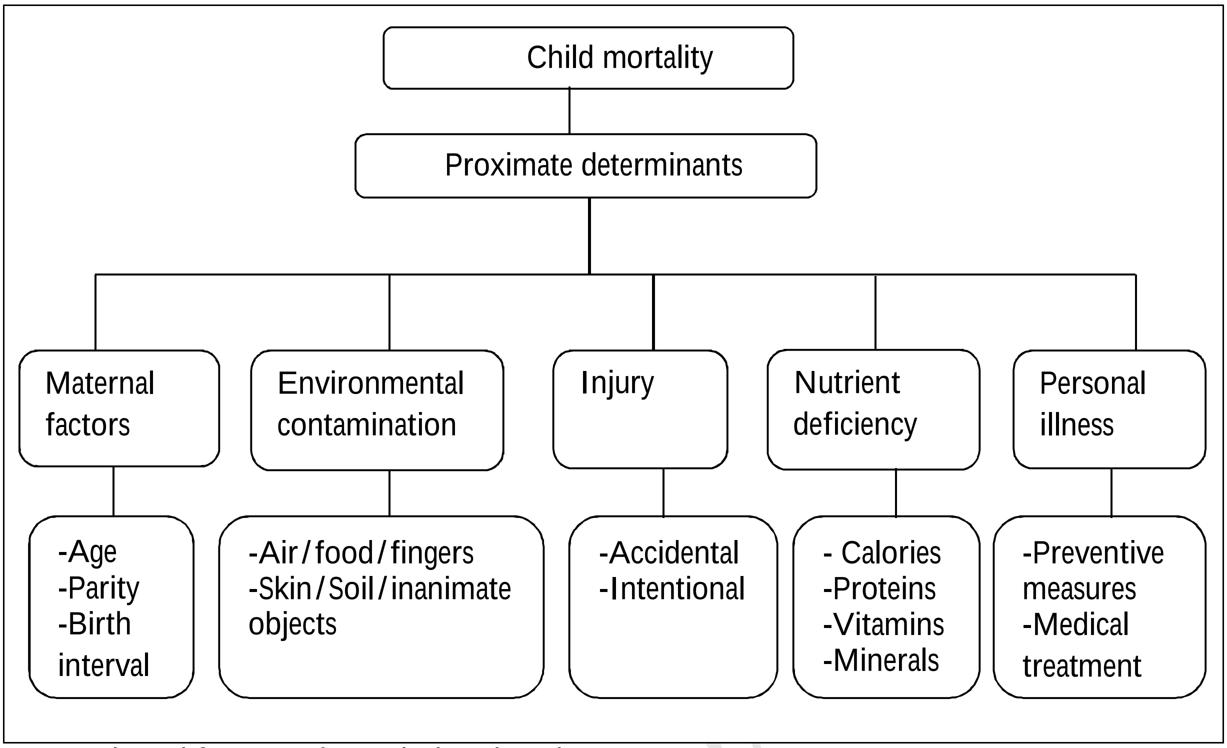
Considering these recent declines in mortality, there are prospects that Malawi will manage to reduce under-five mortality rate by two thirds by 2015 (UNICEF 2013). This implies reducing under-five from 227 deaths per 1000 births in 1990 to 76 deaths per 1000 births in 2015 (UNIGME 2012). UNICEF (2013) observed that Malawi is likely to meet

MDG 4 if the current trend of decline in under-five mortality continues. The Malawi Government is also positive about achieving this goal as it estimates an under-five mortality of 61 deaths per 1000 births and an infant mortality rate of 45 deaths per 1000 in 2015 (Malawi 2013). However the Civil Society Organisations in Malawi emphasised that this can only be achieved with increased effort.

2.2 Conceptual framework

The framework for the analysis of child mortality set out by Mosley and Chen (1984) is employed in this analysis. It identifies a set of proximate determinants, or intermediate variables, that directly influence the risk of morbidity and mortality in children and is appropriate for studying mortality in developing countries (Mosley and Chen 1984). Mosley and Chen (1984) also note that social and economic factors must work through the proximate determinants in order for them to have an impact on child mortality. The development of these determinants was based on the following grounds. First, in countries where conditions for child survival are good, 97 per cent of new-born infants are expected to survive through the first five years of life. This condition is less likely to be met in sub-Saharan Africa, including Malawi, where only 89.1 and 90.3 per cent of children survive the first five years of life as of 2010 respectively (Rajaratnam, Marcus, Flaxman *et al.* 2010). Second, any reduction in the proportion surviving in any society is due to the operation of social, economic, biological and environmental factors. Third, Mosley and Chen (1984) further stress that independent variables, especially socioeconomic determinants, do not influence the risk of disease and the outcome of disease process on their own; they must operate through the more basic proximate determinants, which include maternal factors, environmental contamination, nutrient deficiency and personal illness control. The fourth premise states that the specific diseases and nutrient deficiencies observed in a surviving population may be viewed as biological indicators of the operations of the proximate determinants. Finally, Mosley and Chen (1984), state that the dependent variables in the study of child survival (growth faltering or death) are the cumulative results of multiple disease processes. As illustrated in Figure 2.5, they went further to identify five categories of the proximate determinants.

Figure 2.5 Proximate determinants of child mortality



Adapted from Mosley and Chen (1984)

Mosley and Chen (1984) also pointed out that maternal factors, environmental contamination, injury and nutrient deficiency influence the rate of shift of healthy individuals towards sickness. On the other hand, personal illness controls influence both the rate of illness and the rate of recovery through treatment.

However, there are some limitations with this framework of analysis. In the study of childhood mortality employing the Mosley and Chen framework, the list of proximate determinants is expected to be exhaustive such that child health will change if and only if one or more determinants change (Hill 2003). In practise, some determinants are not included due to data availability and measurement problems. Some determinants, especially environmental contamination, are difficult to measure precisely. The omission of such variables can be misleading when interpreting other factors which they are associated with. Hill (2003) also point it out that sometimes is hard to know what exactly constitutes a proximate determinant. For example, where in the framework is low birth weight to be placed as a potential risk factor for child survival. Regardless of these limitations, the framework is still important and most commonly used in child mortality studies.

2.3 Factors associated with infant and child mortality

Many studies have been conducted focusing on factors associated with infant and child mortality (Becher, Muller, Jahn *et al.* 2004; Dube, Taha and Asefa 2013; Kayode, Adekanmbi and Uthman 2012; Kembo and van Ginneken 2009; Manda 1999). Like this study, they included bio-demographic, socio-economic and environmental factors. Bio-demographic (maternal) factors and environmental factors are categories of proximate determinants of child mortality, as presented in the Mosley and Chen framework. Socioeconomic factors, however, are said to have an indirect influence on infant and child mortality and work through the proximate determinants (Mosley and Chen 1984). Most of these studies found a significant relationship between childhood mortality and the factors considered. The following sections present findings of some of these studies. First, are the bio-demographic factors in Section 2.3.1, then socio-economic factors in Section 2.3.2 and environmental factors in Section 2.3.3. The last section, Section 2.3.4, presents a review of the studies conducted specifically in Malawian settings.

2.3.1 Bio-demographic factors

A number of bio-demographic factors have been considered in studies of infant and child mortality. These factors, also referred to as maternal factors, have an independent direct influence on pregnancy and child survival, as indicated in the Mosley and Chen framework. These affect the health of the child before and after delivery and in some cases affect the mother's caretaking behaviour towards the child (Mahy 2003a). These include length of preceding birth interval, birth order, age of the mother at birth of a child, sex of the child, birth weight and gestation at birth of the child.

The preceding birth interval has been found to have a negative relationship with child and infant mortality, that is, the shorter the interval, the higher the risk of death (Das Gupta 2010; Kayode, Adekanmbi and Uthman 2012; Whitworth and Stephenson 2002). A study in Ethiopia found that a birth interval of 24-35 months, 36-47 months and 47 and above months reduces the risk of mortality by 33, 45 and 65 per cent relative to be born 18 months after the previous birth (Mekonnen 2011). In Nigeria, the odds of under-five mortality in children with 18-36 months and above 36 months of birth interval were reduced by 70 per cent and 91 per cent respectively, relative to those born within a birth interval of less than 18 months (Kayode, Adekanmbi and Uthman 2012)

Mechanisms through which the preceding birth interval influence infant and child mortality are debatable (Whitworth and Stephenson 2002). However, these may include maternal depletion, which stipulates that closely spaced pregnancies jeopardise the mother's health thereby putting the new-born at a higher than average risk of dying (Majumder, May and Pant 1997). This is because a short birth interval denies the mother's body time to fully recover and gain its nutritional status required for the development of pregnancy. This may lead to low birth weight, premature birth and other congenital complications which are associated with increases in childhood death. Majumder and May (1997) also argued that an additional child implies an added responsibility to parents and may lead to a reduction in resources and care per child. Closely spaced children are therefore more likely to face greater competition with the younger ones being more likely to suffer.

In some studies, a relationship was observed between infant and child mortality and birth order. A general consensus has shown that first and higher order births have poor maternal outcomes compared with other birth orders and therefore more likely to die. Hobcraft, McDonald and Rutstein (1985) found increased infant mortality for first births and further observed that first born mortality is lower than that of orders two and above after the first year. In Ethiopia, Mekonnen (2011) found that infants of birth orders 2 and 3 had reduced risks of death of 51 per cent relative to first births while birth order 7 and higher increases infant mortality by 26 per cent compared to first births. A study in Nigeria observed that the odds of under-five mortality in children of birth order 2-4 was 93 per cent higher compared to first births (Kayode, Adekanmbi and Uthman 2012).

A correlation also exists between length of preceding birth interval and birth order, as women who have had many births are more likely to have short intervals between the births. Some scholars therefore opted to combine birth order with preceding birth interval in their studies. Kembo and van Ginneken (2009) observed that infants of birth order six or higher with a short preceding birth interval have the highest risk of mortality. The odds of dying among first born children was 0.57 relative to children of birth orders 2-5 with a long preceding interval (Kembo and van Ginneken 2009). In Lesotho, birth order combined with the preceding birth interval was the only factor that was associated with post neonatal death differently during the two periods studied (Mokoena 2011). Another study in Ethiopia found that among infants of orders 2 to 4, the risk of dying was higher for those with preceding birth intervals of less than two years compared to those with a birth interval of more than or equal to two years (Dube, Taha and Asefa 2013).

Another factor of interest is the mother's age at birth of her child. A U-shaped relationship between mothers' age at birth of the child and childhood mortality is anticipated (Mahy 2003a). Physically, young mothers and older mothers are more likely to have complications in maintaining a pregnancy thereby increasing the chances of poor maternal outcome, which in turn increases the risk of dying early in childhood. In Kenya, this U-shaped relationship was observed with children of the youngest and oldest experiencing the highest risk of death (Mutunga 2007). Another study observed that the odds of death for children born to adolescent mothers and older mothers increased to 1.8 and 1.5 respectively compared to that of other mothers (Kaharuza, Scheutz and Sabroe 2001). A study using World Fertility Survey data from 39 countries found higher child mortality among teenage mothers but not among older mothers (Hobcraft, McDonald and Rutstein 1984). The writers argued that, at higher mother's age, the risk of child deaths is removed when birth spacing is controlled though this has not been confirmed by other studies.

Biologically, males have a higher risk of death relative to females which has been confirmed in some of the studies on determinants of infants and child mortality. In Kenya, Mutunga (2007) found that male children had a lower probability of surviving than females, and in Lesotho, neonatal mortality was 45 per cent higher for boys than for girls (Mokoena 2011). In Bangladesh, female infant mortality was 27 per cent lower relative to male infant mortality (Kabir, Islam, Ahmed *et al.* 2001). However, a study in Zambia observed that while boys overall suffer from higher mortality, girls do badly among the first births (Berger, Fahrmeir and Klasen 2002). In other studies, females have been reported to have higher mortality compared to males, which may be due to sex preferences, which also affect care given to the child (Das Gupta 2010). A study in India observed that the odds of dying before the first birthday was 12 per cent lower for females compared to males but twice as that of males between 12 and 47 months (Kishor and Parasuraman 1998). They therefore concluded that the effects of gender discrimination begin to outweigh the effects of girls' biological advantage sometime after the first birthday.

The impact of HIV/AIDS on child mortality is also well documented in a number of studies. HIV/AIDS affects childhood mortality through vertical transmission of the HIV virus from mother to child during birth and breastfeeding, which then puts the child at a very high risk of dying. In the absence of any intervention, 25 to 35 per cent of children born to HIV positive mothers are infected and almost all would die by the age of five (Adetunji 2000). A number of studies have found increased mortality in HIV infected children as compared to HIV non-infected children (Hogan, Salomon, Canning *et al.* 2012; Newell, Coovadia, Cortina-Borja *et al.* 2004; Villamor, Misegades, Fataki *et al.* 2005). HIV/AIDS also affects child mortality as a positive mother is more likely to die or be terminally ill thereby denying the child the care he/she needs. A mother's death or illness, therefore, has a negative impact on child health even in the absence of transmission

(Ndirangu, Newell, Thorne *et al.* 2012; Newell, Brahmbhatt and Ghys 2004). In rural South Africa, overall, children whose mothers had died were found to have a threefold increased hazard of death compared to children whose mothers were alive (Ndirangu, Newell, Thorne *et al.* 2012). Resources meant to be used in taking care of the child may also be diverted and used to assist the sick person and even pay for funeral costs (Adetunji 2000). These findings have prompted further studies to explore the impact of the mother's HIV status on infant and child mortality.

A study using pooled data from community-based studies found that mortality was between 2.1 and 4.3 times higher among infants born to HIV positive mothers compared to those born to HIV negative mothers (Zaba, Marston, Nakiyingi *et al.* 2003). For child mortality, the differentials were about 2.9 to 3.3 times among children of HIV positive mothers relative to those of negative mothers. A similar study controlled for temporal and geographical differences, and observed that children born to HIV positive mothers were three times more likely to die than children born to HIV negative mothers with the impact persisting throughout childhood years (Newell, Brahmbhatt and Ghys 2004). Even children of mothers who seroconverted to HIV positive after their birth were found to have an increased risk of dying compared to children of HIV uninfected mothers in rural South Africa (Ndirangu, Newell, Thorne *et al.* 2012).

2.3.2 Socio-economic factors

Socio-economic factors include the mother's and father's education, father's and mother's occupation, wealth index, place of residence and marital status of the mother. These operate through proximate determinants which include environmental contamination, health seeking behaviour, personal illness control and nutrient deficiency, to have an impact on child mortality and health (Mosley and Chen 1984). This is due to the association of proximate determinants and socio-economic factors. Socio-economic factors may affect childhood exposure to bad environment, mothers' reproductive behaviour and even health seeking behaviour thereby affecting childhood mortality. For example, household income may lead to good health care and nutrition for children since the parents can afford private health care and nutritious food.

Among the socio-economic factors, the importance of mothers' education on child survival and health has been well documented. Educated mothers are less likely to experience a child death compared to their non-educated counterparts. This could be explained by the benefits of education, which include economic advantage and the ability of educated women to access health services and live a modern life, both of which are associated with increased child survival (Caldwell 1990; UNICEF 2012). Education also gives women power and confidence to make their own decisions (Ware 1984).

A study using data from 175 countries revealed that almost 4.2 million deaths averted between 1970 and 2009 can be attributed to the increase in women's education (Gakidou, Cowling, Lozano *et al.* 2010). This concurs with assertions by UNICEF that more than half of recent reductions in child deaths are linked to gains in women's educational attainment (UNICEF 2012). A study in rural Nigeria found that secondary and tertiary (but not primary) education of mothers had a negative impact on child mortality (Abimbola, Adepoju, Akanni *et al.* 2012). These results are similar to those in Kenya where maternal education had no significant difference between those with primary education and those with no education with regard to its impact on infant deaths (Mustafa and Odimegwu 2008). However, Basu and Stephenson (2005) found that relative to illiterate women, women with primary education had an odds ratio of 0.83 for early post neonatal mortality and 0.56 for mortality among children aged 8 to 24 months. They therefore stressed that even a little schooling makes a difference as far as child survival is concerned. Other studies, however, found no significant relationship between mothers' education and childhood mortality (Mokoena 2011).

A negative correlation has also been observed between fathers' education and child mortality. Fathers' education is said to be more related to household income, which in turn ensures adequate nutrition, clothing and even access to child health facilities (Abimbola, Adepoju, Akanni *et al.* 2012). Fathers' education, like mothers' education is also associated with a detachment of traditional practices and adoption of a modern way of raising kids, which is associated with an increase in child survival. Educated fathers are therefore more likely to support their wives in taking care of their children. Kembo and van Ginneken (2009) reported that father's education has a substantial impact on child mortality but not infant mortality. Completing secondary education reduces the relative risk of child mortality by 33 per cent relative to children whose fathers had no formal education (Kembo and van Ginneken 2009). In Ethiopia, child mortality was highest among children born to illiterate fathers, and declines with increases in education (Kiros and Hogan 2001). The effect of fathers' education on infant mortality was reported to be even greater than that of mothers' education in Bangladesh (Majumder, May and Pant 1997).

Studies have also found a significant relationship between childhood mortality and the occupation status of the mother. In general, infant and child mortality is expected to be lower among working women than those unemployed. This is because these women are more likely to have a good source of income and are able to provide food in the right amount and of high quality for their children (Abimbola, Adepoju, Akanni *et al.* 2012). A study in Bangladesh found a decrease in infant mortality of about 65 per cent among infants whose mothers were working relative to those whose mothers were not employed (Kabir, Islam, Ahmed *et al.* 2001). Others have, however, argued that the need to work, especially outside home, may affect survival chances directly as it prevents the mother from taking care of the child (Hobcraft, McDonald and Rutstein 1984). This has been established in a study in India, which found a high risk of infant mortality among women working away from home for cash (Kishor and Parasuraman 1998), as working conditions usually involve leaving the child at home during long hours of work. This results in less breastfeeding and denied child care, which are associated with increases in the risk of death (Ghosh and Bharati 2010). For children aged 1 to 4, mothers' employment also reduces the probability of survival as the odds of dying increased by about one third if the mother is employed compared to those not employed (Kishor and Parasuraman 1998).

Some scholars also included fathers' occupation in their studies although it has not received much attention compared to that of the mother. In Mozambique, fathers' occupation was significantly associated with post-neonatal mortality but not child mortality. Children of fathers in clerical, sales, services and skilled manual occupations had a risk of dying of 1.57, and those whose fathers were in agricultural and unskilled manual occupations had a risk of dying of 1.76 compared to those whose fathers were in professional occupations (Macassa, Ghilagaber, Bernhardt *et al.* 2003). In Bangladesh, mortality was 1.62 times higher among children whose fathers were agricultural labourers compared to those whose fathers were in service (Mondal, Hossain and Ali 2009). A Demographic Health Survey (DHS) comparative study also found differentials in under-five mortality according to fathers' occupation in 9 of the 25 countries studied, with children whose fathers were in agricultural occupation being two times more likely to die relative to children of professional, technical and clerical workers (Sullivan, Rutstein and Bicego 1994).

Although the occupation of the mother and father are important, income received is more important as it leads to improved economic status of households (Kyei 2011). This income may be used to buy more nutritious food, pay for more hygienic living conditions and also pay for good health services. Children from households with a good source of income are therefore more likely to receive quality care in terms of nutrition and health services, which lead to an increase in child survival. In Southern Sudan, family income was significantly associated with child mortality as those from households with a high income were less likely to die compared to those from low income households (Mahfouz, Surur, Ajak *et al.* 2009). In another study, children living in low occupational class households experienced a 40 per cent higher mortality rate when compared with children from a high occupational class (Blakely, Atkinson, Kiro *et al.* 2003).

Mothers' place of residence is also another variable of interest when studying determinants of infant and child mortality. Provision of social services, which include schools, health services, transport services, economic wellbeing of the household and even the reproductive behaviour of the people in urban areas is different from that in rural areas. The mothers' place of residence, therefore, indirectly affects infant and child mortality by determining a woman's access to a health care facility, ability to find transportation and even ability to have money for paid health care services (Mahy 2003a). Studies have found an increase in the risk of death among children whose mothers reside in rural areas compared to those who stay in urban areas (Kayode, Adekanmbi and Uthman 2012; Kembo and van Ginneken 2009; Mekonnen 2011). In Nigeria, living in rural areas increased under-five mortality by 53 per cent compared to children in urban settlements (Kayode, Adekanmbi and Uthman 2012). Defo (1996) and Mahy (2003) observed that the rural-urban differentials in the odds of dying in childhood were higher than those dying in infancy.

Differentials in childhood mortality by marital status exist, especially in more traditional societies. This is because of the socio-economic advantage of the father's presence who in most cases is the breadwinner of the household. Other scholars therefore concluded that any association of one parent families with child mortality is due to the associated low socioeconomic position (Blakely, Atkinson, Kiro *et al.* 2003). A study in Cameroon found that unmarried mothers at the time of childbirth were more likely to experience a child death than their married counterparts (Defo 1996). In Ethiopia also, the risk of infant mortality among children whose mothers were currently married decreased by about 28 per cent relative to infants whose mothers were not married (Mekonnen 2011). However, in another study, being married increased the risk of a child dying compared to those children of single mothers with a hazard ratio of 2.1 (Kazembe, Clarke and Kandala 2012). This is may be because with a man in the household, a woman is less powerful in making decisions concerning the child's health and nutrition and it becomes a problem if the husband is not really concerned with child health and welfare. This is expected to be more significant in traditional societies where a woman is sub-servant to her husband who is also mostly the breadwinner in the family. Other studies also found no significant impact of marital status on child mortality (Hammera, Kouyat´e, Ramroth *et al.* 2006; Kaharuza, Scheutz and Sabroe 2001).

Women's behavioural characteristics and other health service availability factors have also been found to be significantly associated with infant and child mortality. These include breastfeeding which has been found to be an important determinant for infant mortality (Abimbola, Adepoju, Akanni *et al.* 2012; Hossain, Islam and Chowdhury 2012; Mustafa and Odimegwu 2008). A study in Nigeria found lower risks of mortality among infant who were breastfed relative to those not breastfed significant at 1 per cent significant level (Mustafa and Odimegwu 2008). Breastfeeding is associated with a decrease in incidence of diarrhoeal and also strengthens essential antibody system of the child there by increasing the chances of survival.

Another important factor is the place of delivery. Children born in hospitals and maternity clinics have a lower risk of mortality due to proper health care and attention they receive during and after delivery. This has been supported by different studies (Abimbola, Adepoju, Akanni *et al.* 2012; Buwembo 2010; Rutstein 2000). In relation to that, a study in Ethiopia found that infants whose mothers had no antenatal care follow up were 2.3 times more likely to die than those whose mothers had at least one follow up (Dube, Taha and Asefa 2013). Type of birth and weight of the child at birth are also associated with infant mortality. The risk of childhood mortality is lower among single births as compared to multiple births and also among those with lower birth weight compared to those with average or higher birth weight (Dube, Taha and Asefa 2013; Kembo and van Ginneken 2009; Mutunga 2007). Kembo and van Ginneken (2009) observed that mortality risk among multiple births was 2.08 times greater than among single births.

2.3.3 Environmental factors

Environmental factors also have a significant impact on infant and child mortality although they have received less attention compared to socio-economic and bio-demographic factors. Environmental factors have a direct impact on child mortality as they influence the transmission of infectious disease causing agents to children and to mothers (Mosley and Chen 1984). These include floor material, access to safe drinking water, access to good sanitation facilities, fuels used for cooking, and even roofing material. Environmental factors are considered a source of exposure to disease causing agents. Incidences of diarrhoea and other waterborne diseases, which are some of the causes of childhood death, especially in developing countries, are influenced by these environmental factors (Kosek, Bern and Guerrant 2003). Almost 90 per cent of diarrhoeal deaths globally are attributed to unsafe water, poor sanitation or inadequate hygiene (UNICEF 2012).

An investigation using data from eight sub-Saharan countries found that low mortality countries have a higher proportion of households with improved sources of drinking water, improved toilet facilities, finished flooring and improved sanitation facilities (Fayehun 2010). Another study in Nigeria found lower mortality rates in households that had access to sanitation facilities, those with a good refuse disposal as well as those with good roofing and flooring materials (Mesike and Mojekwu 2012). Children under the age of five in households relying on open well/surface water have higher risks of death than those with piped water/boreholes. This is also the case for infant mortality as infants born to households with access to piped drinking water have a 12 per cent lower mortality relative to infants born to mothers in households without access to piped water (Kembo and van Ginneken 2009). Studies in Uganda and south western Nigeria also found a statistically significant association between source of drinking water and child mortality (Folasade 2000; Kabagenyi and Rutaremwa 2013).

Kayode and Adekanmbi (2012) found a 77 per cent increase in the likelihood of under-five mortality in homes with bad toilet facilities compared to homes with good toilet facilities. For infant mortality, improved toilets reduced the risk of infant death by 38 per cent compared to infants in households without an improved toilet (Kembo and van Ginneken 2009). In another study, child mortality was 24 per cent lower in households with access to sanitary latrines relative to households with no access to such facilities.

2.3.4 Factors associated with infant and child mortality in Malawi

There have been a number of studies on infant and child mortality in Malawi but only a few focused on factors associated with it. Kalipeni (1992) applied correlation and regression analysis to the 1977 and 1987 census data to explore the spatial variation of infant deaths and identify some of the factors behind the variation. Region of residence was one of the important determinants of infant mortality (Kalipeni 1992). He then pointed out that this may be due to underlying socio-cultural factors, which are different in different regions. The same results were also observed in another study where a significant difference in child mortality was found between the north and south and also between north and centre (Baker 1999).

Manda (1998) used a three level logistic regression analysis and found that the family effect was significant. This family effect was significant even after controlling for possible biological and socio-economic factors. Families that suffered multiple infant losses would have a short preceding birth interval as they tend to replace the lost child and an infant death is more likely to be followed by another death. The odds of child death were 1.35 times as high if the preceding child had died. Infant mortality risks were also higher for children whose mothers had 7 or less years of education compared to those whose mothers had at least 8 years of education (Manda 1998).

In another study, both infant and child first births were more likely to die compared to those of birth orders 2-4 and with a long birth interval with hazard ratios of 1.25 and 1.71 respectively (Manda 1999). He, however, stressed that birth intervals together with survival status of preceding birth and maternal age were important factors for infant but not child mortality. The rural-urban differentials in child deaths were also significant as mothers residing in rural areas were 0.37 times likely to experience an infant death compared to those residing in urban areas. The sex of the child was also found to be significantly associated with child mortality in Malawi. Being a female reduced the risk of child mortality (Bolstad and Manda 2001).

Espo (2002), found a significant relationship between infant mortality and the season of child births, maternal HIV infection but not with the socioeconomic variables considered. However, she pointed out that the fact that socio-economic factors were not significant should not be over-interpreted as this may be due to homogeneity of the study population since it was based on only one district in the southern part of Malawi (Espo 2002). Other significant variables included adult educational facilities, females in agricultural occupation, female literacy and fathers' education breastfeeding and supervision at birth of child (Bolstad and Manda 2001; Kalipeni 1992). Children who had never been breastfed or stopped breastfeeding due to illnesses experience 4.30 times higher mortality than children who were breastfed (Bolstad and Manda 2001). They however point it out that the effects of breastfeeding on child mortality are less pronounced compared to infant mortality. Children whose mother's did not receive professionally supervised delivery are 1.26 times more likely to experience infant death as compared to those whose mothers had professional assistance during delivery (Manda 1998).

Recent studies on infant and child mortality in Malawi have also included the impact of HIV/AIDS. Most of these studies, however, did not control for most of the socio-economic and environmental factors and some were based on hospital settings with a small sample size. A study conducted in Zomba district controlled for only age and parity and found out that HIV infected women were 2.2 times more likely to have their previous child dead within 48 hours after birth and 2.3 times in less than a month after birth (Landes, van-Lettow, Chan *et al.* 2012). In another study, infants born to HIV positive mothers experience a mortality of 2.7 times higher if the mother died or is terminally ill relative to those whose mothers were alive in good health (Crampin, Floyd, Glynn *et al.* 2003). Overall, children of HIV positive parents had an increase in mortality of 3.3 times for those aged 30 to 365 days and 5 times for those aged 1-5 years than those of HIV negative parents.

As a summary to section 2.3, the following table presents the covariates and their expected effect on infant and child mortality based on the literature review indicating where the effect is expected to be strong or less strong.

Table 2.1 Expected impact of covariates on infant and child mortality

	Infant Mortality		Child Mortality	
Covariate	**Strong**	**Less strong**	**Strong**	**Less strong**
Bio-demographic				
Age of the mother	√			√
HIV status of mother	√		√	
Birth interval	√		√	
Birth order	√			√
Weight at birth	√			√
Socio-economic				
Mothers education	√		√	
Mothers occupation		√	√	
Father's education		√		√
Father's occupation		√		√
Marital status		√		√
Place of residence		√	√	
Sex of the child		√	√	
Place of delivery	√			√
Breastfeeding	√		√	
Environmental				
Floor material		√		√
Source of water		√		√
Toilet facility		√		√

2.4 Biases in HIV/AIDS data

Since its first case in the mid-1980s, HIV/AIDS has been monitored using sentinel surveillance of pregnant women. A number of antenatal clinics are selected for this purpose and pregnant women who visited them are tested anonymously for HIV (Janssens, van der Gaag and Rinke de Wit 2008). However, data from pregnant women is prone to biases, which may seriously affect the HIV prevalence of the general population. Most of these clinics are located in urban or semi-urban areas; the data collected therefore is not representative as rural women are under-represented and women attending private clinics are also not represented (Gouws, Mishra and Fowler 2008). Data for men is not collected and HIV prevalence among men has been estimated from this data using some other forms of adjustments, which are also prone to errors. These data also cannot be linked to the women's background and biomedical information, thereby preventing further analysis of any associations between HIV and other associated factors.

Measure DHS introduced voluntary HIV testing in DHS data collection in 2001 and has also been conducting AIDS Indicator Surveys, which include voluntary HIV testing of eligible respondents. The data can be anonymously linked to all information collected during the survey thereby allowing a deep analysis of HIV by socio-economic and even demographic factors. However, these data are not completely free of biases. Biases are introduced in these data due to selection of respondents for testing, refusal for a test of the selected respondents and also due to correlation of the mothers and child mortality in high HIV prevalence settings. Scholars have investigated these biases in DHS data and others went further by quantifying their impact on HIV prevalence and child mortality estimates.

2.4.1 Refusal bias

Refusal biases are introduced in the data when respondents with certain characteristics which are associated with either low or high HIV prevalence are more likely to refuse an HIV test relative to others. Studies have found a lower response rate among males than females (Janssens, van der Gaag and Rinke de Wit 2008; Marston, Harriss and Slaymaker 2008; Reniers and Eaton 2009) and also among those who are HIV positive compared to those who are HIV negative (Floyd, Molesworth, Dube *et al.* 2013). Another study found high refusal rates among residents of urban areas, more educated respondents and wealthier respondents (Mishra, Barrere, Hong *et al.* 2008).

Souza (2012) investigated refusal biases in HIV data using the 2004 and 2010 Malawi Demographic and Health Survey. This investigation showed that the 2004 HIV data were more affected by refusal bias compared to the 2010 HIV data. In 2004, people in urban areas, those with no education and respondents from the central region were more likely to refuse HIV testing (Souza 2012). He then noted that this may be due to poor training and management of field work since this was the first DHS to include voluntary HIV testing. In 2010, urban residents were still more likely to refuse HIV testing compared to rural residents.

Some scholars went a step further to adjust data collected in surveys for non-response biases (Marston, Harriss and Slaymaker 2008; Mishra, Barrere, Hong *et al.* 2008; Mishra, Vaessen, Boerma *et al.* 2006). This was done by predicting HIV sero-status of non-tested respondents using a multivariate statistical model for HIV for those who were interviewed and tested using common explanatory variables. Despite the adjusted HIV prevalence being higher than those tested in the survey, the overall effect of non-response on the observed national HIV prevalence estimates were small and insignificant in most cases. This may be due to the small proportion of those who refused compared to those who tested (Mishra, Vaessen, Boerma *et al.* 2006). Exclusion of non-household population groups in the survey also has a very small effect on the observed national prevalence (Mishra, Barrere, Hong *et al.* 2008).

2.4.2 Biases due to correlations between mother's death and child's death.

Reports of child mortality in the surveys are given by the mother. HIV positive mothers experience above average mortality compared to HIV negative mothers, so are children born to an HIV positive mother. This leads to an underestimation of child mortality as some child deaths remain unreported due to the death of the mothers who were supposed to report. The magnitude of the bias depends on the extent to which child mortality is not reported due to the death of their mothers (UNIGME 2009). This depends on HIV prevalence, its past trajectory, the level of background mortality and the time period before the survey to which the estimates refer (Walker, Hill and Zhao 2012). The impact is significant in populations with low background mortality and also where HIV prevalence is greater than 5 per cent (Mahy 2003b).

In 2010, Hallet, Gregson, Kurwa *et al* developed a model to produce an estimate of this bias in the national surveys using data from rural Zimbabwean women and full mortality experience of their children. The bias was found to be 6.7 per cent for infants and 9.8 per cent for children between 1998 and 2005 and 9 per cent and 13 per cent between 2005 and 2009 (Hallett, Gregson, Kurwa *et al.* 2010). UNIGME also adjusts the estimates of child mortality they produce using a simple cohort component projection model which uses spectrum output data as its input data (Walker, Hill and Zhao 2012). The method, however, makes a number of simplifying assumptions, some not feasible.

2.5 Summary

This chapter has reviewed the literature on infant and child mortality. It also presented the Mosley and Chen conceptual framework adopted in this study. Overall, studies have reported a decline in infant and child mortality although the per cent decline may be different in different regions. However, infant and child mortality rates in sub-Saharan Africa remain high.

Studies have found a significant relationship between infant and child mortality and some of the factors. These applied different statistical methods of analysis although most of them adopted the logistic regression, which has also been adopted in the subsequent analysis. The significant factors, however, vary in different settings. The studies also controlled for different factors. Overall, most of the studies considered in this literature review found a significant correlation between infant and child mortality and bio-demographic, socio-economic and environmental factors.

Recent studies also included the impact of HIV/AIDS on infant and child mortality. HIV positive children have been found to have an increased mortality risk, so are the children born to HIV positive mothers. This study, however, focuses only on the impact of mother's HIV status on infant and child mortality.

From this literature, a number of factors have been identified and included in the subsequent analysis whose results are presented in Chapter 4. As observed from the literature, none of the studies has used most recent data to investigate covariates of infant and child mortality in Malawi. This study uses the nationally representative DHS data to inform on the factors associated with childhood mortality using the most recent data, and includes the impact of HIV/AIDS. Accordingly, the study aims at addressing the following research questions: (1) What are the covariates associated with infant and child mortality in Malawi? (2) How have they changed during the period between the 2004 and 2010 DHS?

3 DATA AND METHODOLOGY

This chapter introduces the data and methods used in this study. Section 3.1 gives a description of the data used and biases in the data are described in section 3.2. A brief description of logistic regression and survival analysis methods, which are the methods used in the analysis is given in section 3.3 followed by a description of the variables considered in section 3.4.

3.1 Data source

Data from the 2004 and 2010 Malawi Demographic and Health Survey (MDHS) are used in this study. The field work for the 2004 survey was conducted from October 2004 to January 2005 while that for the 2010 survey was conducted from June to November 2010. Both surveys were implemented by the National Statistical Office (NSO) with technical assistance from ICF Macro (NSO and ORC Macro 2011).

During data collection, 28 administrative districts in Malawi were subdivided into enumeration areas (EAs) and each EA was classified as urban or rural. A stratified two stage cluster sampling design was used to select a representative sample for interviews with the enumeration areas being the sampling units. In 2004, 522 clusters were drawn, 458 in rural areas and 64 in urban areas while in 2010, 849 clusters were sampled of which 691 were rural areas and 158 urban.

The surveys administered three questionnaires: women’s, men’s and household questionnaires. The women’s questionnaire was administered to women aged 15-49 and collected data on background characteristics of women, full birth histories, child mortality and maternal and child health among others. Full birth histories of women include information on the number of births a woman has ever had and for each live born child, the month of birth was recorded as well as whether the child was still alive at the time of the interview. If a child had died, the age of child’s death was also recorded.

Both surveys included HIV testing. Women aged 15-49 and men aged 15-54 in one third of the selected households in both surveys were eligible for the test. Blood specimens were collected from those who voluntarily consented to the testing. The procedure for blood sample collection and analysis was based on an anonymous linked protocol developed by Measure DHS to ensure confidentiality of the information (NSO and ORC Macro 2011). It also allows the merging of the HIV test results with the socio-demographic data collected from the individual questionnaires. This study uses information on women aged 15-49 that were interviewed and HIV information for those tested. Dataset containing one record per child were constructed from the merged standard DHS recode files. The 2010 dataset had 72300 observations while the 2004 dataset had a total of 35883 observations.

3.2 Biases in DHS data

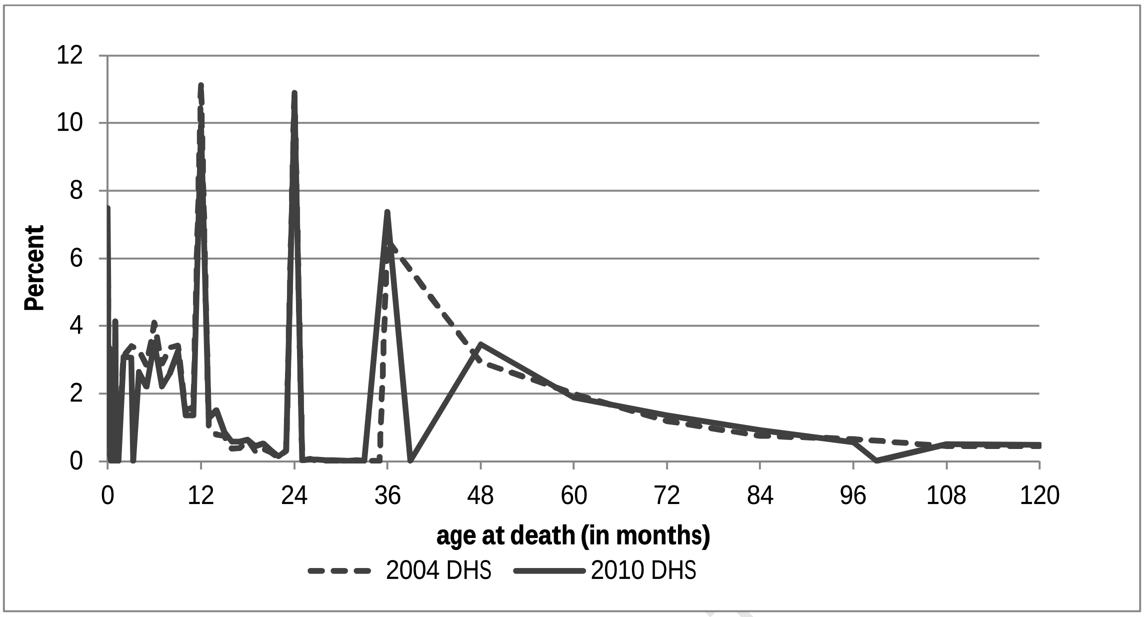
Biases are introduced in survey data by both sampling and non-sampling errors. Non-sampling errors depend on the completeness with which the information is collected and its accuracy. Typically the most serious source of bias in surveys is the omission of births and deaths of children who are not alive at the time of survey as women may be reluctant to talk about their dead children (NSO and ORC Macro 2011). Other sources of bias include non-response, misreporting of age at birth and age at death.

However, in this study, biases due to non-response may be insignificant due to the high response rates among women in both surveys. The response rate was 97 per cent in 2010 and 96 per cent in 2004 (NSO and Macro 2001; NSO and ORC Macro 2011). There may, however, be some bias in the HIV data for 2004 as the response rate among women eligible for HIV testing was 70 per cent compared to 91 per cent in 2010.

Biases may also be introduced in the child mortality data due to the death of the mother. If a mother dies there is no one to report on the survival or death of her children, which may lead to an underestimation of child deaths if maternal and child deaths are correlated. This type of bias is more likely to be significant in populations with high HIV prevalence (greater than 5 per cent) since both the mother and child are more likely to die. The 2010 DHS estimated the HIV prevalence in Malawi at 13 per cent among women aged 15-49.

An attempt was made to assess the accuracy of age at death of children who died as reported by the mothers. Figure 3.1 shows the distribution of age at death of children aged 0 to 10 years old as reported by their mothers (using the variable b6). In both 2004 and 2010 DHS, there is evidence of heaping on ages 12 months, 24 months and 36 months. This shows the tendency of women to report their children's age at death in complete years. This may lead to underestimation of infant mortality and over estimation of child mortality since deaths are pushed further in time than they occur.

Figure 3.1 Age at death distribution of children who die between the ages of 0 months and 120 months



3.3 Methods of analysis

Data analysis has been conducted at univariate, bivariate and multivariate levels. Proportion distributions of the study population by each of the covariates were produced in the univariate analysis while the bivariate analysis involves chi-square tests of association between the dependent variables and each of the independent variables. Bivariate analysis for the survival data was also performed using the Kaplan Meier method and Cox test of equality of survival times as described in Section 3.3.2.1. Two different methods of multivariate analysis have been used; logistic regression method and parametric regression in survival analysis. Both methods require a binary response variable and no assumptions are made about the distribution of the response variable. The units of analysis in all methods are the children. The mortality of children in this study has been analysed at two different ages: infant for those aged less than 12 months and children for those aged 12 to 60 months. For infant mortality, some studies subdivide it into three groups: less than 1 month, 1 to 5 months and 6 to 11 months. However, in the subsequent analysis only one group was used to maintain a large sample size there by having a high statistical power.

3.3.1. Logistic regression

A logistic regression model predicts the probability that an outcome will be 1 rather than 0 for given values of the explanatory variable (Sahai and Khurshid 1996). The dependent variable in this model is a binary outcome taking the value of 1 if the event of interest occurs and 0 otherwise. In this case, the dependent variable takes the value of 1 if a death occurs among children in the age segment 0 to 11 months or 12 to 60 months and a value of 0 otherwise. Logistic regression analysis does not require strict assumptions such as linearity and normality of the dependent variable and the residuals. In general, the logistic regression model is given by the equation:

$$p_i = \frac{\exp(\beta_0 + \beta_i x_i)}{1 + \exp(\beta_0 + \beta_i x_i)}$$

where:

p_i is the probability that a death will occur for the i^{th} individual

β_0 is the intercept

β_i is the regression coefficient for the explanatory variable x_i.

Since this method is based on the log transformation of the odds, the expression can also be written as :$logit(p_i) = \log\left(\frac{pi}{1-p_i}\right) = \beta_0 + \beta_i x_i$

where $\frac{p_i}{1-p_i}$ is the odds of an event occurring. The ratio of odds of an event occurring in one group to the odds of it occurring in the other group is called the odds ratio. This ratio indicates whether the odds of an event occurring in one group are different from the odds of the same event occurring in another group (odds ratio of 1 implies no difference). It is used to determine the strength of the association of the explanatory variable and the response variable and also assess the impact of confounding variables.

In logistic regression analysis, we only considered those fully exposed to the risk of death within the period of interest. This is done to ensure that all births have the chance of dying by the age of interest so that any differences in the risk of death observed among them should be attributed to different factors they were exposed to as opposed to differences brought about by censoring. In this case, we only consider births that occurred 13-24 months and 60-119 months before the interview for infant and child analyses respectively to make sure that only those fully exposed are used in the analysis. This becomes a problem when the determinants of child mortality have changed within the period as it may not reflect the situation at time of the survey. This is more problematic when considering the HIV status of the mother as the status is more likely to change within this period. It is also important to note that going back 10 years for the logistic regression, the sample for 2010 MDHS overlaps with that of 2004 MDHS for survival analysis. However, this may not be a problem since logistic regression and survival regression are two different and independent analyses.

Date of birth and date of death of the infants and children aged 1 to 5 are used to locate births and deaths in the period of interest. The date of birth in DHS is collected in Century Month Code (CMC) and the age at death is coded XYY where X is equal to 1, 2 or 3 which represents days, months and years respectively. YY is the number of units of X at death of the child. The standard recode variable (b7 in DHS) was not used as the age at death is month imputed calculated from the given information. If reported in days they are truncated into complete months and if reported in years they are converted into months (MeasureDHS and ICFInternational 2012). If age at death was not reported, the hot decking approach was applied by taking the age at death of the last child encountered of the same birth order in the data file. This makes it more inaccurate to work with if the information was reported in days and years as it may lead to misallocation of deaths in time. Variable b6 was therefore chosen and used in the subsequent analysis and not b7.

3.3.2 Survival analysis

Survival analysis methods are used to model time to occurrence of an event (Vittinghoff, Glidden, Shiboski *et al.* 2012). The response variable is the waiting time to the occurrence of the event of interest. They follow individuals from a defined starting point to the occurrence of the event of interest. These methods are applied when the distribution of the data is not normal and, unlike the logistic regression method, compensates for censored observations. Censoring occurs if the information on survival time of observations is incomplete. This happens, for example, when the observation did not experience the event of interest for the duration of the study or was lost to follow-up during the study. Censoring also occurs due to late entry of observations in the study. This happens when, for example, one tries to do a regression based on full exposure, as late entries are not fully exposed to the risk of an event occurring. They are therefore censored and survival analysis does accommodate for this. In this study, infants are considered censored if they were born less than 12 months before the survey and children are censored if they were born less than 60 months before the survey since they are not exposed for the whole duration. There was no lost to follow-up in the data used in this study since it is from a cross-sectional study. Survival analysis can also be used to determine the impact of exposure on the survival time. It is therefore appropriate for time-to-failure investigations where exposure to risk is an important consideration.

In this study, we use the information of children born two years before the survey to model the covariates of infant. The “entry” and “exit” commands in STATA were used to limit our investigation to only those aged 0 to 12 months. This was done to increase sample size thereby increasing the statistical power of the test (Warner 2013). For child mortality, only those born 12 to 60 months before the survey were considered. For each infant, survival information is given by: $T_i\theta_i$, $i= 1, 2, \ldots\ldots$ where $T_i \in (0, \ldots\ldots 12)$ is the observation time measured in months and θ_i is the indicator of survival which takes the value 1 if infant *i* had died and zero if it is still alive in each month. A similar construction has been devised for use with the analysis of child mortality allowing *T* to be in the range 12 to 60 months. Two different survival methods have been used: the Kaplan-Meier method and a parametric regression model with an exponential distribution.

3.3.2.1 Kaplan-Meier survival analysis

Kaplan-Meier survival analysis is a non-parametric method for estimating the survivor function *(s(t))*, which is the probability of surviving beyond time t (Cleves, Gould and Gutierrez 2004). It uses the exact survival time for each individual in the sample as compared to life table method which group the survival time into intervals. Random numbers were used to estimate the date of birth and date of death for the infant and children in this analysis. In general, the distribution of survival times is given by a survival function: $s(t) = \Pr(T > t)$, where T is a continuous random variable representing survival time.

The survivor function produced can be used to produce survival curves. Kaplan-Meier survival curves are plotted as a step function and can be used to calculate the survival time corresponding to any proportion of the sample. One can also compare two or more survival curves to determine whether the probabilities of survival between groups of interest are statistically different. The Cox test of equality of survival times has been adopted to do so in this analysis. This test is appropriate for sample weighted data as it can handle complex sample designs, such as that used with the DHS. It is used to test the significance of the regression coefficient in the model and test the null hypothesis of β=0 (Warner 2013). The Wald statistic is given by the expression:

$\left(\beta/_{SE(\beta)}\right)^2$ Where β is the coefficient and SE(β) is the standard error of the coefficient.

It approximately follows a chi-square distribution with (R-1) (C-1) degrees of freedom where R is Row and C is Column. A *p*-value is used to test for significance at 5 per cent level.

3.3.2.2 Parametric regression model

The Kaplan-Meier survival analysis method investigates the impact of each of the covariates independently on the survival time of infants and children. However, in many circumstances a number of covariates are thought to influence the response variable simultaneously. To investigate the significance of a covariate in influencing the response variable in the presence of other covariates, we use a multivariate parametric regression model with an exponential distribution. This has been achieved by using the "streg" command in STATA, which performs a maximum likelihood for parametric regression survival models (StataCorp 2011). The baseline hazard is assumed constant over time and an extra parameter β_0 is estimated, which is the shape parameter. This model is preferred due to its simple form as only one parameter is estimated. More complex parametric models are available which adapt to the different survival patterns and tend to produce more precise estimates (Bull and Spiegelhalter 1997). However due to their complexity, they are beyond the scope of this work and were not considered.

The survivor function for the survival exponential model is given by the expression: $s(t) = \exp(-\lambda_i t_i)$, where λ is a parameter and t is time. Since in this case the parameter is exponentially distributed, the survivor function can be written as:

$s(t) = \exp(-\exp(\beta_0 + \beta_i x_i)\, t)$ where:

β_0 is the intercept

β_i is the regression coefficient for the explanatory variable x_i

t is the time

The exponential parametric model can also be written in form of hazards and is given by the formula:

$h(t) = h_0(t)\exp(\beta_i x_i)$ where:

$h(t)$ is the hazard at time t

$h_0(t)$ is the baseline hazard

β_i is the regression coefficient

x is the covariate

It is also important to note that the sample used in the analysis may be clustered due to women who had two or more children during the analysis time. This implies that the observations in the sample are no longer independent and may lead to too small P-values and narrow confidence interval (Warner 2013). This was dealt with by ignoring marginally significant results, that is, those significant at more than 5 per cent significant level.

Applying an appropriate estimator of the standard error to take into account this clustering was beyond the scope of this study.

3.4 Description of independent variables (covariates)

Variables from the DHS data are reconstructed and coded to form categorical factors for the purpose of this analysis. These covariates are grouped into three main groups: bio-demographic, socio-economic and environmental factors as described in the Mosley and Chen framework set out in Chapter 2.

Bio-demographic factors include age of the mother at birth of the child, sex of the child, birth order and preceding birth interval. Age of mother at birth of the child has been calculated as the difference between the child's birth date and the mother's birth date and then has been categorised into young (below 20), old (20-39) and older (above 40). Women aged below 20 and those aged above 39 are considered more likely to have a poor maternal outcome thereby increasing the risk of infant or child death. Birth order has been grouped into first births, 2 to 4, and 5+. Preceding birth interval, which is given in months, has been coded into five categories: 9-23 months, 24-35 months, 36- 47months, 48-59 months, 60-259 months and first births. These categories were developed taking into consideration the recommendations by World Health Organisation of an interval of at least 24 months (WHO 2005). Those with an interval of 9-23 months are therefore considered as having a short preceding birth interval. The category "first births" has been included in order to keep the observations in the model thereby reducing the number of missing observations. Child's weight at birth, although an important factor especially for infant mortality, was not included in the analysis as it was missing in a number of observations. This information was only reported for 67 per cent and 43.4 per cent in the 2010 and 2004 DHS respectively (NSO and ORC Macro 2005, 2011). The number, therefore, becomes so small as it is collected for only those born five years preceding the survey. Some of these responses also were based on the mothers' recall rather than the child's health passport which is prone to biases.

Environmental variables include source of drinking water, type of toilet facility and type of floor material. The question "what is the main source of drinking water for members of your household?" was asked and fourteen different responses were given. These have been recoded into three categories based on quality; piped water (piped into dwelling, piped into yard and public tap/stand pipe), other protected source (tube well or borehole, protected well, protected spring, bottle water and tanker truck) and unprotected source (unprotected well, unprotected spring, rain water, cart with small tank, river/dam/lake/ponds/stream/canal). Type of toilet facility has been grouped into: improved toilets, traditional toilet and no toilet facility. Observations on floor material have been condensed into two: unfinished floor (earth, sand, dung, wood planks, palm, bamboo, broken bricks) and finished floor (polished wood, vinyl/asphalt strips, ceramic tiles, cement and carpet). This is based on the fact that finished floors are more likely to be clean therefore less likely to be contaminated with disease causing germs as compared to unfinished floors.

Socio-economic variables include mother's level of education, father's education, mother's occupation, father's occupation, mother's marital status, wealth quintile, place of residence (urban or rural) and region of residence. These variables have been found to be significantly associated with infant and child mortality in some settings as presented in the literature review in Chapter 2. It is therefore important to investigate their influence in Malawi. Their availability in the data sets used was also considered during selection. The highest level of education for both mother and fathers has been categorised into three: no education, primary and secondary+ (secondary level and higher). Mother's occupation has four categories: did not work, formal, other manual and self-employed in agriculture while father's occupation has been categorised into three as the categories did not work and self-employed agriculture were combined due to small number of those who did not work. The information on wealth index has been used as presented in the dataset, that is, in five categories: poorer, poor, middle, rich and richer. This index is calculated by Measure DHS from the data on household ownership of selected assess, materials used for housing construction, types of water access and sanitation facilities (Rutstein and Johnson 2004). The principal components analysis procedure is used in the calculation. This index gives a full description of the household economic status since it is a household measure not an individual measure.

The mother's marital status was categorised into two: living together and not living together. Those living together with their partners include those who reported to be married and those who although not legally married but were living together with their partners at the time of the survey. The category "not living together" includes those divorced, widowed, separated and never married. This is because the interest is on the presence of a father in the household who in most cases is responsible for providing for the family and may be involved in the daily care of children which affect child survival.

4 RESULTS

This chapter provides the results of the analyses using the methods outlined in Chapter 3. Section 4.1 presents a brief description of the study population while Section 4.2 gives the results of the bivariate analysis. The results of a multivariate logistic regression analysis are presented in Section 4.3 and those of survival analysis method are presented in Section 4.4.

4.1 Description of the sample

This section gives a brief description of the study population based on mother's background characteristics. As presented in Chapter 3, information of those born less than 10 years before the two surveys have been used in the subsequent analysis. This section therefore gives the description of only those used in the analysis. The study has used 19461 observations from the 2004 survey and 38060 observations from the 2010 survey.

In both surveys, a high proportion of children's mothers were aged 25-29 years and only 4 per cent in 2004 and 3 per cent in 2010 were aged 15-19. More than half of the mothers had primary education while less than 1 per cent of children's mothers in both surveys had post-secondary education. The proportion of mothers without education declined from 29 per cent in 2004 to 20 per cent in 2010. The per cent distribution by region of residence is roughly the same in the two surveys with a high proportion being from the southern region. In both surveys, a high proportion of the children's mothers were married and only 13 per cent in 2004 and 20 per cent in 2010 had formal employment. Table 4.1 presents the distribution of children aged less than 10 by their mother's background characteristics.

4.2 Bivariate analysis

This section gives the results of the chi-square test of association between the response variable and the covariates. The results for infants are presented in section 4.2.1 and those for children aged 1 to 5 are presented in section 4.2.2. These include the distribution of infants and children by each of the covariates considered.

Table 4.1 Distribution of children aged less than 10 years by mother's background characteristics (weighted)

	2004 MDHS		2010 MDHS	
	Number	**Per cent**	**Number**	**Per cent**
Age				
15-19	710.18	3.65	1140.07	3.00
20-24	4565.00	23.46	7287.37	19.15
25-29	5567.77	28.61	11416.03	29.99
30-34	3816.02	19.61	8217.37	21.59
35-39	2562.81	13.17	5676.45	14.91
40-44	1462.64	7.52	2815.43	7.40
45-49	777.02	3.99	1507.06	3.96
Education				
No Education	5732.53	29.46	7504.34	19.72
Primary	12033.82	61.83	25492.36	66.98
Secondary	1644.17	8.45	4795.95	12.60
Higher	50.92	0.20	267.14	0.70
Region				
Southern	8981.33	46.15	17366.64	45.63
Central	8052.80	41.38	16313.14	42.86
Northern	2427.31	12.47	4380.00	11.51
Place of residence				
Rural	16875.19	86.71	32481.03	85.34
Urban	2586.25	13.29	5578.75	14.66
Marital status				
Married	15813.91	81.26	28702.21	75.41
Divorced	992.88	5.10	2019.92	5.31
Widowed	639.77	3.24	1003.78	2.64
Never married	216.44	1.11	406.01	1.07
Living together	1035.30	5.32	4056.25	10.66
Not living together	763.14	3.92	1871.60	4.92
Occupation				
Not working	7702.78	37.01	8356.94	21.96
Self-agriculture	9125.22	46.89	17802.92	46.78
Other manual	520.94	2.68	4143.80	10.89
Formal employment	2612.50	13.42	7756.12	20.38
Total	19461.44	100.00	38059.78	100.00

4.2.1 Bivariate analysis of associations with infant mortality

Table 4.2 shows the proportion in each category of the independent variables and the chi-square test of association between infant deaths and each of the covariates considered. In both surveys, half of infants were of the order 2-4 while 22 per cent in 2004 and 19 per cent in 2010 were first births. The proportion of infants' mothers with at least secondary education increased from 10 per cent in 2004 to 15 per cent in 2010. A high proportion of

Table 4.2 Proportion distribution and chi-square test results for infants

	2004 MDHS			2010 MDHS		
Covariate	**Sample size**	**Proportion**	**p- value**	**Sample size**	**Proportion**	**p- value**
Birth order	2385		0.3883	4043		0.2032
First births		0.2180			0.1907	
2-4		0.4965			0.5099	
5+		0.2855			0.2994	
HIV status	2385		0.0090	4043		0.0002
Negative		0.2310			0.2985	
Positive		0.0257			0.0318	
Not tested		0.7433			0.6697	
Mother's education	2385		0.0545	4043		0.0601
No education		0.2532			0.1635	
Primary		0.6412			0.6800	
Secondary+		0.1056			0.1564	
Father's education	2316		0.9826	3929		0.9196
No education		0.1596			0.1095	
Primary		0.6061			0.6154	
Secondary+		0.2343			0.2751	
Sex of the child	2385		0.6325	4043		0.7980
Female		0.4998			0.4974	
Male		0.5002			0.5026	
Place of residence	2385		0.3218	4043		0.3496
Rural		0.8773			0.8527	
Urban		0.1227			0.1473	
Floor material	2354		0.9663	3993		0.6564
Unfinished		0.8364			0.8121	
Finished		0.1636			0.1879	
Toilet facility	2352		0.6156	3964		0.2498
No toilet		0.1670			0.1093	
Traditional		0.8077			0.8469	
Improved		0.0252			0.0438	
Source of water	2353		0.9068	3980		0.7963
Unprotected		0.4012			0.2144	
Other Protected		0.4419			0.5771	
Piped water		0.1569			0.2085	
Marital status	2385		0.1263	4043		0.4357
Not living together		0.1132			0.1301	
Living together		0.8868			0.8699	
Wealth index	2385		0.8910	4043		0.5013
Poorer		0.2039			0.2194	
Poor		0.2367			0.2119	
Middle		0.2154			0.2153	
Rich		0.1903			0.1906	
Richer		0.1537			0.1628	
Birth interval	2380		0.0385	4036		0.0033
9-23 months		0.1044			0.1185	
24-35 months		0.2710			0.2737	
36-47 months		0.1928			0.1935	
48-59 months		0.0975			0.1140	
60-259 months		0.1158			0.1094	
First births		0.2185			0.1909	
Mother's occupation	2385		0.9101	4043		0.5343
Did not work		0.3934			0.2396	
Self-agriculture		0.4720			0.4694	
Other manual		0.0213			0.1058	
Formal		0.1133			0.1852	
Father's occupation	2200		0.2750	3960		0.3748
Self-agriculture		0.5718			0.4806	
Other manual		0.1540			0.2568	
Formal		0.2742			0.2627	
Mother's age	2385		0.4625	4043		0.0153
Less than 20 years		0.1971			0.1651	
20-34 years old		0.6776			0.705	
35+old		0.1253			0.1298	

infants' mothers in both 2004 and 2010 were from the rural areas and lived in houses with unfinished floors.

As can be seen from the table, the chi-square tests were significant for only three covariates in 2010 and only two covariates in 2004. This means the differences in infant mortality were only statistically different within categories in these variables. These include: HIV status of the mother; length of preceding birth interval; and age of the mother at birth of the child in 2010. In the 2004 survey, only HIV status of the mother and length of the preceding birth interval were significantly associated with infant mortality. As can be observed, only biological factors considered were significantly associated with the risk of death during infancy. This is because biological factors affect the formation and growth of the foetus and may lead to premature births or births with congenital defects who are more likely to die early in life. Region of residence was also included in the analysis and was found insignificant although the results are not included in the table.

4.2.2 Bivariate analysis of associations with mortality of children aged 1 to 5

Table 4.3 presents the distribution of children and deaths, and the results of the chi-square test. The distribution of children aged 1 to 5 by the independent variables in the two surveys is consistent. The proportion of first born children in 2004 was 24 per cent, just slightly higher than that in 2010, which was 23 per cent. As with infants, the highest proportions of children in both surveys were those of order 2-4. Only 7 per cent and 12 per cent of children's mothers had at least secondary school education in 2004 and 2010 respectively. The proportions were higher for fathers' education with 18 per cent and 24 per cent of children's fathers having post-primary education. 4 per cent of children's mothers tested HIV positive in both 2004 and 2010. A high proportion of the children's mothers in both surveys was from the rural areas and had a traditional toilet.

The chi-square test of association using the 2010 data was significant for all covariates of child mortality at 5 per cent significance level except for toilet facility and father's occupation. The association is even stronger for HIV status of the mother, fathers' education and preceding birth interval where the *p*-value is less than 0.0001. For 2004, birth order, HIV status of the mother and source of drinking water were the only covariates not significantly associated with child deaths. Mother's education, type of floor material, wealth index, preceding birth interval and age of the mother at birth of the child had *p*-values less than 0.0001. It is also important to note that none of the covariates considered was found insignificant in both time periods. This indicates changes in factors affecting child mortality between the two survey periods.

Table 4.3 Proportion distribution and chi-square test results for children

	2004 MDHS			2010 MDHS		
Covariate	**Sample size**	**Proportion**	**p- value**	**Sample size**	**Proportion**	**p-value**
Birth order	8914		0.123	18659		0.0210
First births		0.2443			0.2305	
2-4		0.4715			0.5005	
5+		0.2842			0.2690	
HIV status	8914		0.0810	18657		0.0000
Negative		0.2138			0.2707	
Positive		0.0373			0.0444	
Not tested		0.7489			0.6849	
Mother's education	8914		0.0000	18659		0.0003
No education		0.3391			0.2213	
Primary		0.5955			0.6615	
Secondary+		0.0654			0.1172	
Father's education	8804		0.0004	18409		0.0001
No education		0.1827			0.1272	
Primary		0.6332			0.6280	
Secondary+		0.1841			0.2449	
Sex of the child	8914		0.0224	18659		0.0030
Female		0.4953			0.5011	
Male		0.5047			0.4989	
Placeof residence	8914		0.0026	18659		0.0161
Rural		0.8663			0.8497	
Urban		0.1337			0.1503	
Floor material	8832		0.0000	18434		0.0019
Unfinished		0.8172			0.7947	
Finished		0.1828			0.2053	
Toilet facility	8836		0.0006	18343		0.0704
No toilet		0.1655			0.1060	
Traditional		0.7980			0.8507	
Improved		0.0365			0.0433	
Source of water	8835		0.1059	18389		0.0386
Unprotected		0.3741			0.2117	
Other Protected		0.4508			0.5807	
Piped water		0.1751			0.2075	
Marital status	8914		0.0273	18659		0.0044
Not living together		0.1485			0.1491	
Living together		0.8515			0.8509	
Wealth index	8914		0.0000	18659		0.0073
Poorer		0.1944			0.2093	
Poor		0.2082			0.2070	
Middle		0.2164			0.2029	
Rich		0.2103			0.2049	
Richer		0.1707			0.1760	
Birth interval	8890		0.0000	18605		0.0001
9-23 months		0.2022			0.1601	
24-35 months		0.2907			0.2718	
36-47 months		0.1422			0.1785	
48-59 months		0.0576			0.0859	
60-259 months		0.0622			0.0728	
First births		0.2450			0.2310	
Mother's occupation	8914		0.0263	18659		0.0250
Did not work		0.3476			0.2019	
Self- agriculture		0.4747			0.4693	
Other manual		0.0302			0.1147	
Formal		0.1475			0.2142	
Father's occupation	8412		0.0049	18580		0.0581
Self- agriculture		0.5682			0.4842	
Other manual		0.1598			0.2515	
Formal		0.2719			0.2644	
Mother's age	8914		0.0000	18659		0.0002
Less than 20 years		0.2541			0.2343	
20-34 years old		0.6419			0.6673	
35+old		0.1040			0.0983	

4.3 Multivariate logistic regression

The chi-square test discussed in the previous section tests for the presence of association between the response variable and each of the independent variable. This does not take into account the effect of other variables and also does not give the direction of the association. To correct for this, a multivariate logistic regression is used to test the significance of the independent variables in influencing the response variable in the presence of the other variables considered.

4.3.1 Logistic regression for infants

All fifteen covariates were initially included in the model. Five of them were dropped from the final model one at a time as they were found to be more insignificant and their presence had no impact on the model. These include: father's occupation status, mothers occupation status, region of residence, fathers education and source of drinking water. Interaction effects were **c**onsidered in the analysis. An interaction occurs when the effect of an explanatory variable on the dependent variable depends on another explanatory variable (Vittinghoff, Glidden, Shiboski *et al.* 2012). This implies that the odds ratios cannot be interpreted as the odds of the event occurring for one group relative to the reference category holding the other covariates constant. This is handled by including interaction terms between the variables which an interaction may exist. However, for infant mortality, none of the interaction terms included was found significant using the 2004 data set. In 2010, the interaction between birth order and mothers' education was significant and was included in the final model. In total, 2385 observations from the 2004 DHS and 4043 observations from the 2010 DHS were used in the infant logistic regression analysis.

Table 4.4 presents the results of a multivariate logistic regression analysis for the two time periods. In 2004, only two bio-demographic covariates were found to be significant in influencing the risk of death during infancy in the presence of the other covariates. These are HIV status of the mothers and preceding birth interval. These covariates were also significant in the bivariate analysis presented in the previous section. In 2010, three covariates, namely HIV status of the mother, preceding birth interval and mother's education were significant. Age of the mother at birth of the child, though significant in the bivariate analysis, was not significant in the multivariate analysis. This implies that controlling for the effect of other covariates, age of the mother at birth had no significant impact on infant mortality.

The odds of dying for infants whose mothers were HIV positive was 5.49 times higher relative to that of infants born to HIV negative mothers in 2004. In 2010, infants of HIV positive mothers were 4.40 times likely to die compared to those of HIV negative mothers, slightly lower than that in 2004. There was no significant difference in the odds of dying among infants of HIV negative mothers and infants whose mothers were not tested in 2004. However in 2010, the odds were statistically different as those whose mothers were not tested were 1.99 times likely to die than those whose mothers tested HIV negative. This implies that approximately 29 per cent of infants' mothers who were not tested in 2010 were actually HIV positive and had a high chance of experiencing an infant death. This is because the proportion of mothers not tested but HIV positive is just a weighted average of those known positive and those known negative.

The length of the preceding birth interval was also significant as a predictor of infant mortality in both 2004 and 2010. Three categories in 2004 and one category in 2010 had odds ratios, which were statistically different from that of the reference category. In 2004, infants with a preceding birth interval of 24-35 months and 36-47 months were less likely to die relative to those with an interval of 9-23 months with odds ratios of 0.491 and 0.322 respectively. The odds of infant death for an interval of between 24 and 35 months declined to 0.381 in 2010.

As can be observed from Table 4.4, none of the environmental factors are statistically significant in influencing the risk of death for infants. Only one category of mothers' education was significant among the socio-economic covariates and still using the 2010 DHS only.

4.3.2 Logistic regression for the risk of death during childhood

This section presents the results of the logistic regression analysis for the co-factors affecting deaths of children aged 1 to 5. Information from 8914 children and 18659 children from 2004 and 2010 DHS respectively were used in the logistic regression models for children. Table 4.5 shows the results. The results confirm some of the bivariate results in the previous section. Four bio-demographic and one socioeconomic variable were found significant in 2004 of which only one (birth order) was found not significant in the bivariate analysis. In 2010, four bio-demographic and two socio-economic variables, which were also significant in the bivariate analysis, were found significant. As with the analysis of the covariates of infants' mortality the interaction effects were considered and those significant were included in the final models.

Table 4.4 Multiple logistic regression results for infants

	2004 DHS			2010 DHS		
Covariate	Odds ratio	Standard error	P-value	Odds ratio	Standard error	P-value
HIV status						
Negative (Ref)	1.000			1.000		
Positive	5.497	2.535	0.000	4.404	1.932	0.001
Not tested	1.585	0.496	0.142	1.986	0.429	0.002
Birth order						
First births (Ref)	1.000			1.000		
2-4	0.698	0.188	0.184	1.165	0.660	0.787
5 and above	Omitted			Omitted		
Birth interval						
9-23 months (Ref)	1.000			1.000		
24-35 months	0.491	0.162	0.032	0.381	0.112	0.001
36-47 months	0.322	0.121	0.003	0.556	0.169	0.055
48-59 months	0.803	0.358	0.624	0.576	0.193	0.102
60-259 months	0.328	0.159	0.022	0.826	0.273	0.565
First births	0.531	0.206	0.105	1.894	1.561	0.438
Mother's education						
No education (Ref)	1.000					
Primary	1.744	0.523	0.064	1.317	0.946	0.702
Secondary+	0.784	0.437	0.664	0.156	0.145	0.047
Wealth index						
Poorer (Ref)	1.000			1.000		
Poor	1.083	0.356	0.809	1.623	0.439	0.074
Middle	1.096	0.336	0.765	1.651	0.487	0.090
Rich	1.198	0.487	0.657	1.128	0.369	0.711
Richer	0.810	0.402	0.627	0.719	0.381	0.535
Sex of the child						
Female (Ref)	1.000			1.000		
Male	0.898	0.155	0.538	1.102	0.182	0.554
Type of residence						
Rural (Ref)	1.000			1.000		
Urban	0.538	0.255	0.192	1.521	0.494	0.196
Floor material						
Unfinished (Ref)	1.000			1.000		
Finished	1.705	0.622	0.144	1.447	0.539	0.320
Toilet facility						
No toilet (Ref)	1.000			1.000		
Traditional	1.113	0.312	0.701	0.811	0.192	0.380
Improved toilet	0.674	0.605	0.661	2.032	1.035	0.164
Marital status						
Not married (Ref)	1.000			1.000		
Married	0.669	0.179	0.135	0.969	0.229	0.897
Mother's age						
Less than 20 years (Ref)	1.000			1.000		
20-34 years	0.905	0.269	0.739	0.956	0.273	0.877
35+	0.838	0.450	0.743	1.955	0.738	0.076

In 2004, no interaction was found significant while in 2010 the interaction between birth order and preceding birth interval; and birth order and mothers' education were found significant.

In 2010, HIV status of the mothers had a significant impact on child death but not in 2004. Children of HIV positive mothers were almost two times more likely to die compared to those whose mothers were HIV negative. Birth order had a strong impact (*p*-value of less than 0.001) on child mortality in 2004 with the children of orders 2-4 and 5+

being more likely to die relative to first births. However, the differentials in the odds were not significant in 2010. The preceding birth interval was also significant in influencing child mortality with the odds of dying declining as the interval increases in both time periods. The odds ratios of children born 36-47 months, 48-50 months and 60-259 months after the preceding birth were higher in 2004 compared to 2010. This implies an improvement in survival of children from these categories between 2004 and 2010.

Children whose mothers were aged 20-34 at the time of their birth were less likely to die with odds ratios of 0.694 and 0.811 in 2004 and 2010 respectively. Considering the sex of the child, deaths among male children increased by 0.2 times relative to that of female children in both time periods. Another important factor is mothers' education, which was significant in both 2004 and 2010. The risk of death among children whose mothers had primary and secondary education was 0.637 and 0.516 times that of children whose mothers had no education in 2010. In 2004, only children whose mothers had at least secondary education experienced the risk of dying statistically different from that of children with no education (OR= 0.576). Fathers' education was only significant in 2010 and those whose fathers had at least secondary education were less likely to die compared to those whose fathers had no education (OR=0.721). This is significant with a *p*-value of 0.007.

Three environmental factors were included in the model; type of floor material, toilet facility and source of drinking water for the households and none of these was significant in influencing child mortality in both time periods.

4.3.3 Goodness of fit.

The test for goodness of fit for the logistic regression models was performed using the "estat gof" command. This command performs a survey adjusted test of goodness of fit and replaces the "svylogitof" command, which was originally implemented as ado file (Archer and Lemeshow 2006). The command has now been incorporated into the svy: logistic commands as a post estimation option. For both infants and children models, the F statistics for the goodness of fit test were not significant at 5 per cent significance level with p-values of 0.951 and 0.810 for infants and children models respectively using 2010 MDHS. Using the 2004 MDHS data, the p-values were 0.994 and 0.366 for infant and children models respectively. This indicates good model fits.

Table 4.5 Multiple logistic regression results for children aged 1 to 5

	2004 DHS			2010 DHS		
Covariate	**Odds ratio**	**Std error**	***P*-value**	**Odds ratio**	**Std error**	***P*-value**
HIV status						
Negative (Ref)	1.000			1.000		
Positive	1.442	0.279	0.059	2.150	0.272	0.000
Not tested	0.920	0.078	0.330	1.023	0.065	0.720
Birth order						
First births (Ref)	1.000			1.000		
2-4	1.587	0.171	0.000	0.893	0.176	0.569
5 and above	1.841	0.240	0.000	1.064	0.240	0.782
Birth interval						
9-23 months (Ref)	1.000			1.000		
24-35 months	0.576	0.052	0.000	0.633	0.095	0.003
36-47 months	0.375	0.050	0.000	0.340	0.062	0.000
48-59 months	0.354	0.066	0.000	0.254	0.056	0.000
60-259 months	0.317	0.055	0.000	0.288	0.065	0.000
First births	Omitted			Omitted		
Mother's education						
No education (Ref)	1.000			1.000		
Primary	0.920	0.071	0.286	0.637	0.109	0.009
Secondary+	0.576	0.110	0.004	0.516	0.119	0.004
Father's education						
No education (Ref)	1.000			1.000		
Primary	0.922	0.079	0.347	0.956	0.080	0.603
Secondary+	0.875	0.107	0.277	0.721	0.086	0.007
Wealth index						
Poorer (Ref)	1.000			1.000		
Poor	0.932	0.104	0.536	0.968	0.084	0.716
Middle	0.920	0.105	0.473	1.035	0.089	0.684
Rich	0.878	0.108	0.292	0.981	0.096	0.851
Richer	0.914	0.214	0.704	1.171	0.207	0.372
Sex of the child						
Female (Ref)	1.000			1.000		
Male	1.194	0.078	0.007	1.207	0.069	0.001
Type of residence						
Rural (Ref)	1.000			1.000		
Urban	0.842	0.103	0.163	0.895	0.106	0.355
Floor material						
Unfinished (Ref)	1.000			1.000		
Finished	0.739	0.132	0.091	0.864	0.115	0.279
Toilet facility						
No toilet (Ref)	1.000			1.000		
Traditional	0.897	0.088	0.270	0.931	0.077	0.396
Improved toilet	0.819	0.187	0.384	0.793	0.149	0.219
Marital status						
Not married (Ref)	1.000			1.000		
Married	0.813	0.086	0.053	0.794	0.064	0.004
Mother's age						
Less than 20 years (Ref)	1.000			1.000		
20-34 years	0.694	0.064	0.000	0.811	0.075	0.026
35+	0.682	0.106	0.015	0.920	0.136	0.578

4.4 Survival analysis

The section that follows presents the results of the survival analysis. This is important as a complement to the logistic regression analysis since, unlike logistic methods, survival analysis methods do not require full exposure therefore uses most recent data. Both bivariate and multivariate analysis has been conducted in this study. Section 4.3.1 gives the results of the bivariate analysis for infant and children aged 1 to 5. Section 4.3.2 presents the results of a multivariate survival analysis for infants and that of children.

4.4.1 Bivariate survival analysis

4.4.1.1 Bivariate survival analysis for infants

This section investigates the importance of each covariate in influencing infant mortality without taking into account the effect of the other covariates. This has been done by using the Kaplan-Meier survival method and Cox regression based test of equality of survival curves as described in Chapter 3. This bivariate analysis is similar to the chi-square test of association conducted in the previous section. The most important survival curves are presented here and others are included in the appendix. In total 4838 observations from the 2004 DHS and 8069 observations from the 2010 DHS have been used in the survival analysis for infants. Figure 4.1 and Figure 4.2 show the survival curves for infants by mothers' HIV status for the 2004 and 2010 surveys.

The Kaplan-Meier survival curves for infants by mother's HIV status shows the same trend in both 2004 and 2010 with the curve of infants of HIV positive mothers being below that of infants of HIV negative mothers. However, the survival curves of infants of mothers who tested HIV positive falls below the curves of infants in the other two categories after 1 month in 2004 and after 3 months in 2010. This indicates a rapid decline in the proportions surviving among infants of HIV positive mothers after 1 month in 2004 and after 3 months in 2010.

As can be observed from the figures, the survival curve for infants whose mothers were not tested lies below that of infants whose mothers tested HIV negative in 2010 survey. This is not the case for these two curves using the 2004 survey. This implies that infants of mothers who were not tested experienced high mortality in 2010 compared to those whose mothers tested HIV negative. The Cox regression tests of equality of survival curves were statistically significant with p-values of 0.0172 and 0.0002 for 2004 and 2010 respectively.

Figure 4.1 Kaplan-Meier survival curves for infants by HIV status of the mother using 2004 MDHS

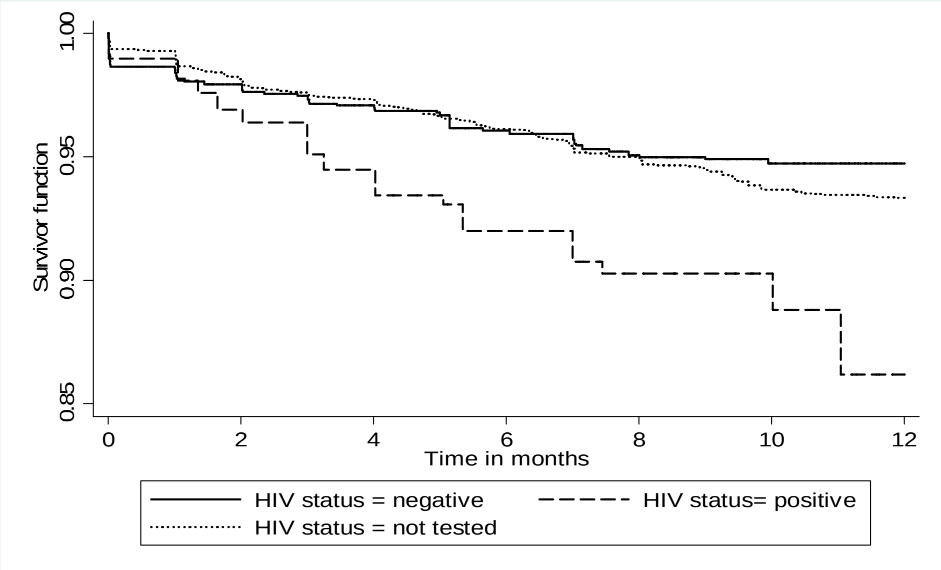
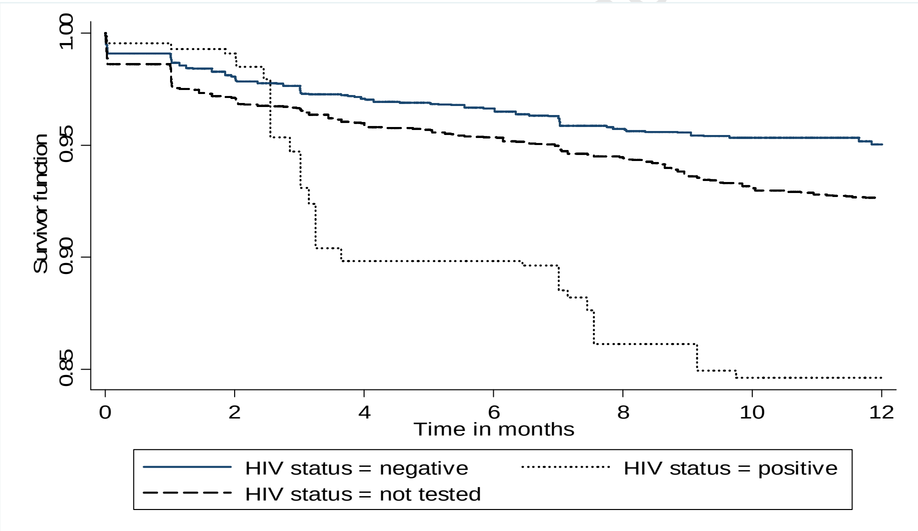


Figure 4.2 Kaplan-Meier survival curves for infants by HIV status of the mother using 2010 MDHS



Birth order is another significant factor in both time periods. The trend in the Kaplan-Meier survival curves in the two time periods is also similar, with the curve for first born infants lying below the curves of infants of the order 2-4 and 5+. This implies first births experience the highest mortality without taking into account the effect of other factors. This was significant with *p*-values of 0.0403 in 2004 and 0.0223 in 2010. Figure 4.3 and Figure 4.4 show the survival curves for infants by birth order using 2004 and 2010 surveys.

Figure 4.3 Kaplan-Meier survival curves for infants by birth order using 2004 MDHS

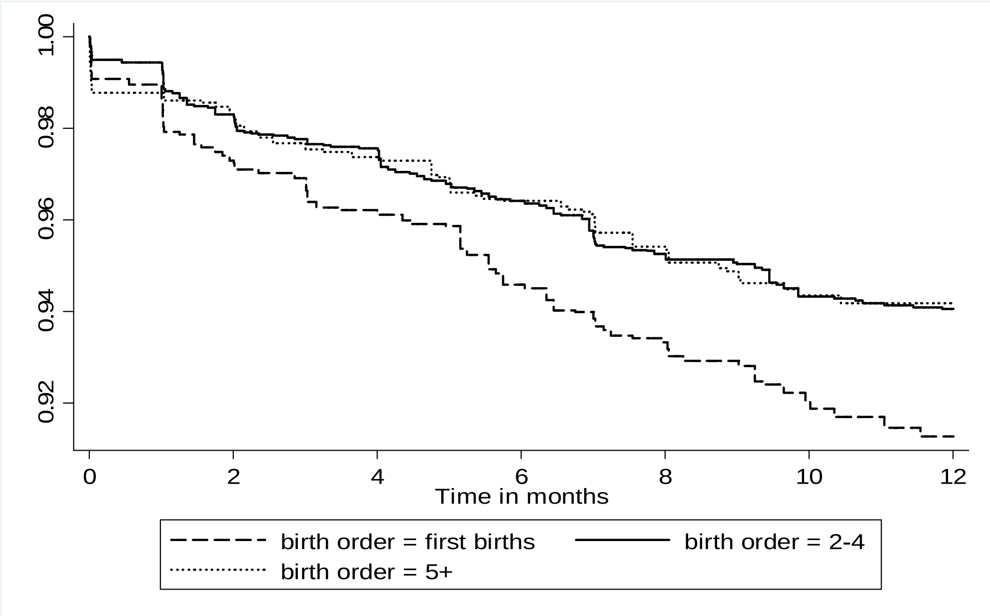
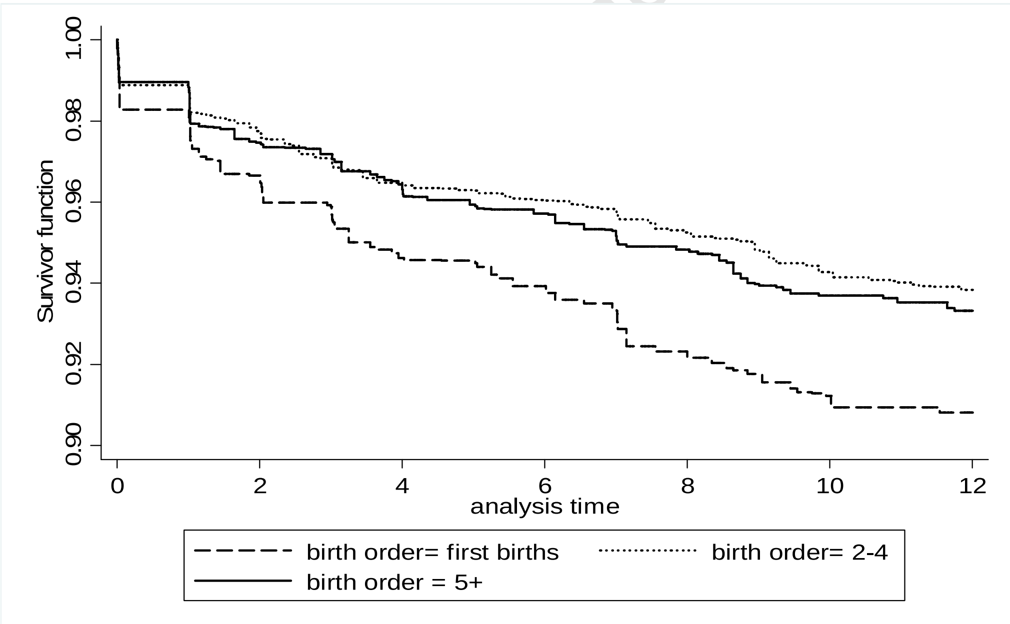


Figure 4.4 Kaplan-Meier survival curves for infants by birth order (2010 MDHS)



Other significant factors include birth interval which was associated with infant mortality in both time periods, wealth index and sex of the child, which were statistically significant only in 2010. Marital status of the mothers was also found significantly associated with infant mortality both in 2004 and 2010 with *p*-values of 0.0405 and 0.0374 respectively. Table 4.6 gives a summary of the Cox regression based test of equality of survival curves.

Table 4.6 Cox regression based test for equality of survival curves for infants

	2004 MDHS		2010 MDHS	
Covariate	**Wald chi2 value**	**Pr>chi2**	**Wald chi2 value**	**Pr>chi2**
HIV status of mother	8.130	0.0172	16.850	0.0002
Birth order	6.420	0.0403	7.610	0.0223
Birth interval	19.410	0.0016	37.590	0.0000
Mother's education	3.480	0.1756	0.850	0.6547
Father's education	0.830	0.6598	1.200	0.5484
Wealth index	2.110	0.7150	12.550	0.0137
Sex of child	0.880	0.3477	5.340	0.0209
Place of residence	2.330	0.1266	1.610	0.2045
Floor material	0.520	0.4709	2.550	0.1100
Toilet facility	1.010	0.6043	0.770	0.6820
Source of water	1.710	0.4247	3.810	0.1486
Father's occupation	2.670	0.2631	4.000	0.1350
Mother's occupation	0.180	0.9811	1.830	0.6079
Marital status	4.200	0.0405	4.330	0.0374
Mother's age	5.940	0.0514	13.180	0.0014

4.4.1.2 Bivariate survival analysis for children aged 1 to 4

This section presents the results of the Kaplan-Meier survival method and Cox regression based test of equality of survivor curves for children aged 1 to 5 by individual explanatory variables. The analysis has been conducted using 7738 observations from the 2004 DHS and 14931 observations from the 2010 DHS. Type of toilet facility, birth order, father's occupation and mothers' occupation are not significantly associated with child mortality using both 2004 and 2010 data. The trend in the survival curves is similar to that seen in infant mortality for both 2004 and 2010. Some of the Kaplan-Meier survival curves are presented here and some are included in the appendix. The drop off at age 60 months of the survival curves for 2010 survey may be explained by age heaping.

The survival curves for children whose mothers tested HIV positive lie below that of children whose mothers tested HIV negative and those whose mothers were not tested. This implies that HIV status of the mothers is associated with child mortality with the children of HIV positive mothers experiencing high mortality. The test for equality of survival curves is significant with *p*-values of 0.0001 for both surveys.

Figure 4.5 and Figure 4. 6 show the survival curves of children aged 1 to 5 by their mothers' HIV status.

Figure 4.5 Kaplan-Meier survival curves for children by HIV status of the mother using 2004 MDHS

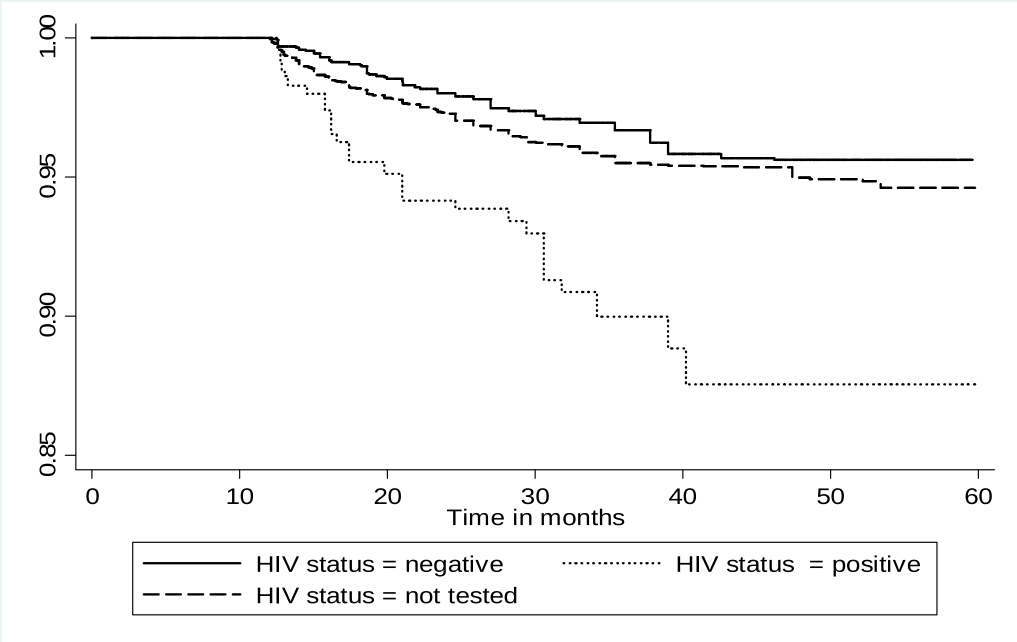
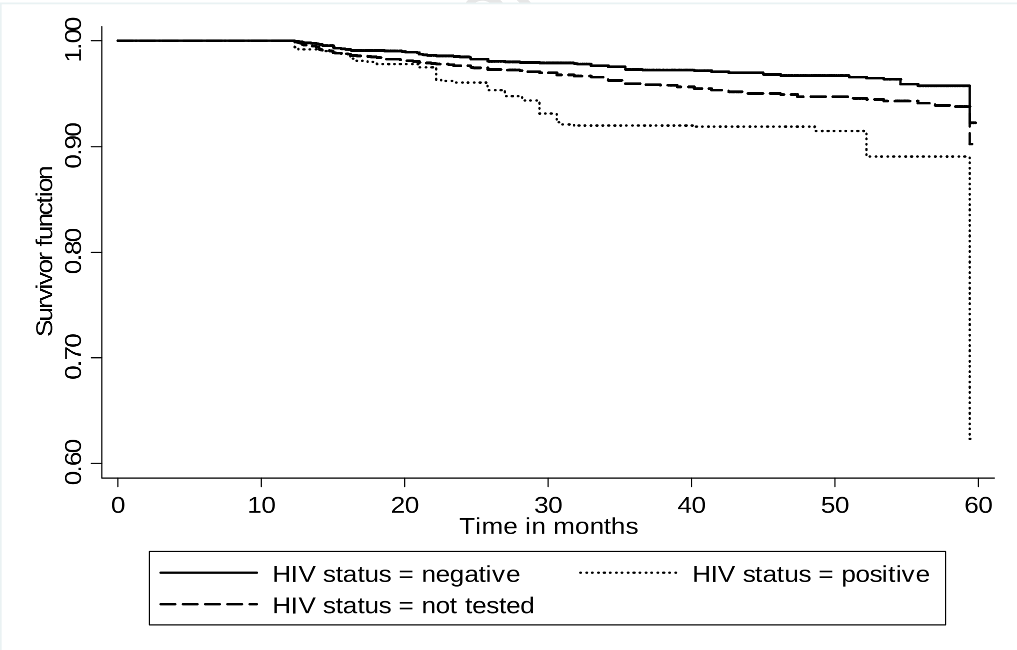


Figure 4. 6 Kaplan-Meier survival curves for children by HIV status of the mother using 2010 MDHS



Both mothers' education and fathers' education also had a statistically significant influence on child mortality both in 2004 and 2010. Their survival curves show an increase in the probability of survival as the level of education increases. Figure 4.7 and Figure 4.8 show the survival curves of children by mother's education level.

Figure 4.7 Kaplan-Meier survival curves for children by mothers' education using 2004 MDHS

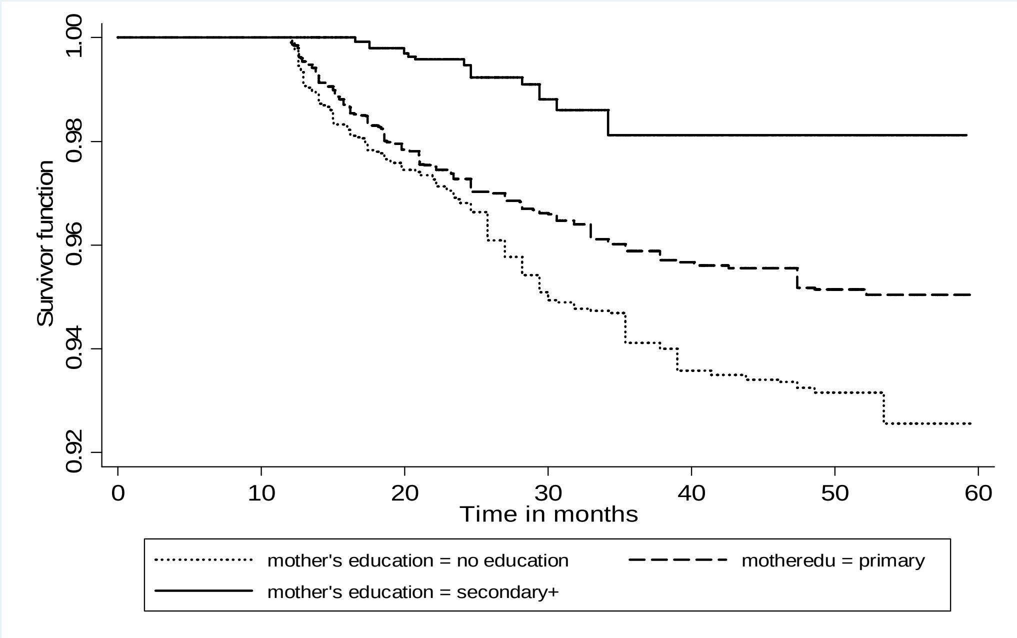
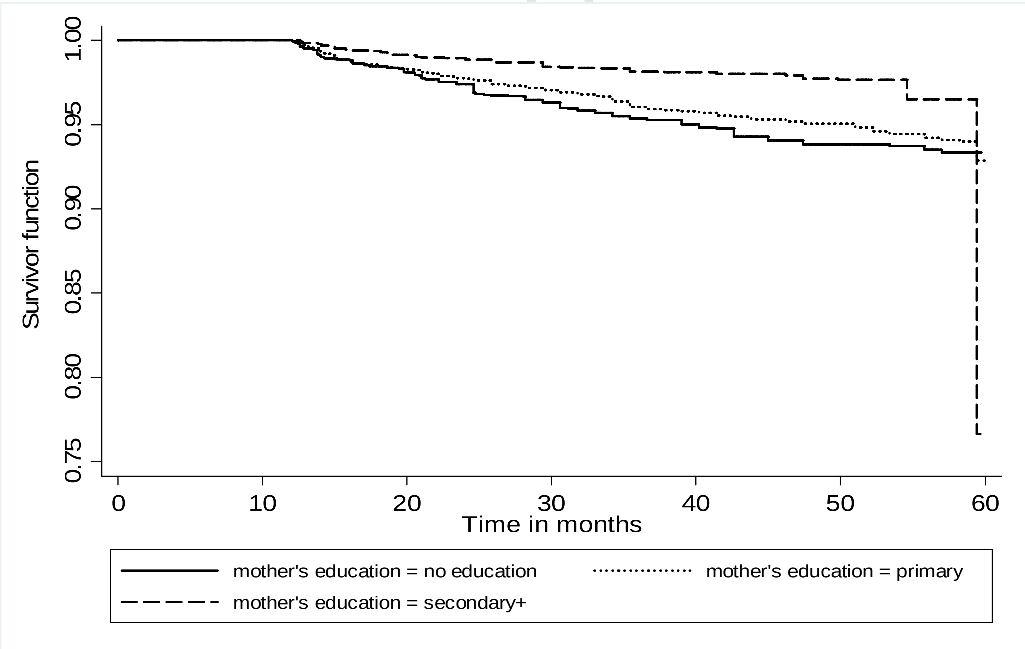


Figure 4.8 Kaplan-Meier survival curves for children by mothers' education using 2010 MDHS



Other covariates significant in both 2004 and 2010 include wealth index, preceding birth interval, mothers' place of residence, type of floor material and marital status of the mother. Table 4.7 gives a summary of the equality of survival curves test for children.

Table 4.7 Cox regression based test for equality of survival curves for children aged 1 to 5

	2004 MDHS		2010 MDHS	
Covariate	**Wald chi2 value**	**Pr>chi2**	**Wald chi2 value**	**Pr>chi2**
HIV status of mother	17.610	0.0001	19.700	0.0001
Birth order	2.410	0.2994	5.950	0.0512
Birth Interval	11.380	0.0444	32.190	0.0000
Mother's education	19.960	0.0000	13.010	0.0015
Father's education	6.620	0.0364	11.480	0.0032
Wealth index	14.050	0.0071	15.280	0.0042
Sex of child	4.940	0.0263	1.690	0.1933
Place of residence	4.090	0.0433	5.300	0.0213
Floor material	7.540	0.0060	13.520	0.0002
Toilet facility	2.570	0.2768	2.320	0.3133
Source of water	6.030	0.0490	11.390	0.0034
Father's occupation	3.490	0.1743	2.620	0.2656
Mother's occupation	1.100	0.7766	6.920	0.0745
Marital status	5.810	0.0159	4.940	0.0263
Mother's age	1.260	0.5328	8.430	0.0147

4.4.2 Multivariate survival analysis

This section presents findings for the multivariate survival analysis. The findings confirm some of the bivariate results outlined above.

4.4.2.1 Multivariate survival analysis for infants

Table 4.8 shows the results of a multivariate survival regression for covariates of infant mortality using both the 2004 and 2010 DHS. As with the multivariate logistic regression, father's occupation, mothers' occupation, fathers' education and source of drinking water were dropped in the final model. Their presence in the model had no impact. Interaction effects were also considered and were found insignificant using the 2004 data. However, in 2010, the interaction between birth order and the preceding birth interval was found significant and was included in the final model.

Women who tested HIV positive had increased risk of experiencing an infant death compared to those who tested HIV negative in both time periods. This was statistically significant with *p*-values of 0.003 in 2004 and 0.002 in 2010. In 2004, infants born after an interval of 24-35 months, 36-47 months and 60-259 months after the preceding birth experienced lower mortality compared to those born 9-23 months after the preceding birth (hazard ratios of 0.509, 0.466 and 0.372 respectively). In 2010, however, the category 60-

259 was not statistically significant while the mortality in the category 48-59 months was lower (hazard ratio 0.236) relative to that of the reference category (9-23 months) and also to that of the same category in 2004.

Wealth index had a significant influence on infant mortality only in 2010. Infants from poor and middle households experienced double the risk of mortality as infants from poorer households. Mortality of infants whose mothers were married was 0.671 times that of infants whose mothers were not married in 2004. This was significant with a *p*-value of 0.046. Birth order, although significant in the bivariate analysis using both 2004 and 2010 surveys, was not significant in the multivariate analysis. This implies that, after controlling for the effect of other factors, birth order is no longer important in influencing infant mortality.

4.4.2.2 Multivariate survival analysis for children

This section presents the results of multiple survival regression for children aged 1 to 5. Fathers' occupation, mothers' occupation and source of drinking water were dropped from the final model. Among the interaction terms considered, the interaction between preceding birth interval and birth order was found significant in 2004 and that between birth order and mothers' education was found significant in 2010. These were included in the final model. These results are presented in Table 4.9.

HIV status of the mother still had a significant impact on children's mortality in both 2004 and 2010. Children whose mothers tested positive had hazard ratios of dying of 3.108 in 2004 and 3.358 in 2010 relative to those whose mothers tested negative. Significant differentials were also observed among children whose mothers were not tested in 2010 as they were 1.6 times more likely to die compared to those whose mothers tested HIV negative. The impact of birth order was only significant in 2010 with children of orders 2-4 and 5 above experiencing higher mortality than first births with *p*-values of 0.006 and 0.027 respectively.

As with infant mortality, length of the preceding birth interval had an impact on child death in both 2004 and 2010. There is a clear trend of an increase in child survival as the length of the preceding birth interval increases in 2010 as the hazard ratios are 0.475, 0.506, 0.436 and 0.386 for the categories 24-35 months, 36-47 months, 48-59 months and 60-259 months respectively. In 2004, only the mortality experiences of children with an interval of 48-59 months was not statistically different from that of the reference category. In 2004, children whose mothers had at least secondary education had almost 0.8 times lower risk of dying compared to those whose mothers had no education.

Table 4.8 Multivariate survival regression results for infants

	2004 DHS			2010 DHS		
Covariate	**Hazard ratio**	**Standard error**	**P-value**	**Hazard ratio**	**Standard error**	**P-value**
HIV status						
Negative (Ref)	1.000			1.000		
Positive	2.883	1.005	0.003	2.442	0.701	0.002
Not tested	1.182	0.248	0.427	1.519	0.228	0.006
Birth order						
First births (Ref)	1.000			1.000		
2-4	1.037	0.305	0.901	0.677	0.196	0.181
5 and above	1.029	0.351	0.932	1.465	0.394	0.156
Birth interval						
9-23 months (Ref)	1.000			1.000		
24-35 months	0.509	0.125	0.006	0.310	0.100	0.000
36-47 months	0.466	0.123	0.004	0.479	0.158	0.027
48-59 months	0.782	0.285	0.500	0.236	0.121	0.005
60-259 months	0.372	0.136	0.007	0.585	0.206	0.130
First births	Omitted			Omitted		
Mother`s education						
No education (Ref)	1.000			1.000		
Primary	1.023	0.211	0.910	1.243	0.252	0.283
Secondary+	0.528	0.190	0.078	1.102	0.358	0.764
Wealth index						
Poorer (Ref)	1.000			1.000		
Poor	1.198	0.278	0.438	2.063	0.401	0.000
Middle	1.099	0.261	0.691	1.616	0.331	0.019
Rich	1.096	0.319	0.751	1.338	0.309	0.208
Richer	1.088	0.526	0.860	1.740	0.621	0.212
Sex of the child						
Female (Ref)	1.000			1.000		
Male	1.123	0.148	0.377	1.361	0.183	0.022
Type of residence						
Rural (Ref)	1.000			1.000		
Urban	0.617	0.217	0.172	1.123	0.391	0.738
Floor material						
Unfinished (Ref)	1.000			1.000		
Finished	1.152	0.411	0.691	1.086	0.271	0.738
Toilet facility						
No toilet (Ref)	1.000			1.000		
Traditional	1.230	0.256	0.320	0.731	0.140	0.103
Improved toilet	1.226	0.735	0.685	0.690	0.252	0.311
Marital status						
Not married (Ref)	1.000					
Married	0.671	0.133	0.046	0.799	0.147	0.227
Mother`s age						
Less 20 years (Ref)	1.000			1.000		
20-34 years	1.026	0.242	0.910	0.775	0.152	0.197
35+	1.084	0.412	0.831	1.296	0.347	0.332

The impact of mother's education was not significant in 2010.

The hazard ratio for male mortality relative to females in 2004 was 1.4. The hazard ratios were, however, not significant in 2010. For children mortality, marital status of the mothers was significant for both 2004 and 2010. Children whose mothers were married had lower risks of death with hazard ratios of 0.611 in 2004 and 0.668 in 2010 relative to children whose mothers were not married. Another important covariate in 2010 was the mothers' age. Children born to mothers who were aged above 35 at the time of their birth experience double the mortality of children who were born when their mothers were less than 20 years old.

Table 4.9 Multivariate survival regression results for children aged 1 to 5

	2004 DHS			2010 DHS		
Covariate	**Hazard ratio**	**Std error**	**P-value**	**Hazard ratio**	**Std error**	**P-value**
HIV status						
Negative (Ref)	1.000			1.000		
Positive	3.108	0.915	0.000	3.358	0.890	0.000
Not tested	1.316	0.251	0.151	1.613	0.245	0.002
Birth order						
First births (Ref)	1.000			1.000		
2-4	1.149	0.495	0.747	5.833	3.760	0.006
5 and above	1.522	0.653	0.328	4.179	2.705	0.027
Birth interval						
9-23 months (Ref)	1.000			1.000		
24-35 months	0.655	0.130	0.034	0.475	0.084	0.000
36-47 months	0.422	0.113	0.001	0.506	0.091	0.000
48-59 months	0.603	0.172	0.077	0.436	0.116	0.002
60-259 months	0.475	0.145	0.016	0.386	0.098	0.000
First births	Omitted			Omitted		
Mother's education						
No education (Ref)	1.000			1.000		
Primary	0.859	0.321	0.685	3.111	1.907	0.064
Secondary+	0.222	0.148	0.025	1.884	1.397	0.393
Father's education						
No education (Ref)	1.000			1.000		
Primary	1.098	0.237	0.664	0.911	0.154	0.587
Secondary+	0.965	0.256	0.895	0.782	0.160	0.232
Wealth index						
Poorer (Ref)	1.000			1.000		
Poor	1.012	0.204	0.951	1.230	0.198	0.199
Middle	1.124	0.231	0.568	1.027	0.196	0.886
Rich	0.801	0.200	0.378	1.214	0.233	0.313
Richer	0.670	0.306	0.383	0.801	0.240	0.460
Sex of the child						
Female (Ref)	1.000			1.000		
Male	1.402	0.227	0.037	1.192	0.128	0.104
Type of residence						
Rural (Ref)	1.000			1.000		
Urban	1.093	0.342	0.775	0.823	0.265	0.547
Floor material						
Unfinished (Ref)	1.000			1.000		
Finished	1.137	0.418	0.726	0.729	0.154	0.136
Toilet facility						
No toilet (Ref)	1.000					
Traditional	0.959	0.171	0.816	0.959	0.179	0.826
Improved toilet	1.215	0.652	0.716	1.649	0.585	0.159
Marital status						
Not married (Ref)	1.000			1.000		
Married	0.611	0.117	0.011	0.668	0.114	0.019
Mother's age						
Less 20 years (Ref)	1.000			1.000		
20-34 years	1.134	0.221	0.517	1.362	0.288	0.144
35+	1.251	0.386	0.468	2.045	0.554	0.008

4.5 Discussion

This section gives a discussion of the results presented in the previous sections. Results for both logistic regression and survival analysis indicate that bio-demographic factors were significantly associated with infant mortality. For children aged 1 to 5, both bio-demographic and socio-economic factors were associated with their mortality. This is in line with assertions by Majumnder, May and Pant that in traditional societies, both demographic and socio-economic factors have a strong impact on child mortality. They, however, point out that this influence diminishes with increase in development.

The Section is organised as follows: first is a discussion of bio-demographic factors in Section 4.5.1 followed by socio-economic factors in Section 4.5.2. Section 4.5.3 gives discussion on environmental factors.

4.5.1 Bio-demographic factors

The results for both logistic regression and survival analysis show that HIV status of the mothers was significantly associated with infant mortality in both time periods. HIV status of the mother is associated with childhood mortality mainly through vertical transmission of the virus from the mother to the child. Infants of mothers who tested HIV positive had increased risk of death compared to those whose mothers tested HIV negative. Similar results have also been found for children aged 1 to 5. These results are expected in Malawi where HIV prevalence is high. Even infants and children of mothers who were not tested experienced high mortality compared to those whose mothers tested negative using the 2010 DHS data. This is expected as among those not tested were those who were HIV positive and their children had a higher risk of death.

The odds ratios for the two time periods show a decline in the risk of death during the inter-survey period among infants whose mothers tested HIV positive. The odds ratios declined from 5.497 in 2004 to 4.404 in 2010. The decline in risk has also been observed in the results of survival analysis (hazard ratios). This may be explained by the effect of Prevention of Mother to Child Transmission (PMTCT) programmes and expansion of paediatric HIV treatment which increased the survival of the child. National PMTCT programme in Malawi was launched in June 2003, just a year before the 2004 MDHS and only a few pregnant women had access to these services then (Malawi 2012). Access to PMTCT services has, however, increased in the recent past thereby improving the survival of infants born to HIV positive mothers. On the contrary, risks of death for children aged 1 to 5 increased during the period between the two surveys.

HIV status of the mother was not significant for child mortality using the 2004 data in logistic regression. This may be explained by sampling problems identified in 2004 HIV data (Souza 2012). This may also be due to low access to PMTCT services prior to 2004, which led to increased risks of death during infancy among those born to HIV positive mothers. This result in a few surviving to age one, therefore there were less deaths between the age of 1 and 5 among those whose mothers were HIV positive.

The length of the preceding birth interval was significantly associated with both infant and child mortality. Infant and children born less than 24 months after the preceding birth were at a greater risk of death compared to those born at least 24 months after the preceding birth. The risks of death decrease with increase in the length of the preceding birth interval. This is consistent with other studies (Das Gupta 2010; Kayode, Adekanmbi and Uthman 2012; Kembo and van Ginneken 2009; Rutstein 2000). Short preceding birth interval is clearly a risk factor for both the child and mother. Mothers who wait for at least 24 months have enough time to regain the nutrients and blood loss during the previous child birth and breast feeding. This reduces the risks of obstetric complications and also enhances the full development of foetus in the next pregnancy thereby reducing the risks of death early in life.

The results of logistic regression are consistent with those of survival analysis. In 2004, the same categories of preceding birth interval significant in the logistic regression were also significant in the survival analysis for infants. For children aged 1 to 5, mortality in all other categories was significantly different from that in the reference category except category 48-59 for survival analysis using 2004 survey data. The insignificance of some of the categories for both infant mortality and child mortality may be due to the small number of observations. The risk of death for infants of interval between 24 and 35 months decreased during the period between the two surveys, implying an improvement in survival for infants born in this category.

Age of the mother at childbirth is associated with child mortality but not infant mortality in both time periods. Children born to mothers aged less than 20 years at the time of their birth had an increased risk of death relative to those born when their mothers were aged above 20. This indicates the disadvantages of teenage childbearing, which in most cases is associated with low socioeconomic status of the population which is also associated with increase in child deaths. The results of survival analysis using the 2010 MDHS, however, show an increase in the risk of death among children born to mothers aged 35 and above at the time of their birth. This may imply an increase in the risk of death for children born to older mothers since survival analysis uses most recent data compared to logistic regression. The results for survival analysis using 2004 data indicate no significant association between mothers' age at birth of child and mortality.

The results also show high mortality among males rather than females, and more significant for child mortality than infant mortality. This is consistent with other studies (Baker 1999; Bolstad and Manda 2001; Kabir, Islam, Ahmed *et al.* 2001; Mokoena 2011; Mutunga 2007). The odds ratios for 2004 and 2010 survey data indicate no change in the risk, 1.194 and 1.207 respectively. This confirms the fact that differentials in mortality between males and females are endogenous (biological), therefore less likely to be improved through an intervention.

Birth order was significantly associated with child mortality using the 2004 survey data in the logistic regression. Children of order 2 to 4 experience 0.6 times increase in mortality and those of order 5 and above experience 0.8 times increase in mortality compared to first births. These results are consistent with those in survival analysis using 2010 survey data as first births were more likely to survive compared to the other birth orders. A study in Nigeria also found an increase in mortality among under-five children of order 2 to 4 compared to first births (Kayode, Adekanmbi and Uthman 2012). This is, however, contrary to another study, which found a reduction in mortality among children or birth order 2 to 4 compared to first births (Mekonnen 2011). The influence, however, disappears in the results for 2010 survey logistic regression model. In the survival analysis, birth order was significant only using the 2010 MDHS.

4.5.2 Socio-economic factors

Education of the mother was significantly associated with both infant and child mortality. This factor, as expected, is more strongly associated with child mortality than infant mortality. For infants, only those whose mothers had at least secondary education experienced significantly lower mortality compared to infants whose mothers had no education using the 2004 survey in the logistic regression. For children aged 1 to 5, even those whose mothers had primary education, had lower risks of death compared to those whose mothers had no education. This is in agreement with what Basu and Stephenson (2005) suggested that even a little schooling may have an impact on child survival. In survival analysis, however, mothers' education was significantly associated with child mortality and only using the 2004 data. Children whose mothers had at least secondary education experienced lower mortality compared to those whose mothers had no education.

Maternal education is often viewed as an indication of level of skills and knowledge of effective use of the available child care resources, which include health services. It also leads to improvement in economic status of the household, which is associated with increases in child survival, as educated women (at least secondary) are more likely to be employed. These results are, however, contrary to other studies, which found no significant association between mother's education and childhood mortality (Mokoena 2011).

For father's education, only children whose fathers had secondary and higher education had higher chances of survival compared to those whose fathers had no education and only using the 2010 DHS data. These fathers are more likely to secure a good job thereby able to provide basic necessities for their children which include paying for good health services. This favours assertions that father's education is associated with child mortality only through the economic advantage of educated fathers rather than skills and knowledge gained (Hobcraft, McDonald and Rutstein 1984). Other studies in Ethiopia and Bangladesh also found a significant association between father's education and childhood mortality (Kiros and Hogan 2001; Majumder, May and Pant 1997).

The significance of marital status of the mother with both infant and child mortality is expected in Malawi where the father is mostly considered the breadwinner of the family. Children of mothers who reported being married at the time of the survey experienced low mortality compared to those whose mothers were not married. This supports the findings of other studies (Defo 1996; Mekonnen 2011). This is due to the support that the father, as head of the family, offers in taking care of the children.

Using 2010 DHS in survival analysis, infants from poor and middle income households were more likely to die compared to those from poorer households (OR=2.063 and 1.616 respectively). These results are, however, contrary to that observed in other settings where children from households with the lowest economic status experienced increased mortality (Blakely, Atkinson, Kiro *et al.* 2003; Mahfouz, Surur, Ajak *et al.* 2009).

4.5.3 Environmental factors

Mosley and Chen (1984) identified environmental contamination as one of the proximate determinants of morbidity and mortality among children. This study investigated the impact of three environmental factors on infant and child mortality. These are: type of toilet facility, source of drinking water, and type of floor material. However, none of these had significant impact on infant and child mortality. This is contrary to other studies, which found that environmental factors were significantly associated especially with child mortality (Folasade 2000; Kembo and van Ginneken 2009; Mesike and Mojekwu 2012). However, other studies found no significant relationship between environmental factors and childhood mortality after controlling for the effects of other factors (Mekonnen 2011; Rutstein 2000). In Malawi, Manda (1999) also found no significant association between environmental factors and childhood mortality although the odds were in the expected direction. The insignificance of environmental factors in this study may be due to the fact that these may not really reveal the sanitation and hygienic conditions of the households. For example, the presence of a toilet facility does not necessarily mean that it will be used correctly and by all household members (Baker 1999). The same applies to source of drinking water. The source of water does not really reflect the quality of water at the time it is used as contamination may occur depending on how the water is handled from source. This may be important in the Malawian setting where most people walk long distances to draw water and the water may be stored for some days before being used (NSO and ORC Macro 2011).

5 CONCLUSION

This study sought to identify factors associated with infant and child mortality in Malawi. It used the 2004 and 2010 MDHS and applied logistic regression and survival analysis. The results support the hypothesis that demographic factors are strongly associated with infant mortality while demographic and socioeconomic factors are significant in influencing child mortality. HIV status of the mother and length of preceding birth interval have been found to be significantly associated with infant mortality using data from both time periods. Other significant factors include mothers' education, wealth index and sex of the child, which were only significant using the 2010 data. Using the 2004 data set, the only socio-economic factor significantly associated with infant mortality was marital status of the mother as those whose mothers were married were less likely to die compared to those whose mothers were not married at the time of the survey.

As with infant mortality, HIV status of the mother and length of the preceding birth interval were also significantly associated with child mortality in both time periods. Children born to HIV positive mothers were more likely to die compared to those born to HIV negative mothers, so are the children born less than 24 months after the preceding birth. Other significant factors include birth order, mothers' education, fathers' education, sex of the child and mothers age at time of birth of the child. None of the environmental factors have been found to the significantly associated with both infant and child mortality.

Although Malawi has managed to achieve a significant reduction in infant and child mortality rates, the rates remain high compared to most African countries. More effort is still required to reduce these mortality rates. This study has provided insights into the risk factors of infant and child mortality in Malawi, which contains vital information for health policy makers in government and non-governmental organisations. According to the findings of this study, child spacing will help reduce both infant and child deaths. There is therefore a need to sensitise people on the importance of child spacing and implement health programmes that will encourage use of contraception for child spacing. There is also a need to scale up Prevention of Mother to Child Transmission (PMTCT) services and early HIV diagnosis and treatment in order to reduce infant and child deaths among children born to HIV positive mothers.

Our results suggest that mothers' education should be made more easily accessible to women. This will help women to be independent and able to make good decisions regarding child health. Education (at least secondary) and creation of job opportunities will also help women to get employment thereby improving their economic status. This means that they will be able to provide necessities to the child including paying for good health care even without the help of their husbands. This may help reduce the child mortality differentials by marital status observed in this study. Keeping girls in school will also help reduce early marriages thereby avoiding teenage child bearing, which has been found to be significantly associated with increased risks of child deaths.

This study has been conducted using nationally representative data with a large sample size, and the results can be generalised to the whole study population. The proportion of missing data was also very small. However, the study faced a number of limitations ranging from those in the data and even the methodology adopted which may have affected the results to some extent. First, the assessment of age accuracy in Chapter 3 indicates age heaping especially at ages 1, 2 and 3 years. This may lead to an underestimation of deaths, especially for infants and may produce compromised results. The number of women who were tested for HIV was less, especially in the 2004 data. This led to few observations when they are categorised further to those found HIV positive and HIV negative. This may lead to less statistical power thereby producing false results.

This study also did not include some of the child care variables like breastfeeding, immunisation, antenatal attendance, place and assistance at birth of the child and type of birth. These factors have been found to be significantly associated with childhood mortality in different settings. (Abimbola, Adepoju, Akanni *et al.* 2012; Buwembo 2010; Mekonnen 2011; Mustafa and Odimegwu 2008). They were, however, not included because in Demographic and Health Surveys, this information is only collected for children born less than 5 years before the survey. This study used information for children born as far as 10 years before the survey. This was done to take into account full exposure in the logistic regression, as discussed in Chapter 3. Future research may include these factors in the analysis of infant and child mortality to determine their impact in the Malawian setting.

This study has been conducted at an individual level. Childhood mortality may be affected by factors at individual, familial and even community levels (Mosley and Chen 1984). It is therefore important to take into account the hierarchical nature of information as analysis only at individual level could produce biased results if the familial and community effects are significant in determining childhood deaths. Manda (1998) applied a multilevel logistic regression to the 1992 MDHS data to investigate familial and community effects on infant mortality in Malawi and found that the familial effect was significant. Future research may conduct the multilevel investigation using the recent data and also including the impact of other factors e.g. HIV status of the mothers and child.

The changes in the covariates between the two time period has been investigated simply by comparing odds ratios (hazard ratios for survival analysis) for the 2004 and 2010 surveys based on the same model. This involves looking at whether the covariates were significant in both time periods or not and whether there are changes in the ratios which imply changes in the risk for infant and child death for those covariates. This comparison may be misleading especially when the two regressions are not based on the same model. More appropriate methods might produce different results but this is outside the scope of this thesis.

It is also important to note that the HIV status of the mother was the status at time of survey not at birth or death (for those who died) of the child. This study, therefore, looked at the associations of HIV status of the mother and child mortality regardless of whether the child was infected or not.

DHS data used are cross-sectional in nature making it hard to measure causal effects. Future research may want to use longitudinal data to note the changes in the factors considered and their impact on childhood mortality to substantiate the results from cross-sectional data.

In conclusion, this study has revealed that HIV status of the mother and length of the preceding birth interval are associated with increased risks for both infant and child mortality after controlling for the effects of other factors. Other significant factors include age of the mother at birth of the child, sex of the child, birth order, mothers' education, fathers' education and marital status of the mother. These factors need to be considered when planning and developing policies against infant and child mortality in order to successfully work towards achieving the Millennium Development Goal of reducing childhood deaths.

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APPENDIX

KAPLAN-MEIER SURVIVAL CURVES FOR INFANTS

Figure 1. Kaplan-Meier survival curves for infants by birth interval using 2004 survey data

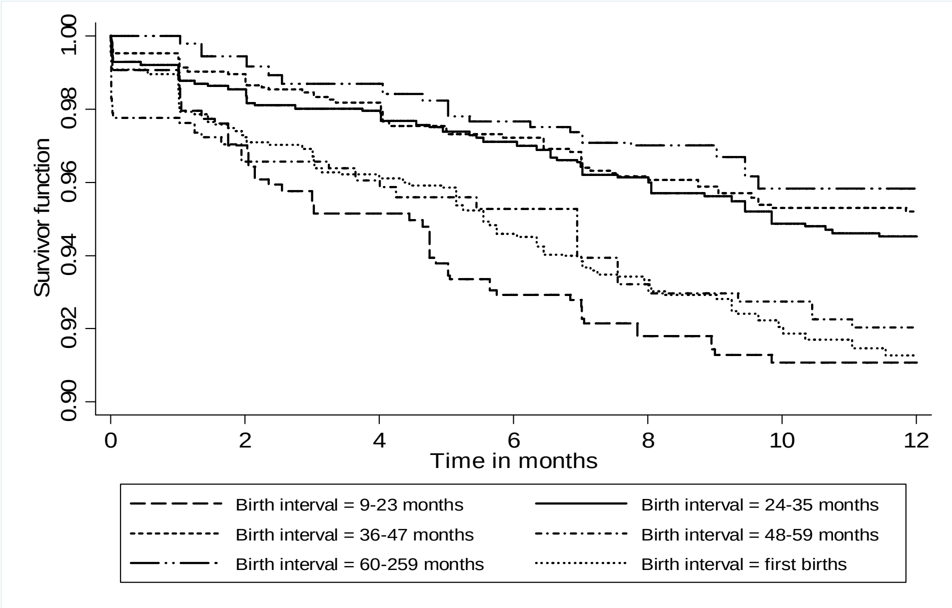


Figure 2. Kaplan-Meier survival curves for infants by birth interval using 2010 survey data

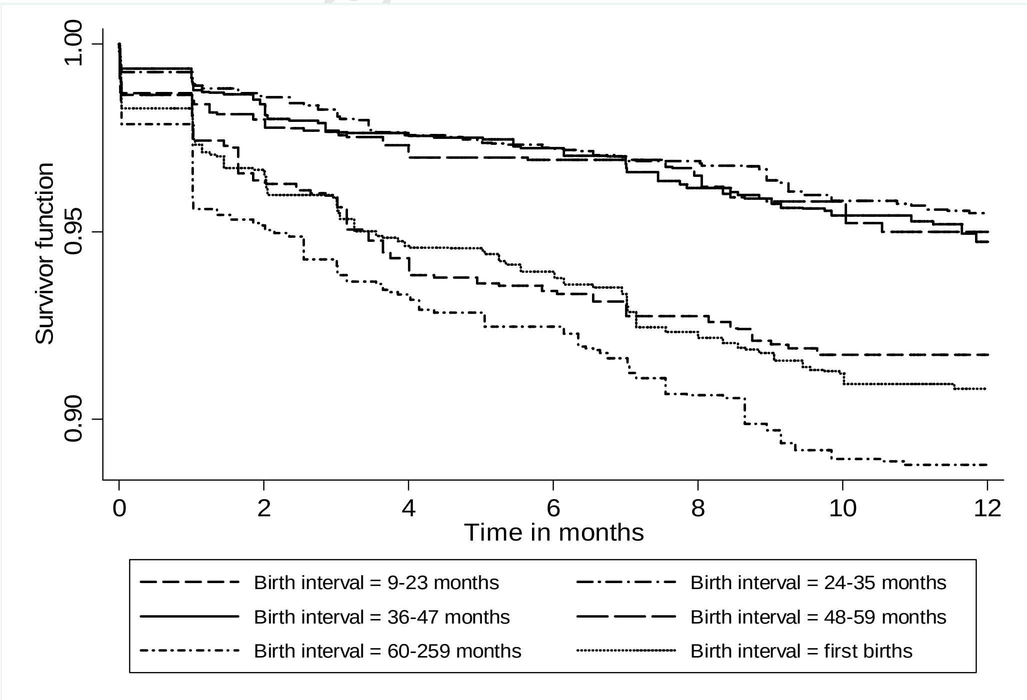


Figure 3. Kaplan-Meier survival curves for infants by mothers' education using 2004 survey data

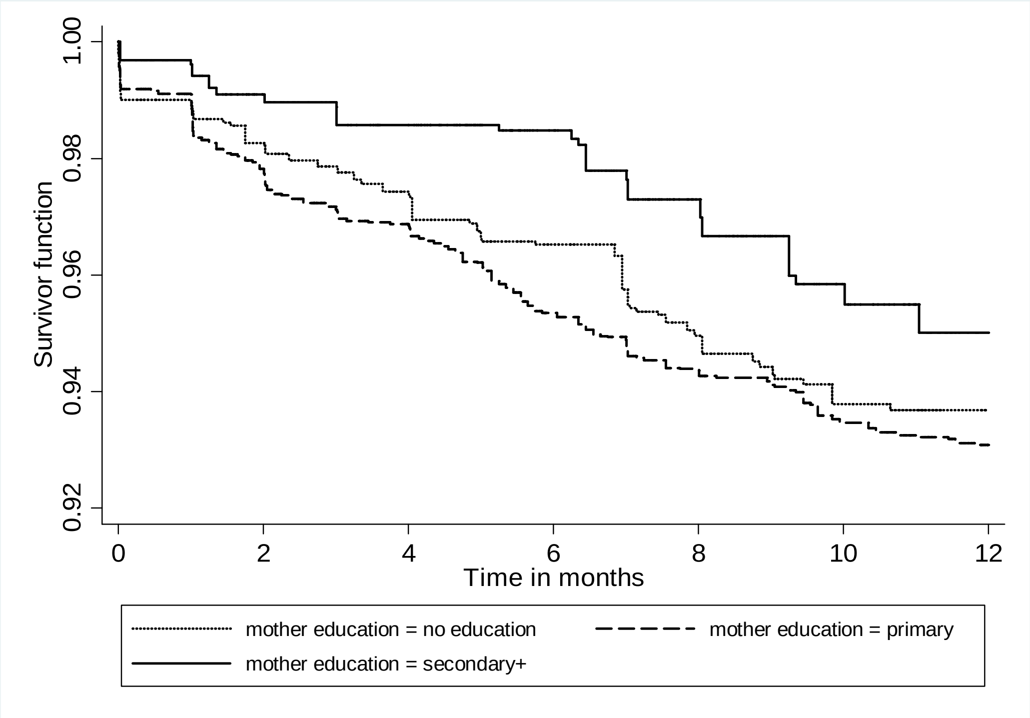


Figure 4. Kaplan-Meier survival curves for infants by mothers' education using 2010 survey data

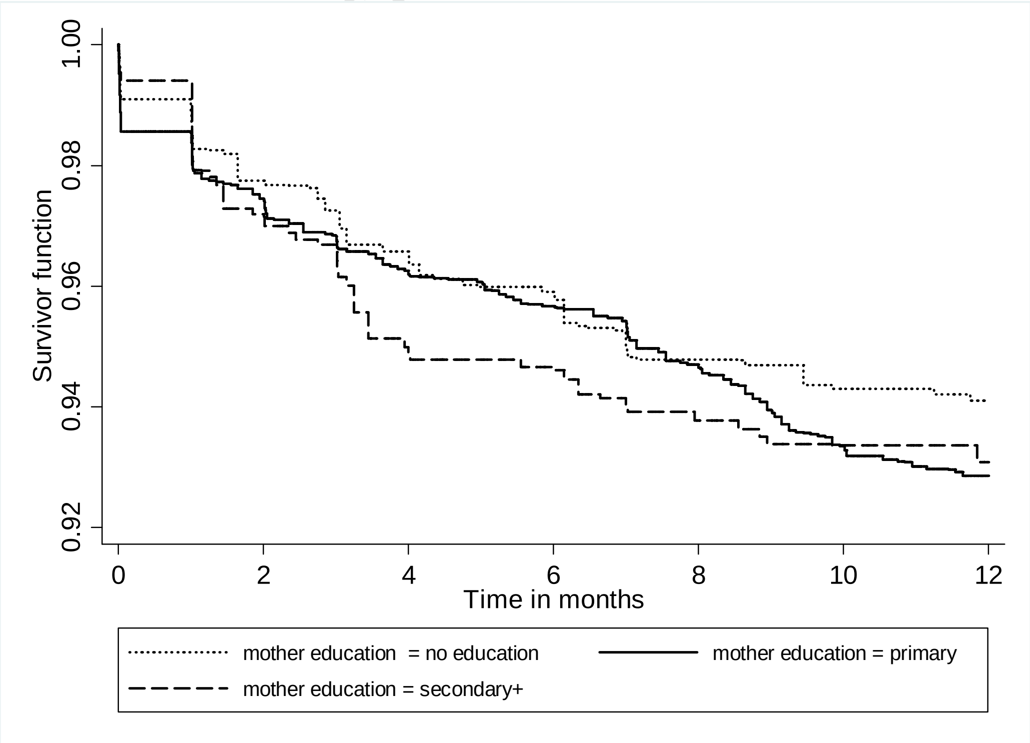


Figure 5. Kaplan-Meier survival curves for infants by fathers' education using 2004 survey data

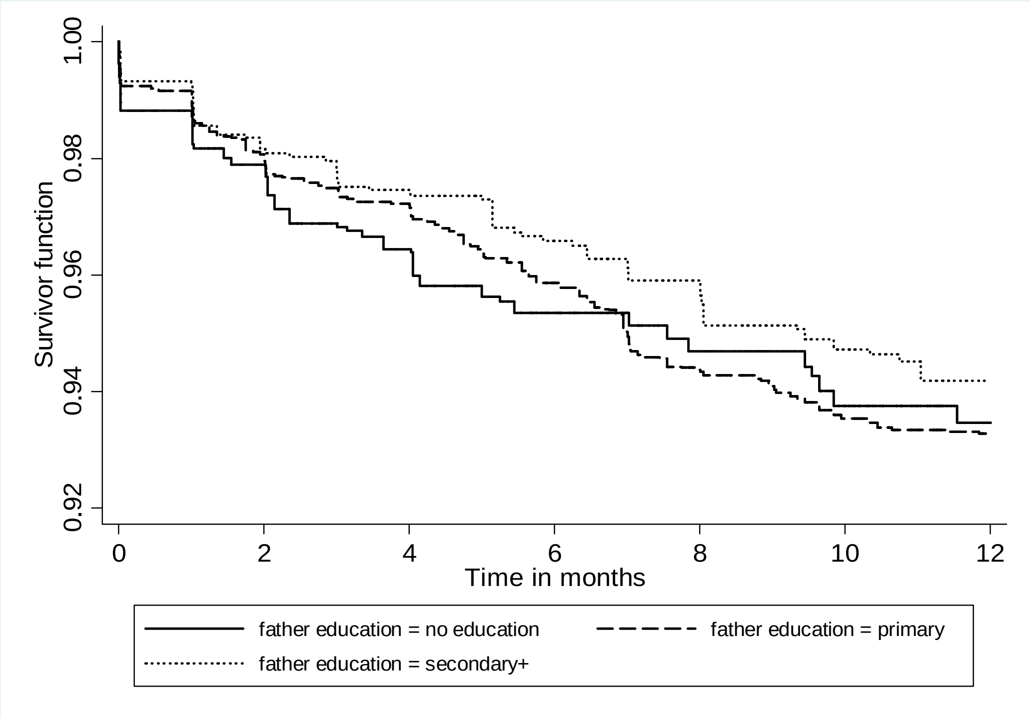


Figure 6. Kaplan-Meier survival curves for infants by fathers' education using 2010 survey data

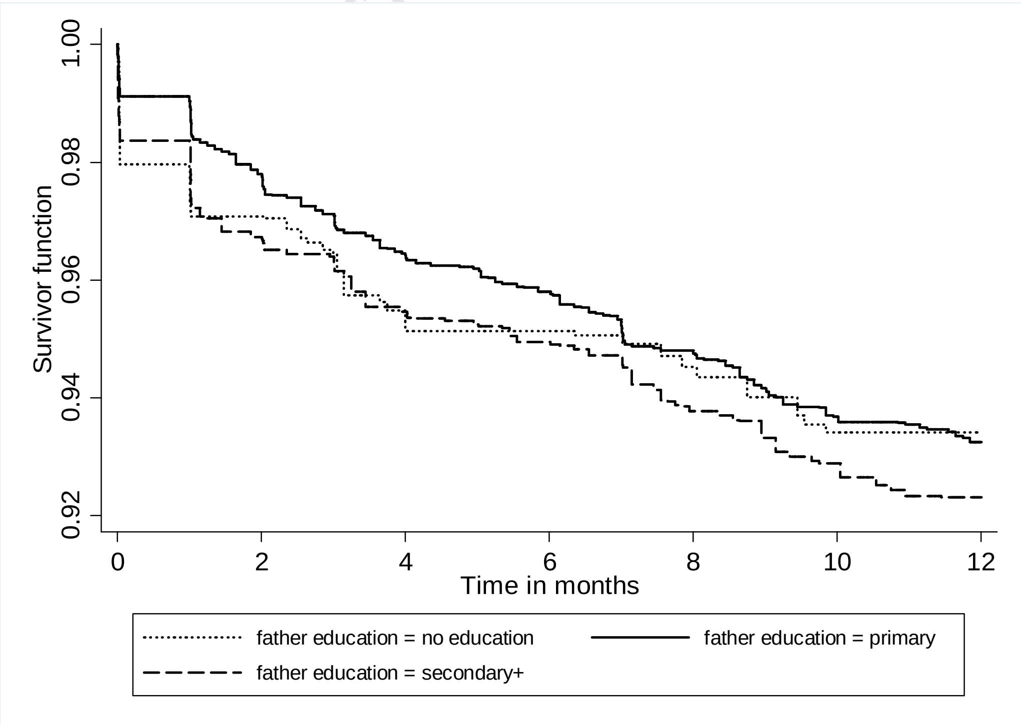


Figure 7. Kaplan-Meier survival curves for infants by wealth index using 2004 survey data

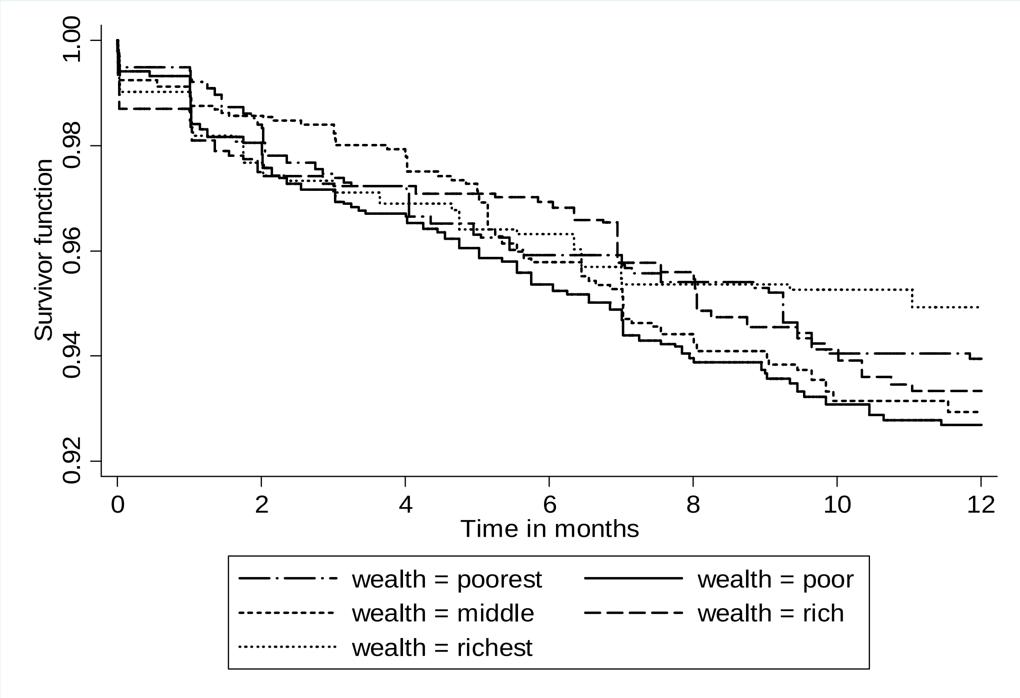


Figure 8. Kaplan-Meier survival curves for infants by wealth index using 2010 survey data

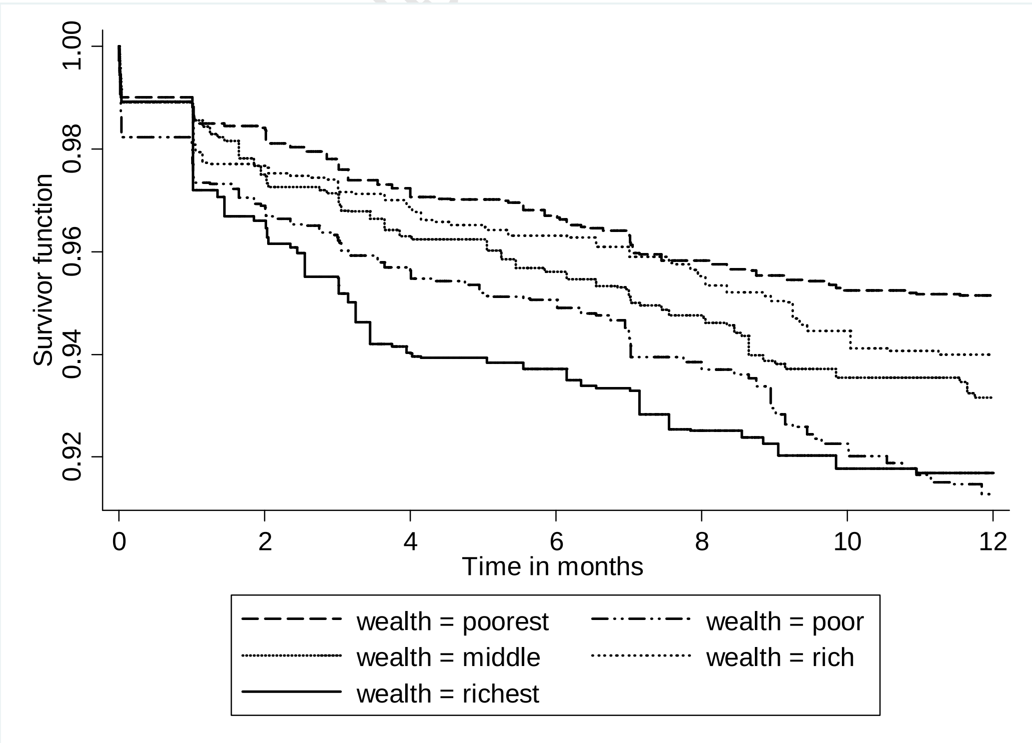


Figure 9. Kaplan-Meier survival curves for infants by sex using 2004 survey data

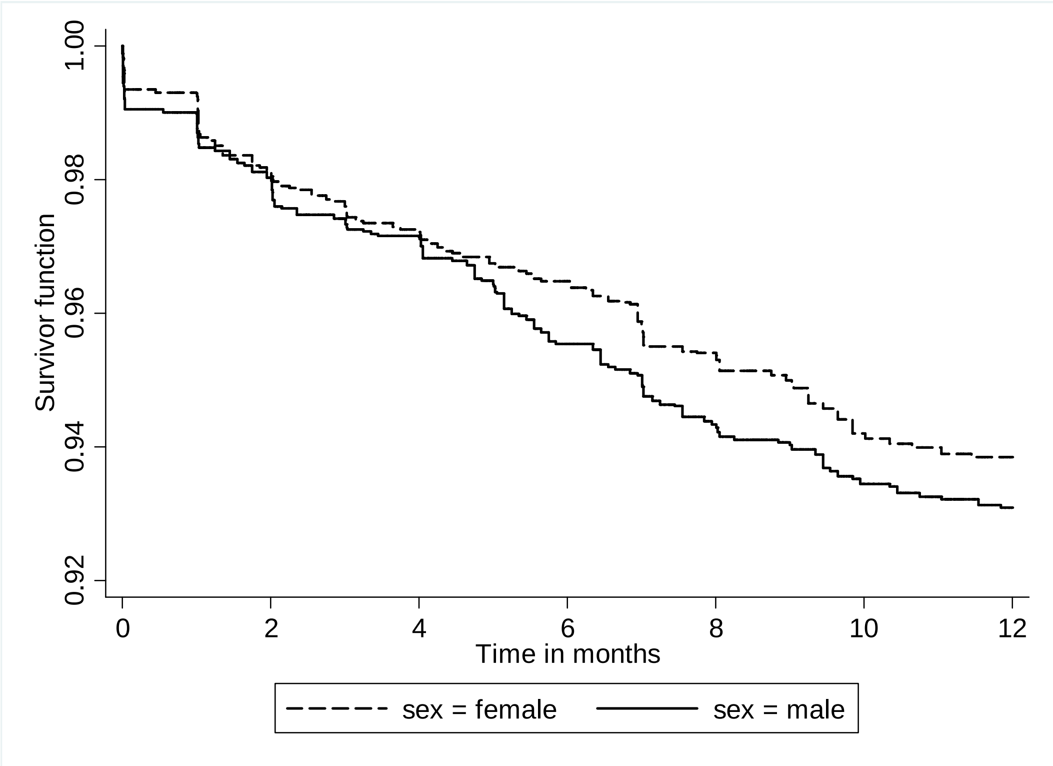


Figure 10. Kaplan-Meier survival curves for infants by sex using 2010 survey data

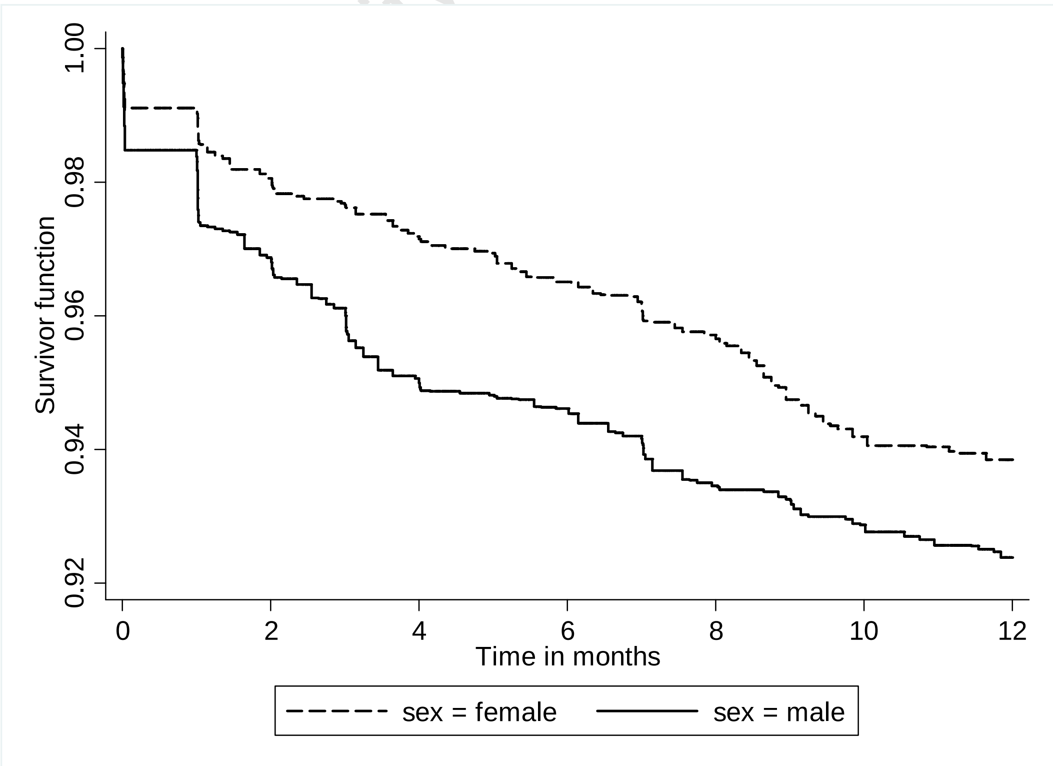


Figure 11. Kaplan-Meier survival curves for infants by residence using 2004 survey data

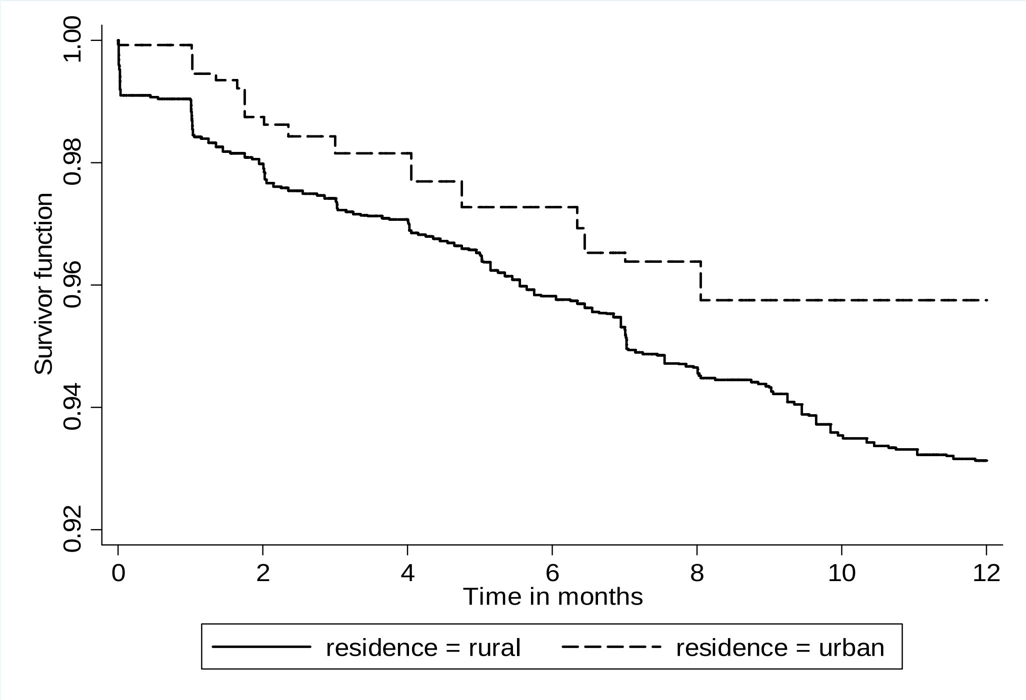


Figure 12. Kaplan-Meier survival curves for infants by residence using 2010 survey data

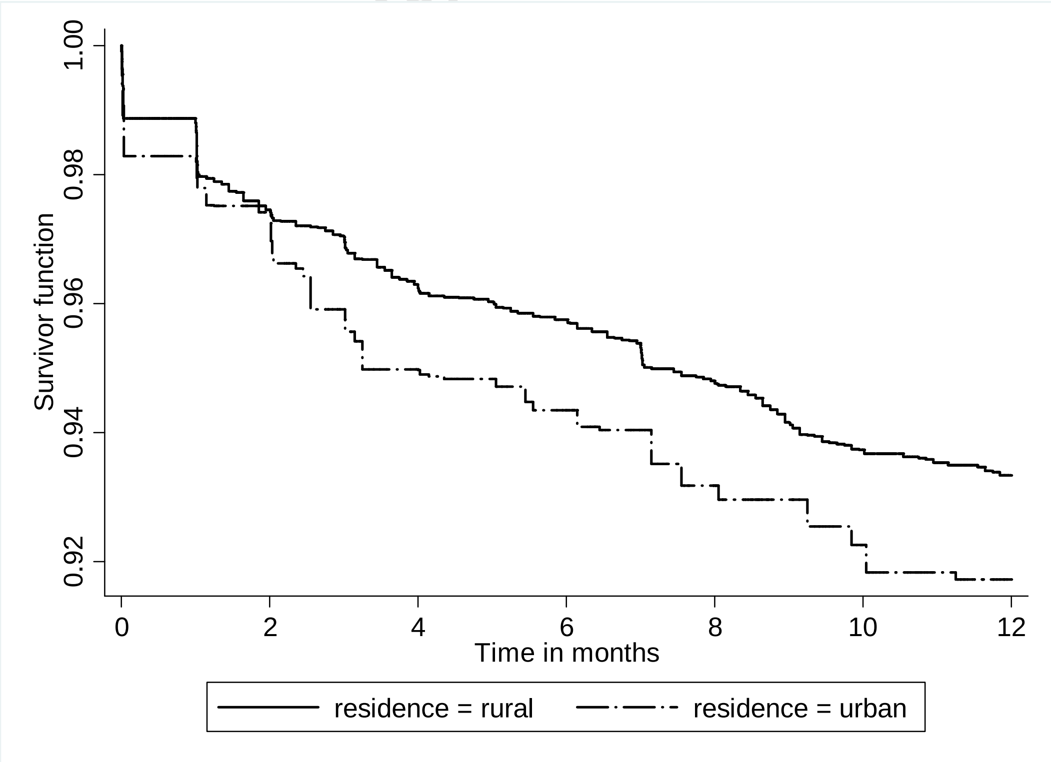


Figure 13. Kaplan-Meier survival curves for infants by floor material using 2004 survey data

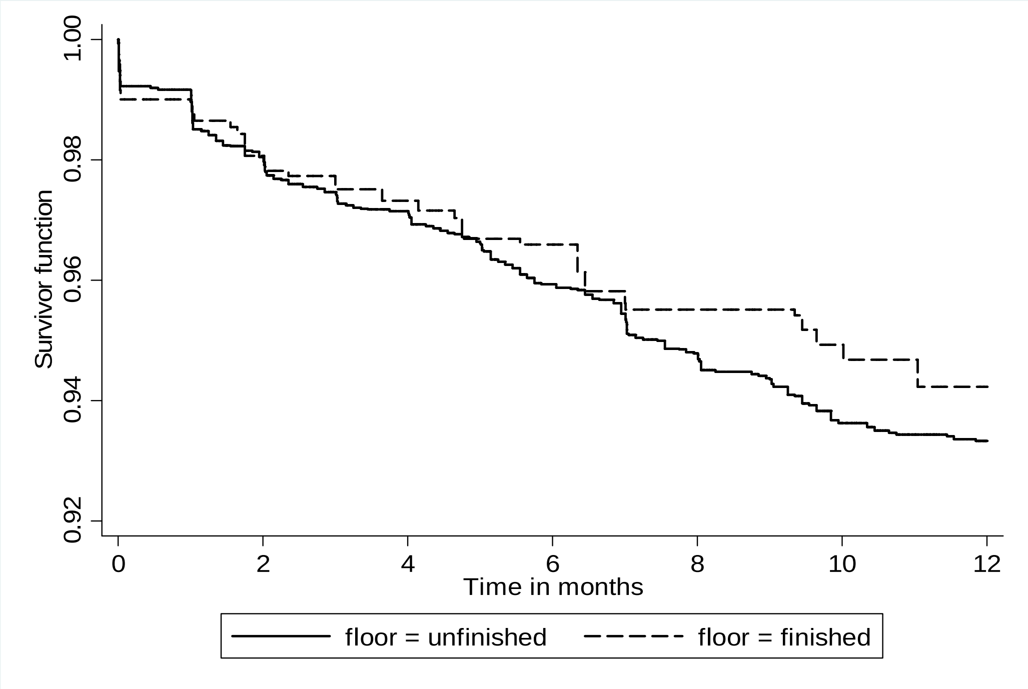


Figure 14. Kaplan-Meier survival curves for infants by floor material using 2010 survey data

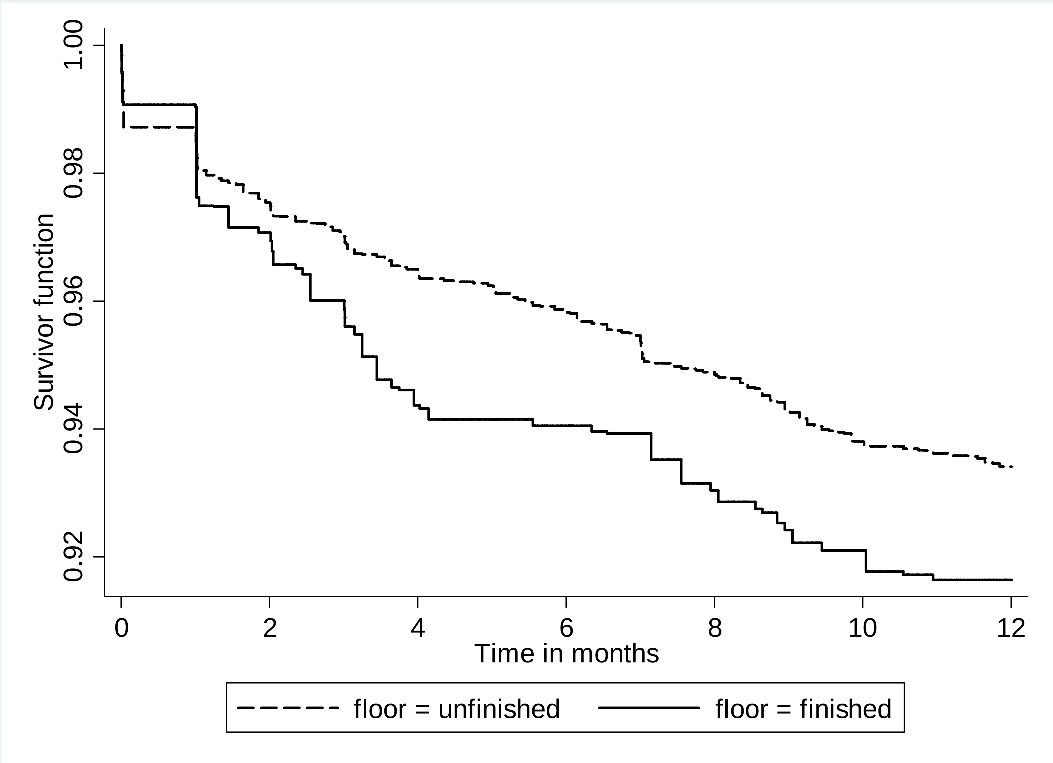


Figure 15. Kaplan-Meier survival curves for infants by type of toilet using 2004 survey data

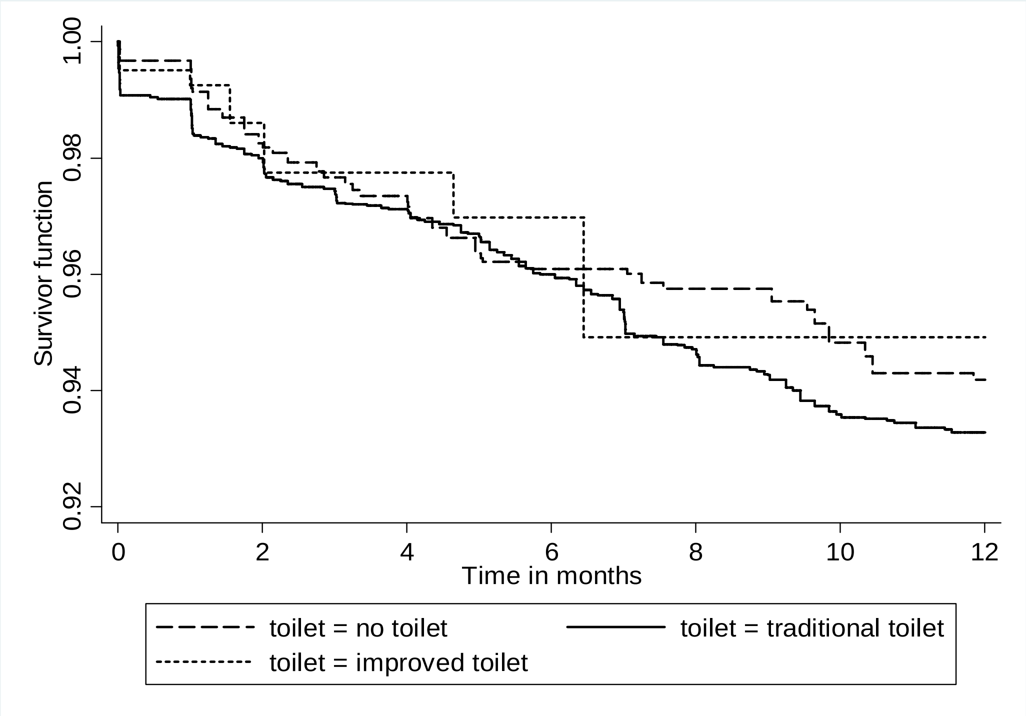


Figure 16. Kaplan-Meier survival curves for infants by type of toilet using 2010 survey data

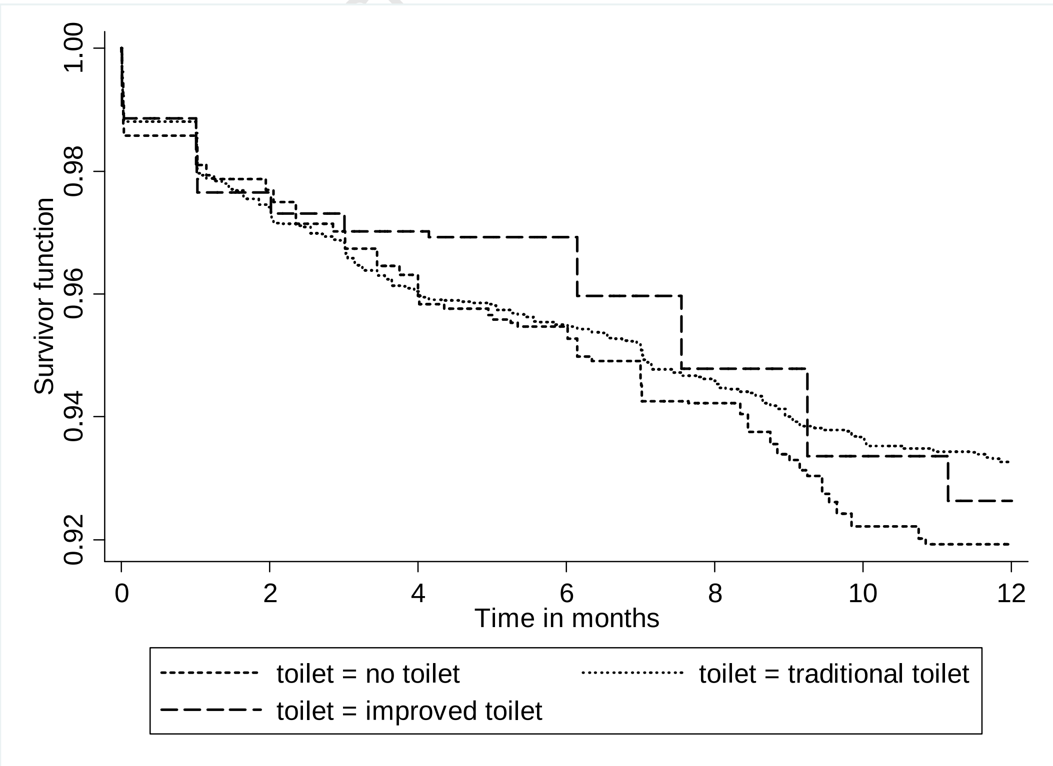


Figure 17. Kaplan-Meier survival curves for infants by source of water using 2004 survey data

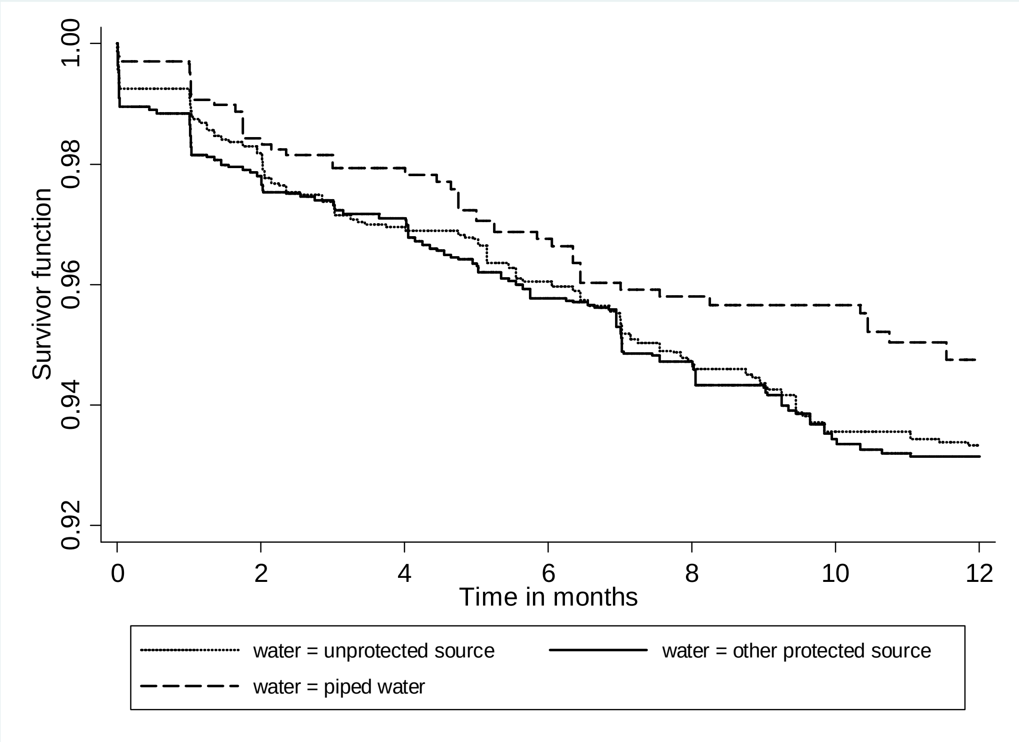


Figure 18. Kaplan-Meier survival curves for infants by source of water using 2010 survey data

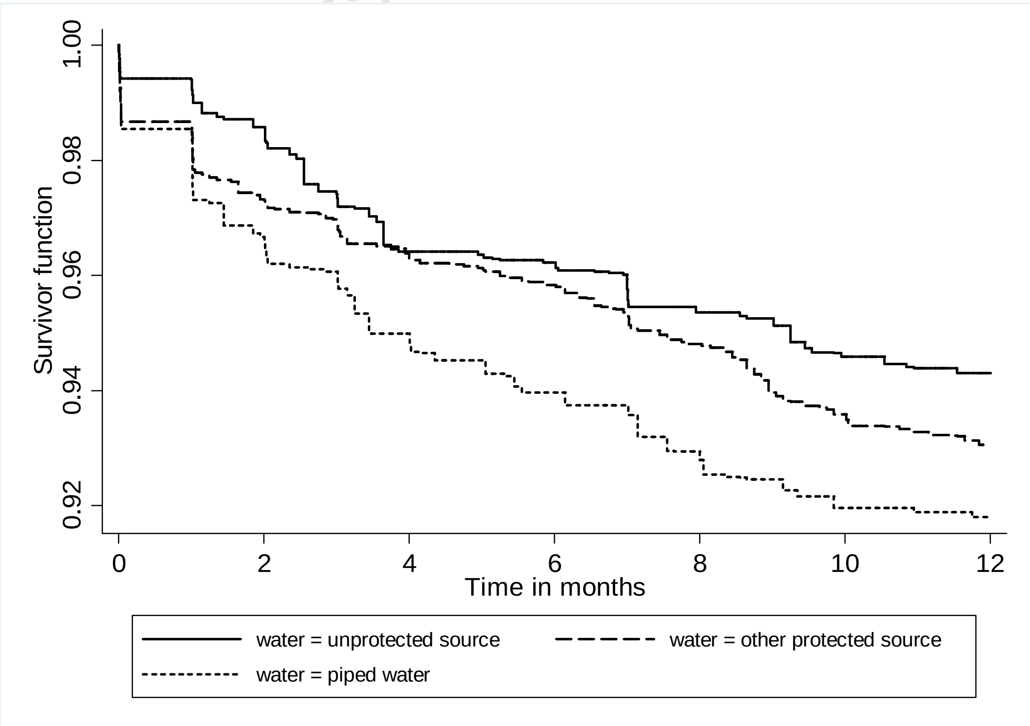


Figure 19. Kaplan-Meier survival curves for infants by fathers' occupation using 2004 survey data

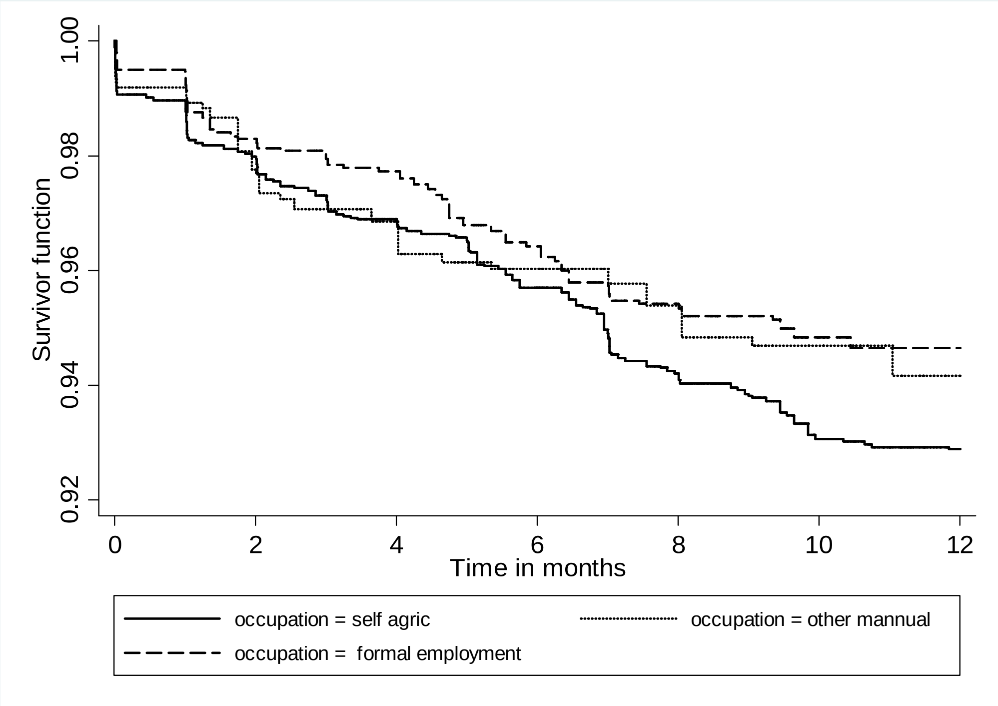


Figure 20. Kaplan-Meier survival curves for infants by fathers' occupation using 2010 survey data

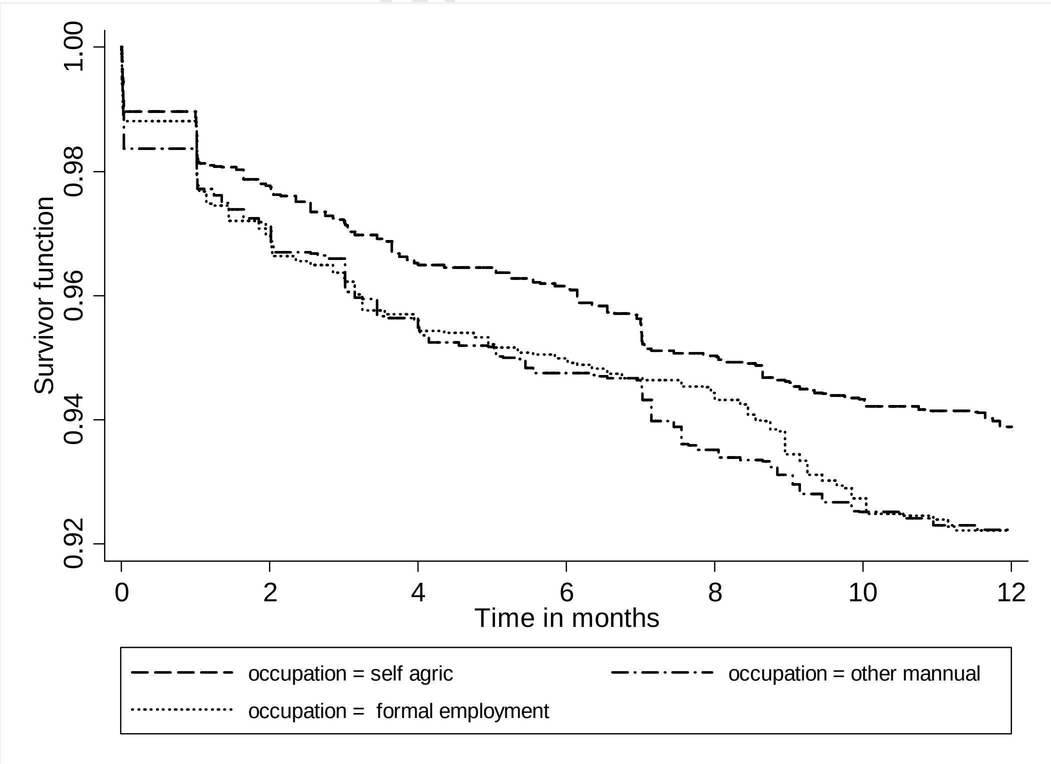


Figure 21. Kaplan-Meier survival curves for infants by mothers' occupation using 2004 survey data

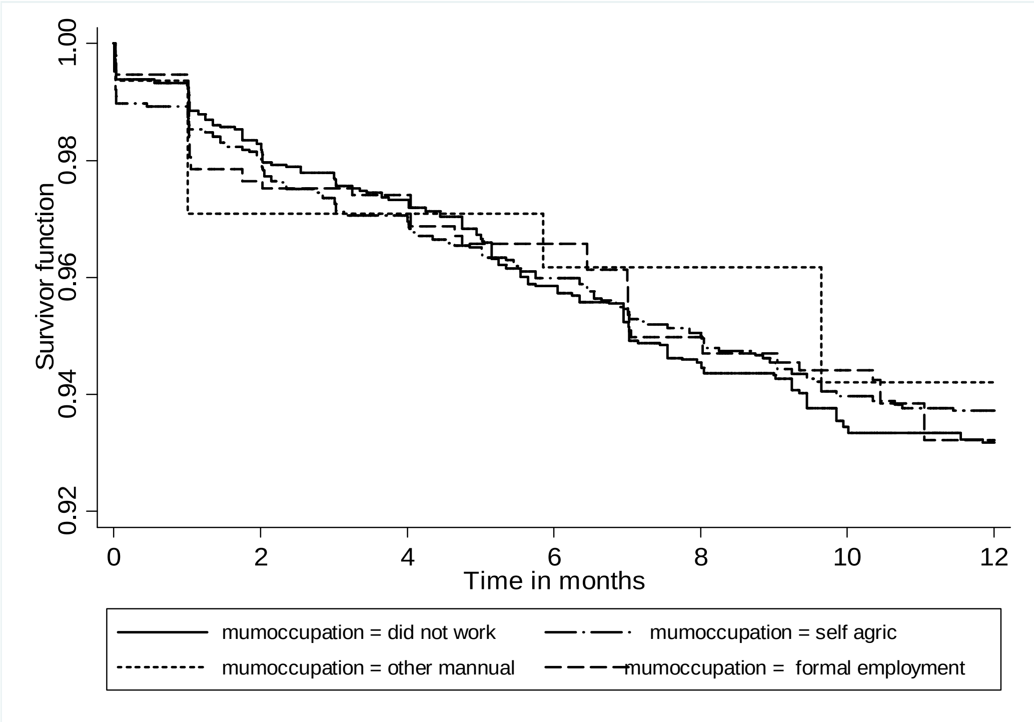


Figure 22. Kaplan-Meier survival curves for infants by mothers' occupation using 2010 survey data

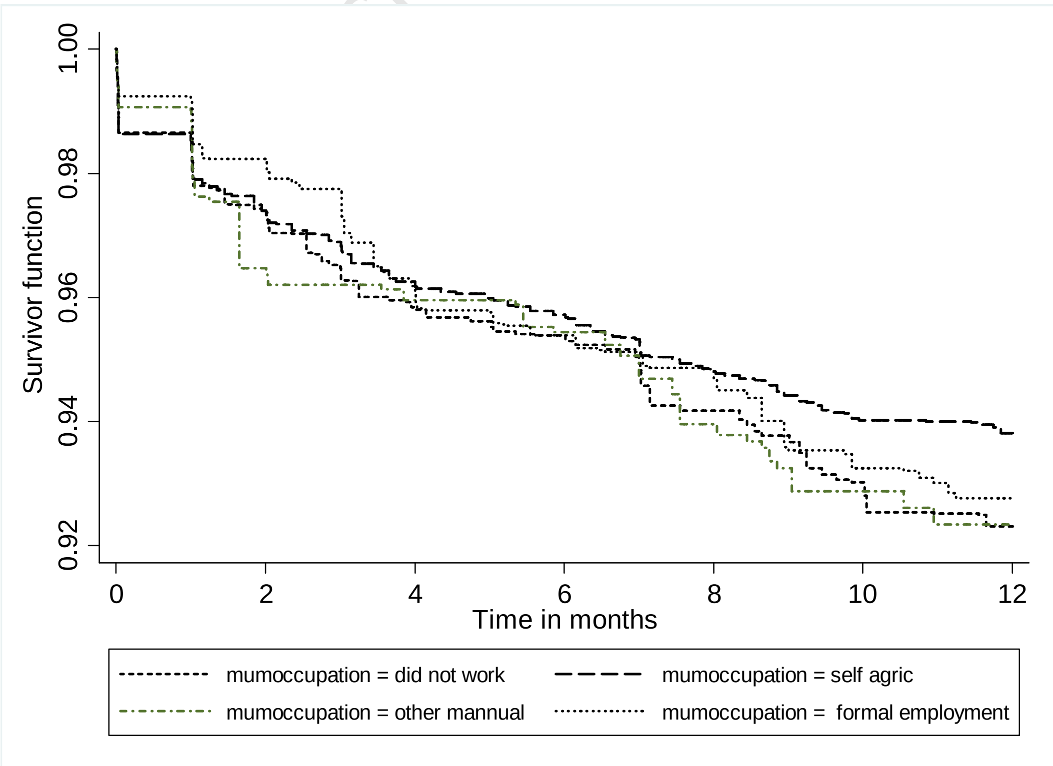


Figure 23. Kaplan-Meier survival curves for infants by marital status of mothers using 2004 survey data

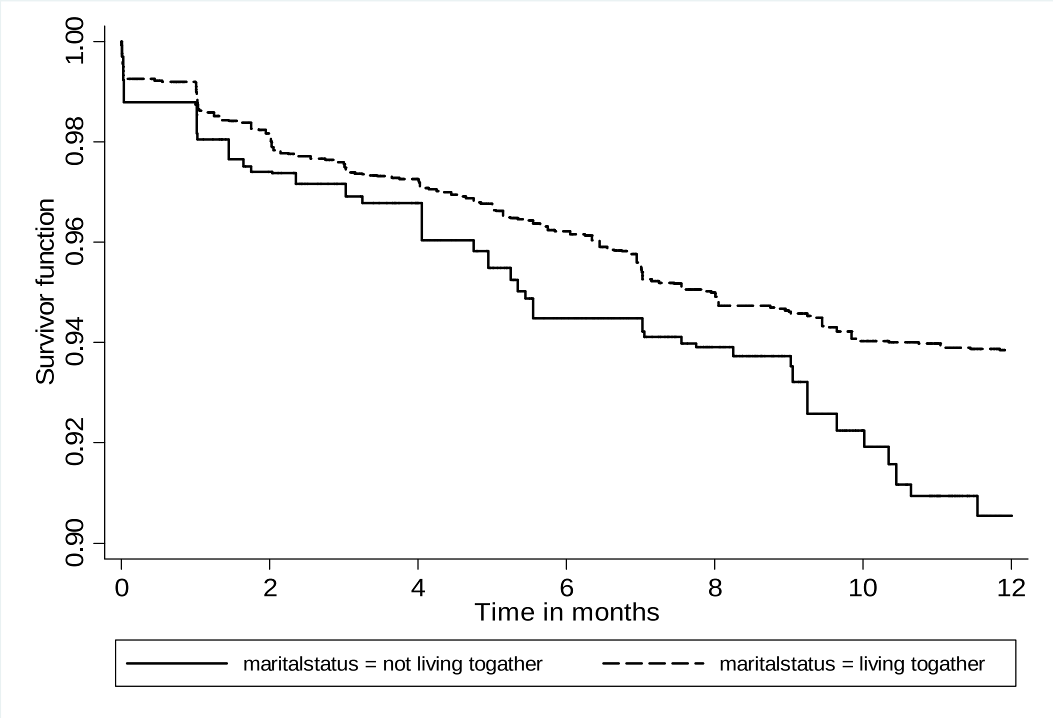


Figure 24. Kaplan-Meier survival curves for infants by marital status of mothers using 2010 survey data

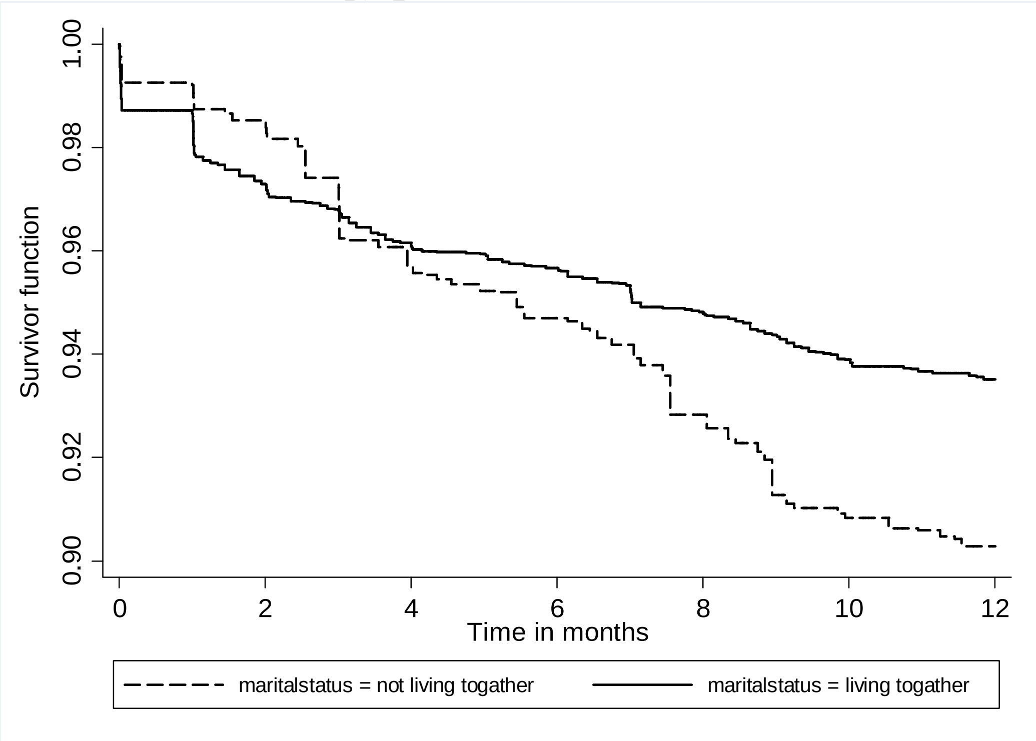


Figure 25. Kaplan-Meier survival curves for infants by mothers' age using 2004 survey data

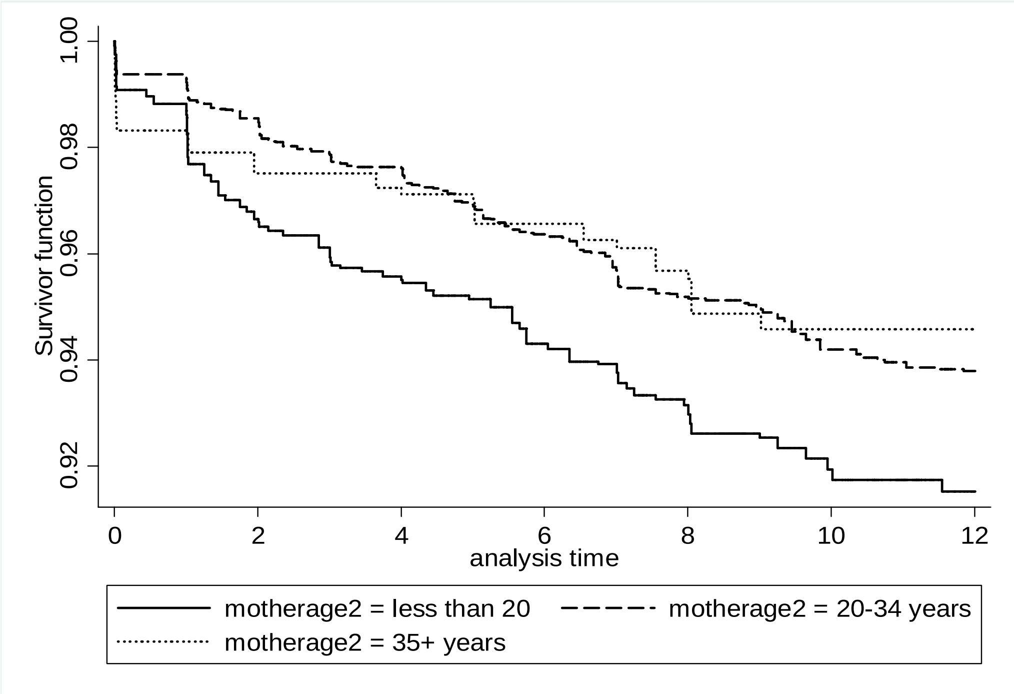
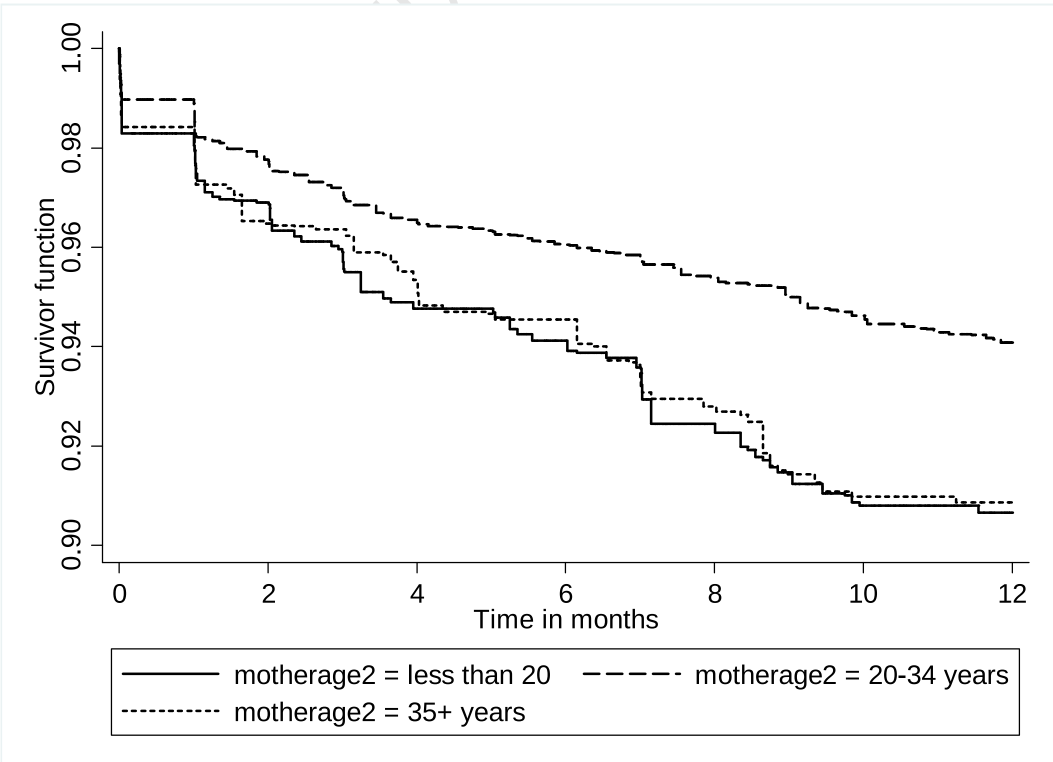


Figure 26. Kaplan-Meier survival curves for infants by mothers' age using 2010 survey data



KAPLAN-MEIER SURVIVAL CURVES FOR CHILDREN AGED 1 TO 5

Figure 27. Kaplan-Meier survival curves for children by birth order using 2004 survey data

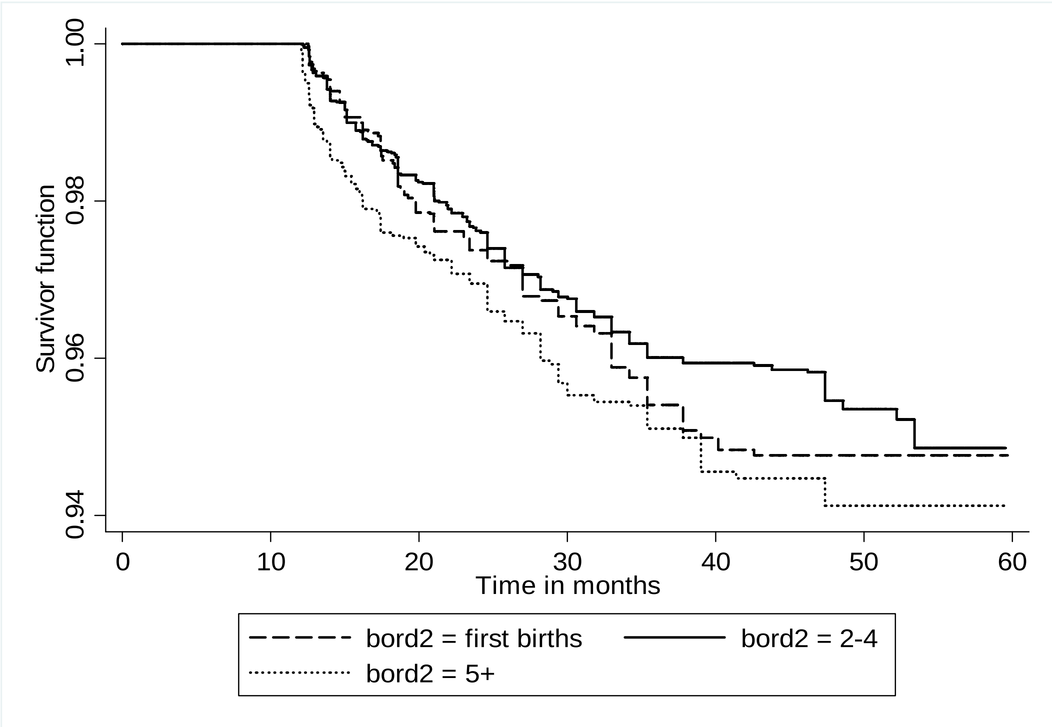


Figure 28. Kaplan-Meier survival curves for children by birth order using 2010 survey data

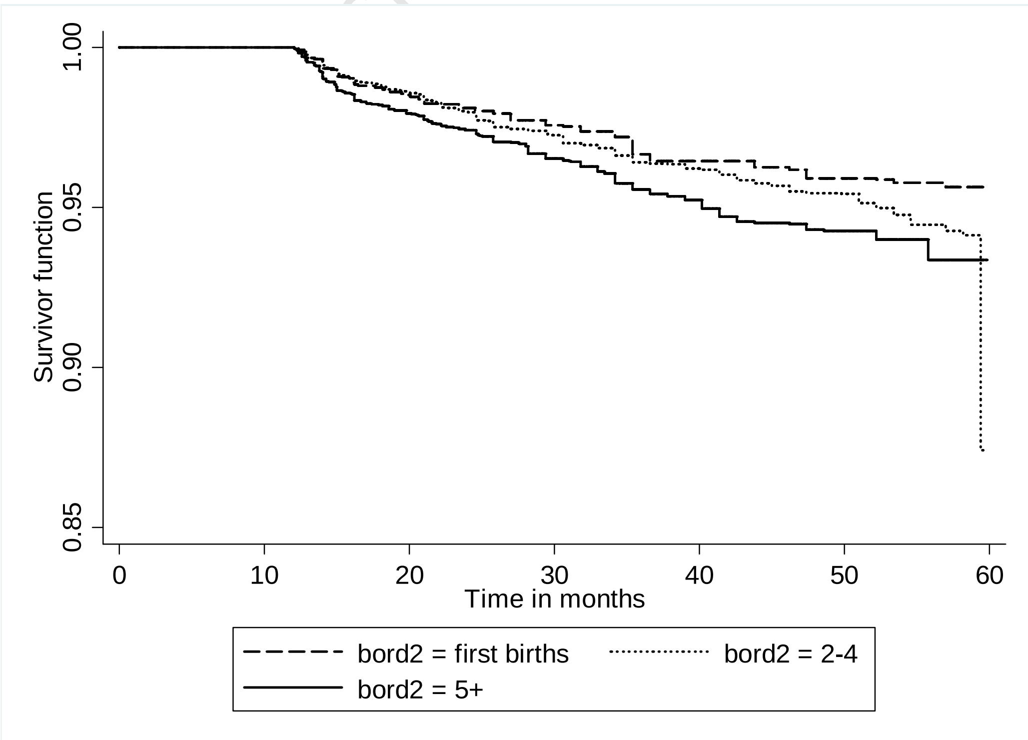


Figure 29. Kaplan-Meier survival curves for children by preceding birth interval using 2004 survey data

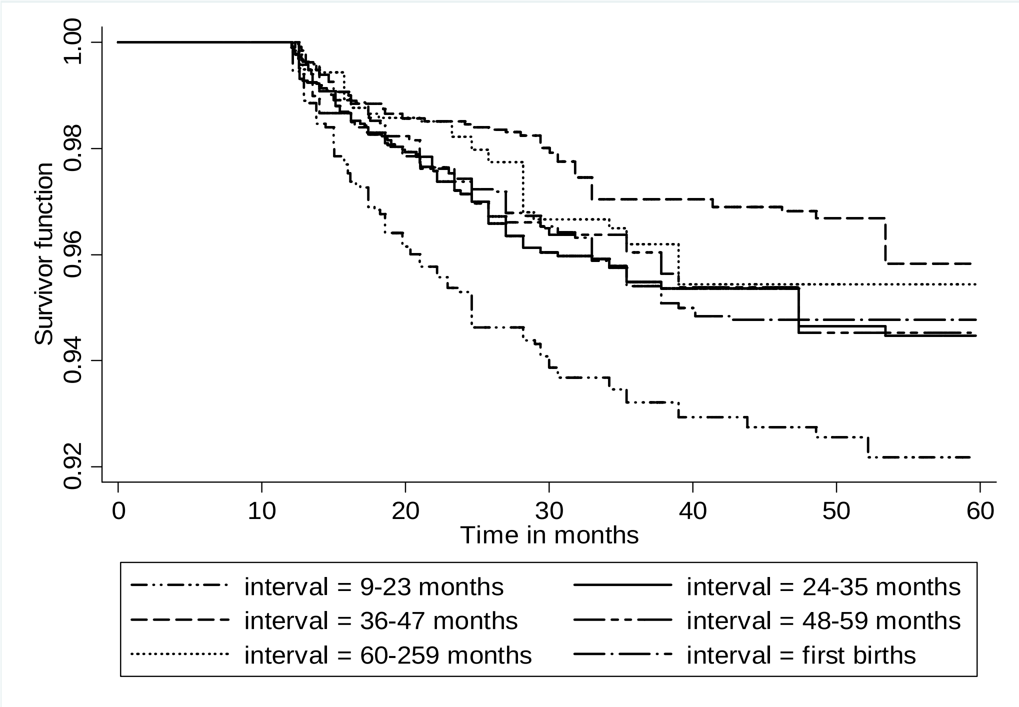


Figure 30. Kaplan-Meier survival curves for children by preceding birth interval using 2010 survey data

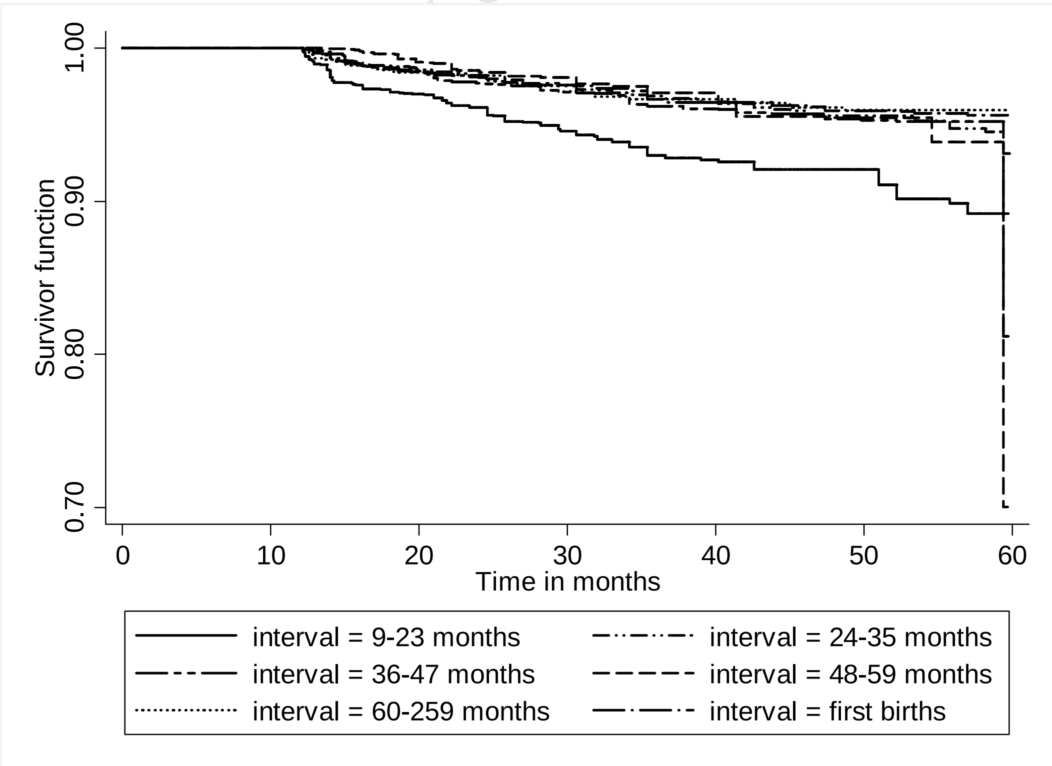


Figure 31. Kaplan-Meier survival curves for children by father's education using 2004 survey data

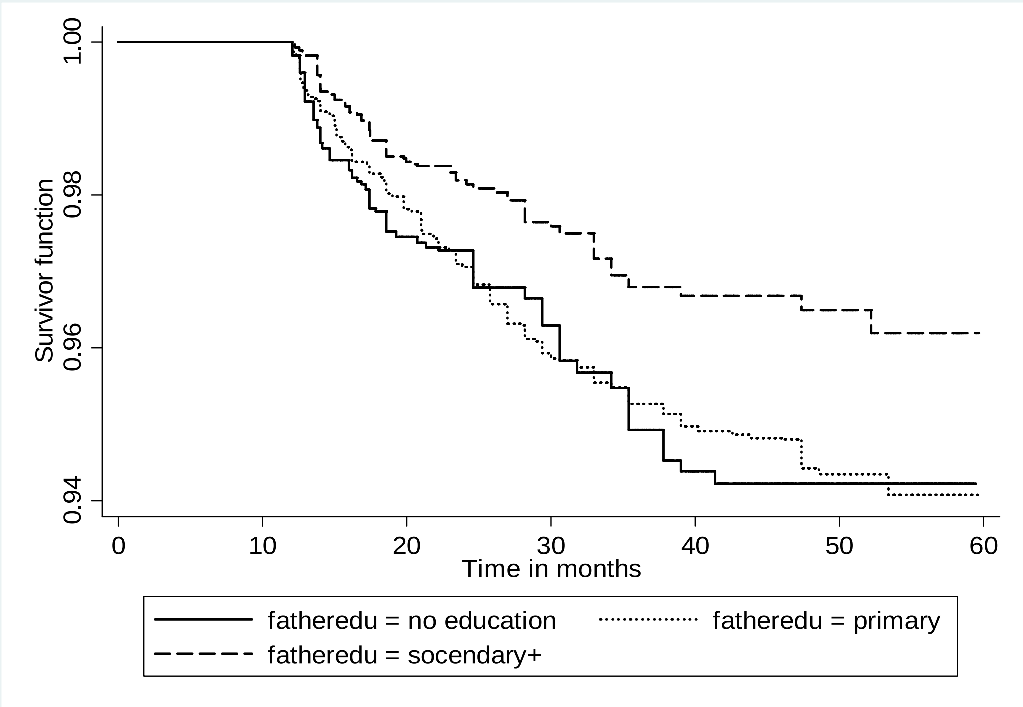


Figure 32. Kaplan-Meier survival curves for children by father's education using 2010 survey data

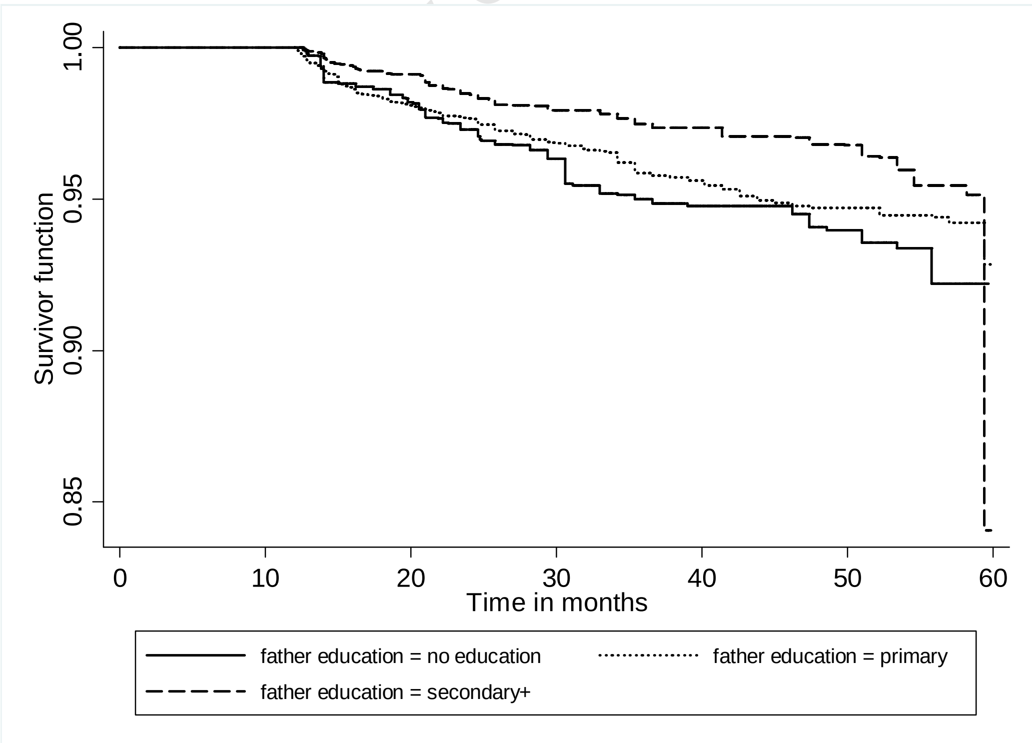


Figure 33. Kaplan-Meier survival curves for children by wealth index using 2004 survey data

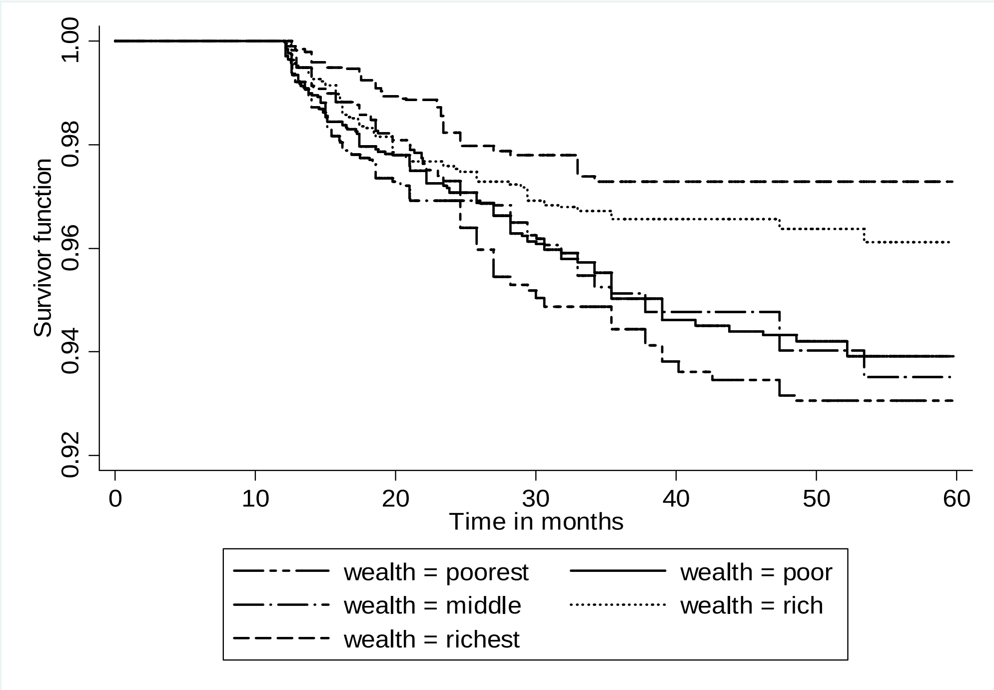


Figure 34. Kaplan-Meier survival curves for children by wealth index using 2010 survey data

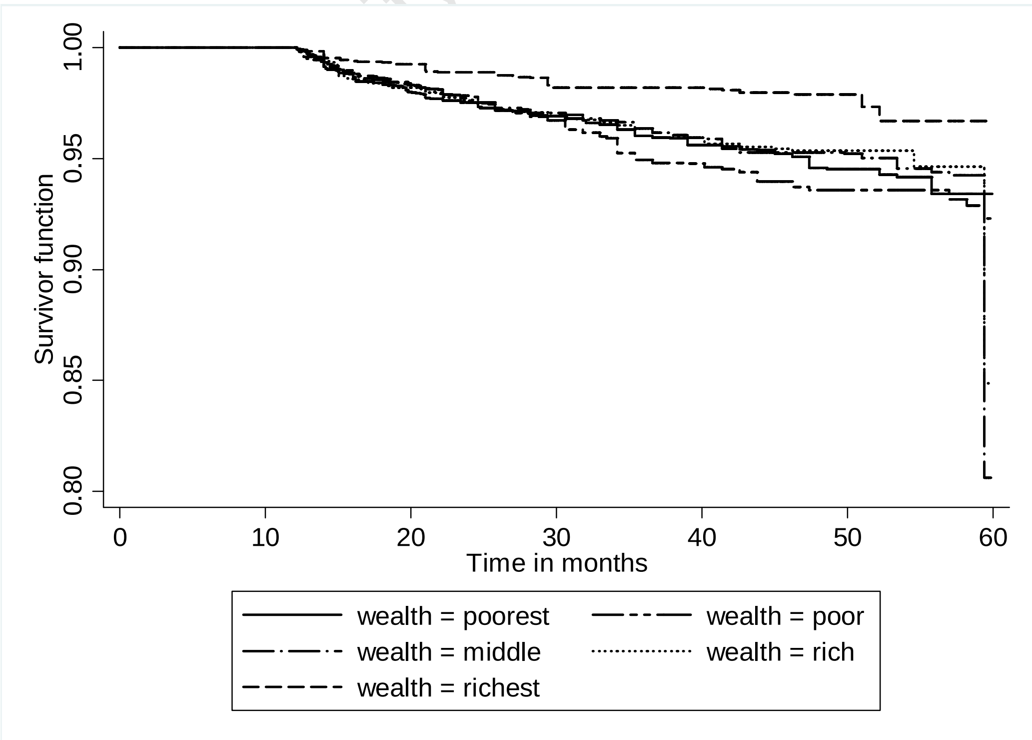


Figure 35. Kaplan-Meier survival curves for children by sex using 2004 survey data

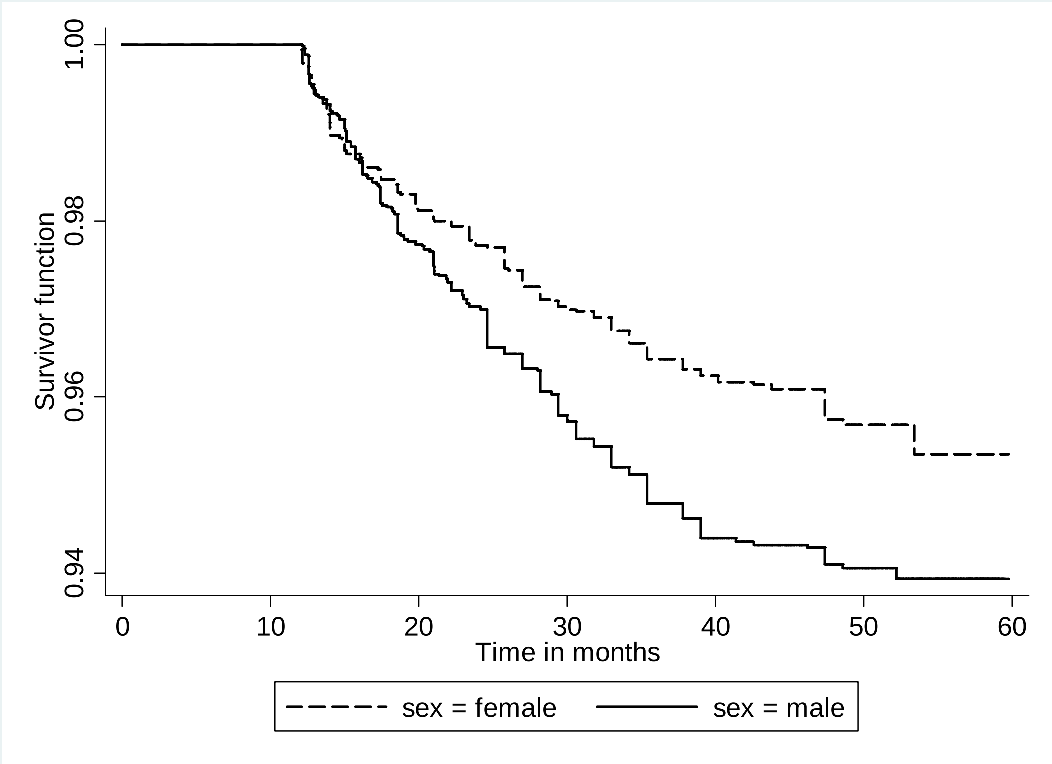


Figure 36. Kaplan-Meier survival curves for children by sex using 2010 survey data

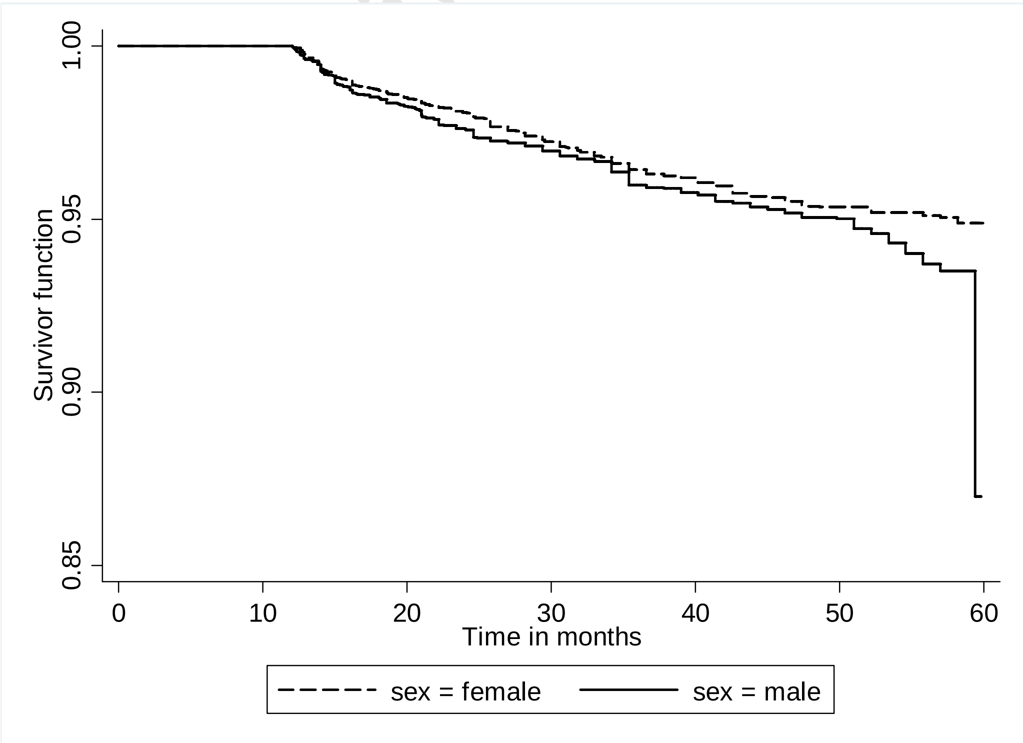


Figure 37. Kaplan-Meier survival curves for children by residence using 2004 survey data

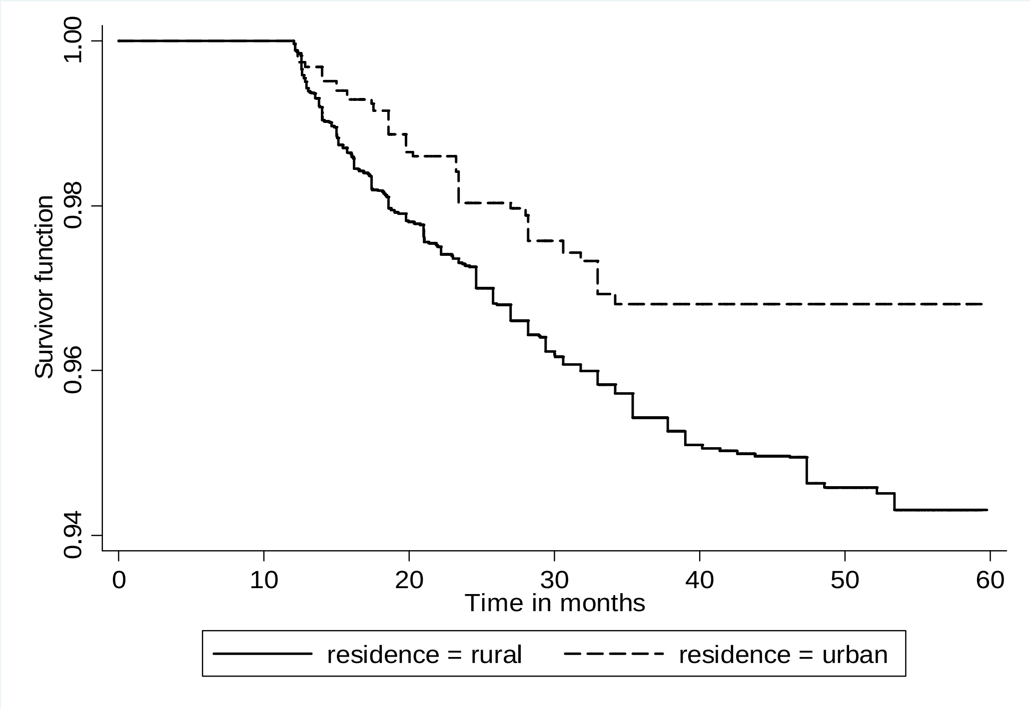


Figure 38. Kaplan-Meier survival curves for children by residence using 2010 survey data

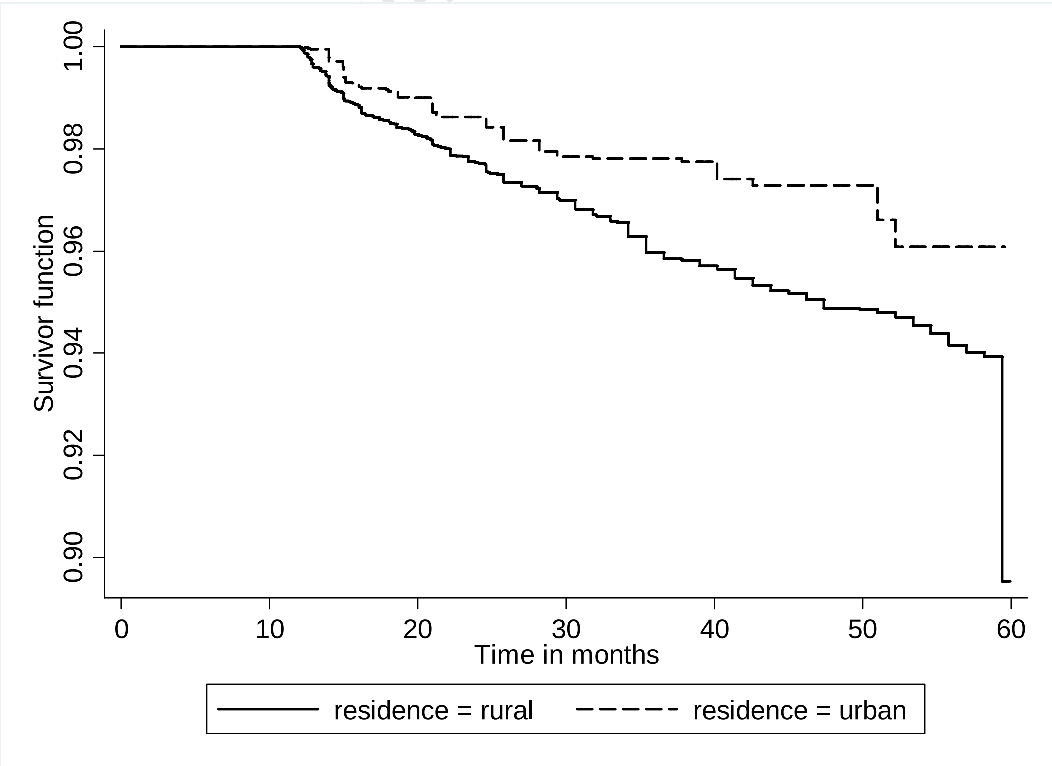


Figure 39. Kaplan-Meier survival curves for children by type of floor material using 2004 survey data

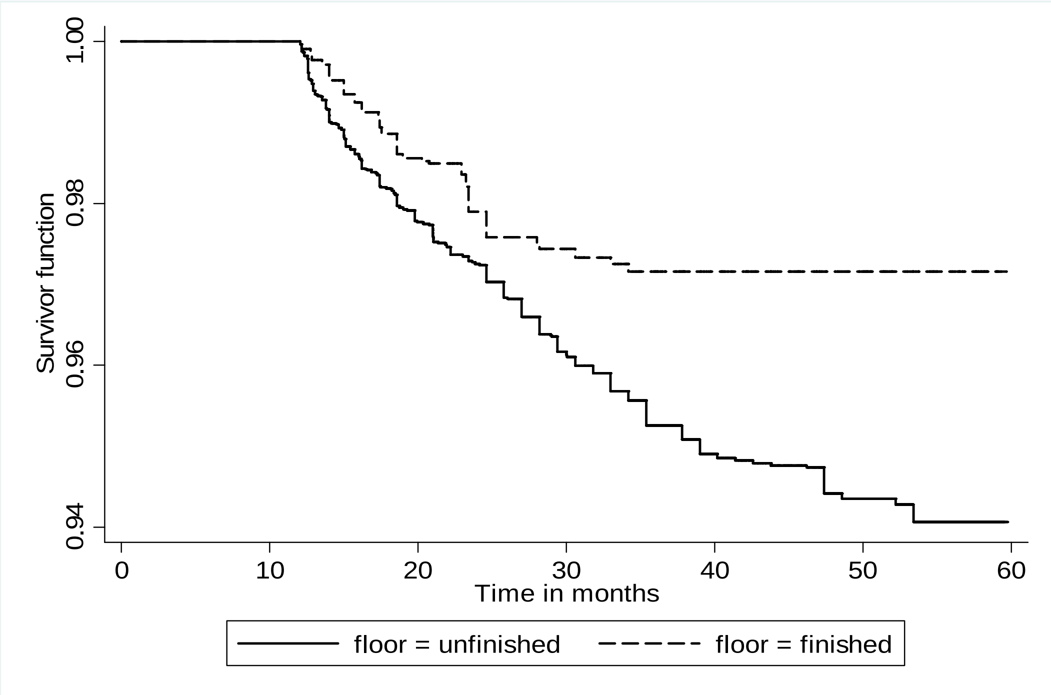


Figure 40. Kaplan-Meier survival curves for children by type of floor material using 2010 survey data

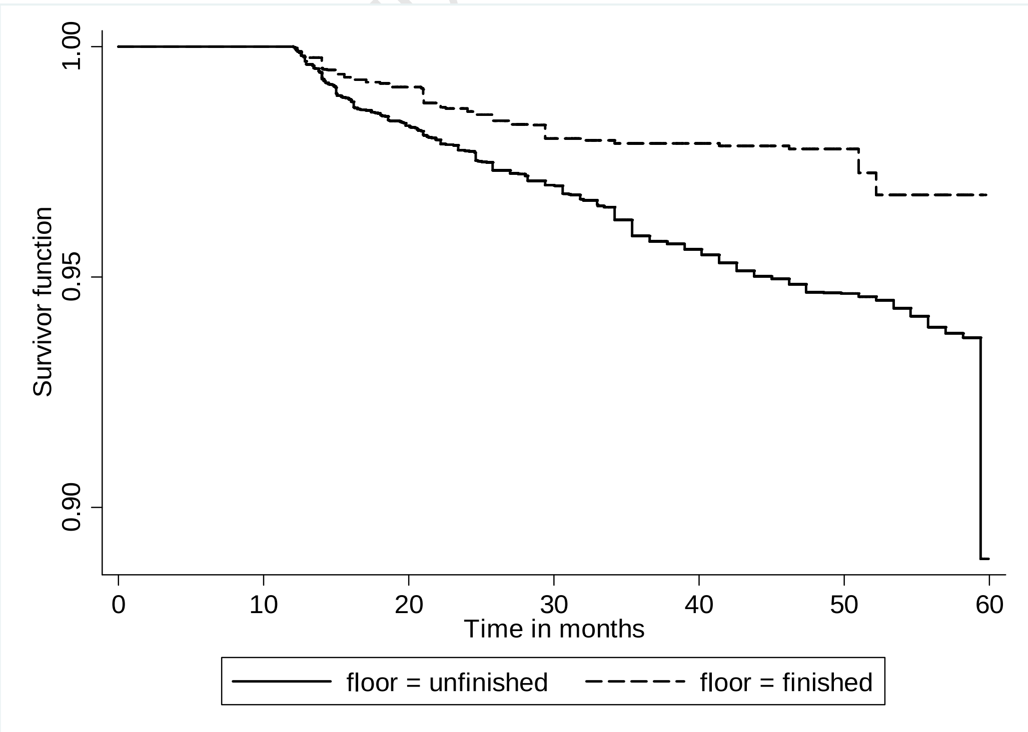


Figure 41. Kaplan-Meier survival curves for children by toilet facility using 2004 survey data

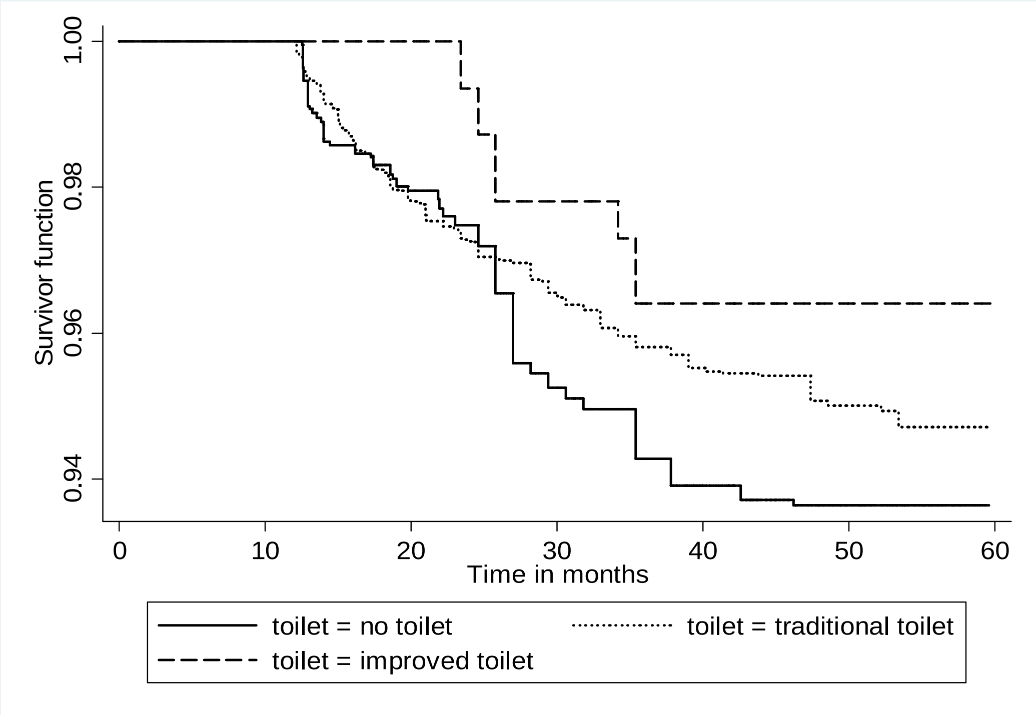


Figure 42. Kaplan-Meier survival curves for children by toilet facility using 2010 survey data

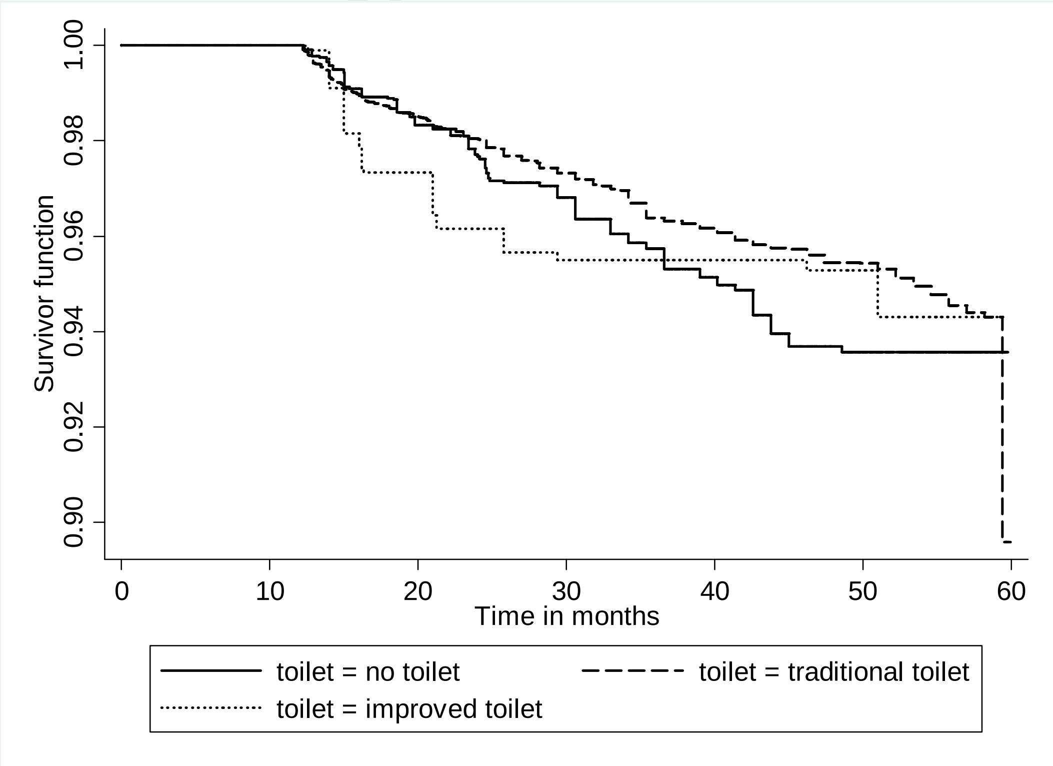


Figure 43. Kaplan-Meier survival curves for children by source of water using 2004 survey data

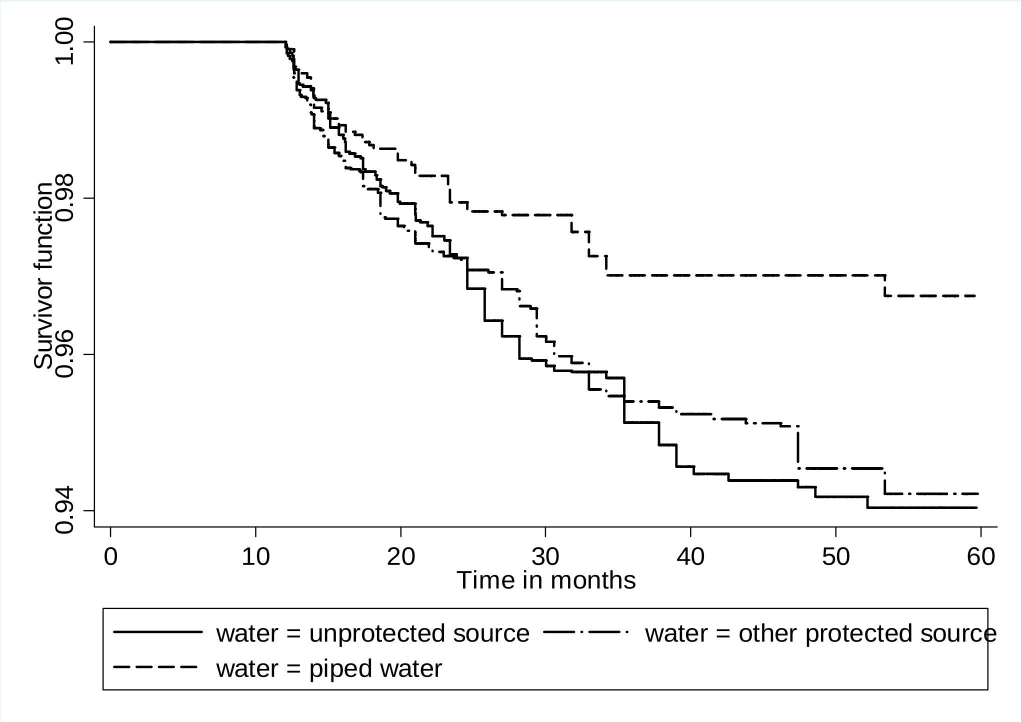


Figure 44. Kaplan-Meier survival curves for children by source of water using 2010 survey data

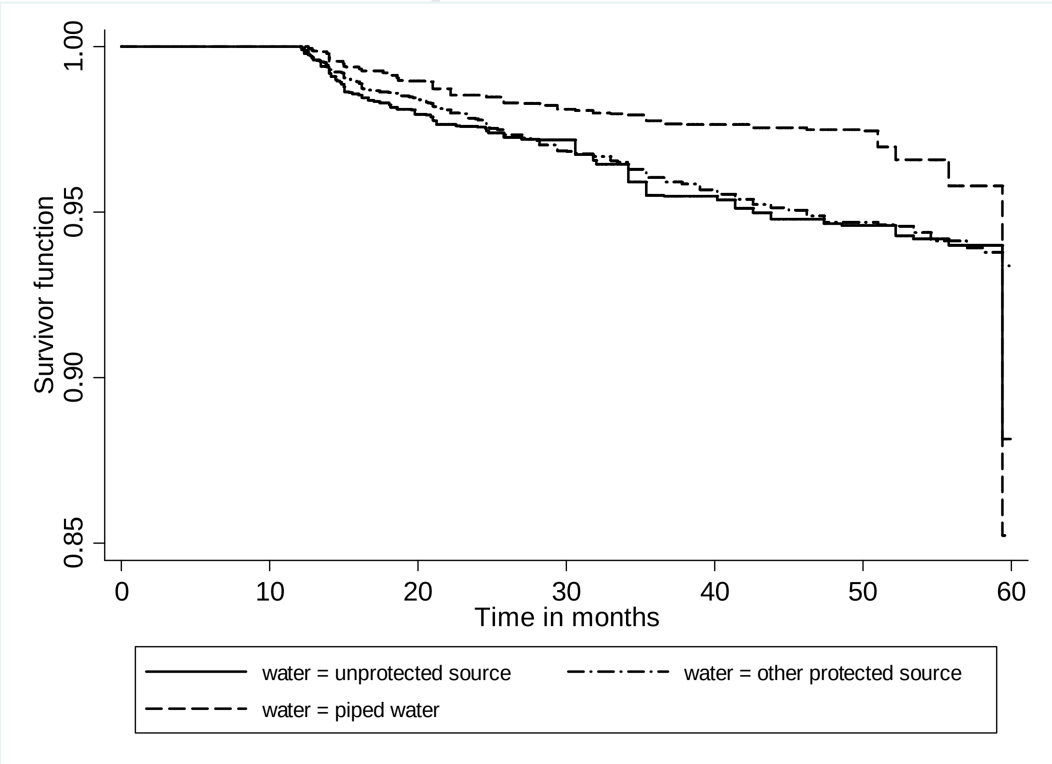


Figure 45. Kaplan-Meier survival curves for children by fathers' occupation using 2004 survey data

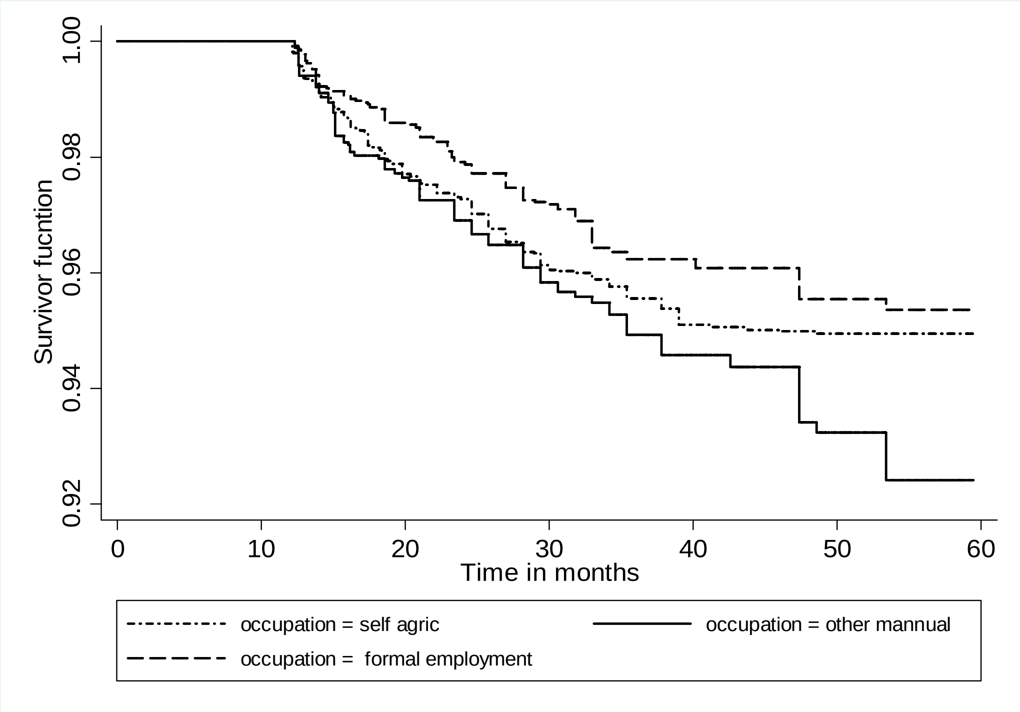


Figure 46. Kaplan-Meier survival curves for children by fathers' occupation using 2010 survey data

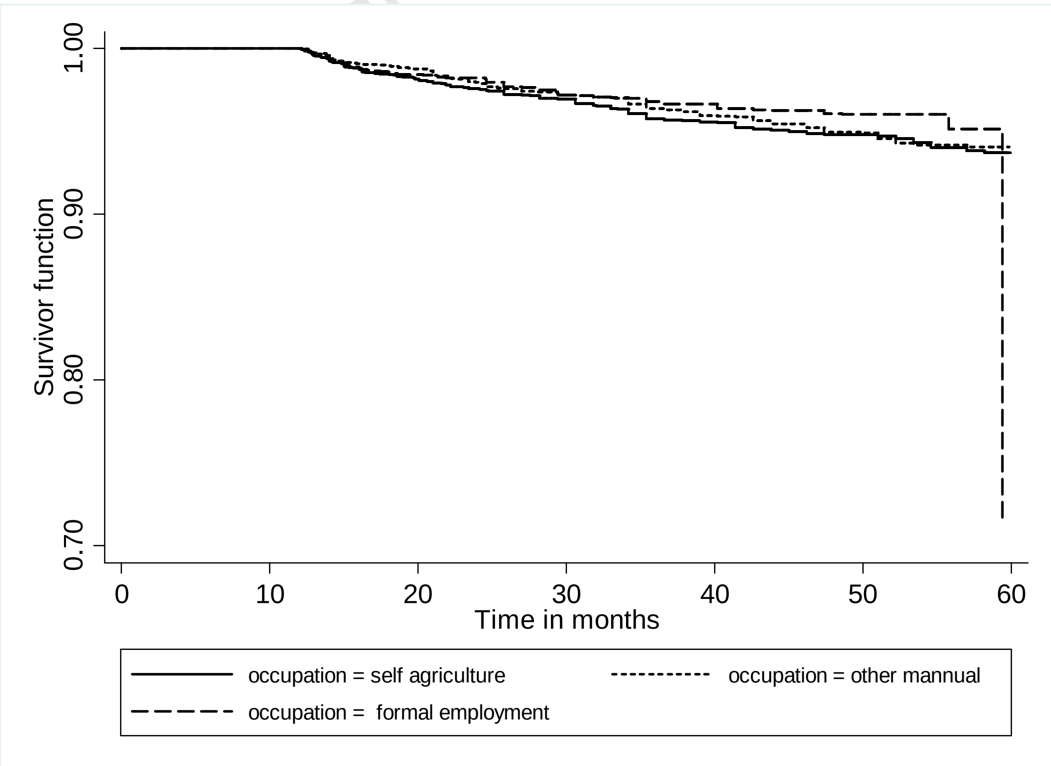


Figure 47. Kaplan-Meier survival curves for children by mothers' occupation using 2004 survey data

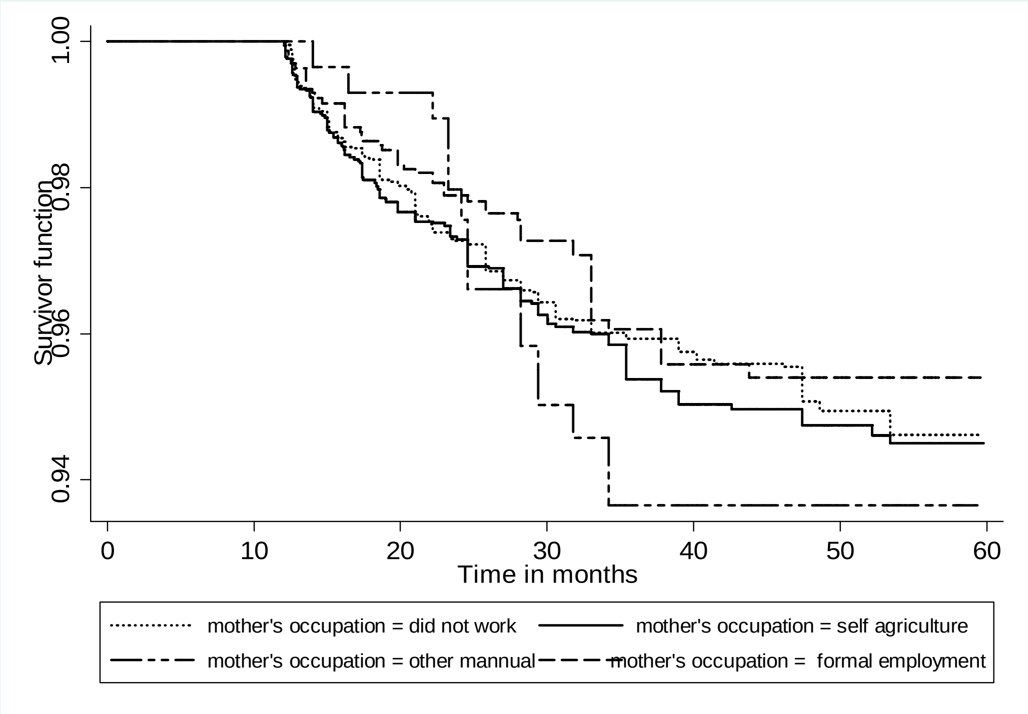


Figure 48. Kaplan-Meier survival curves for children by mothers' occupation using 2010 survey data

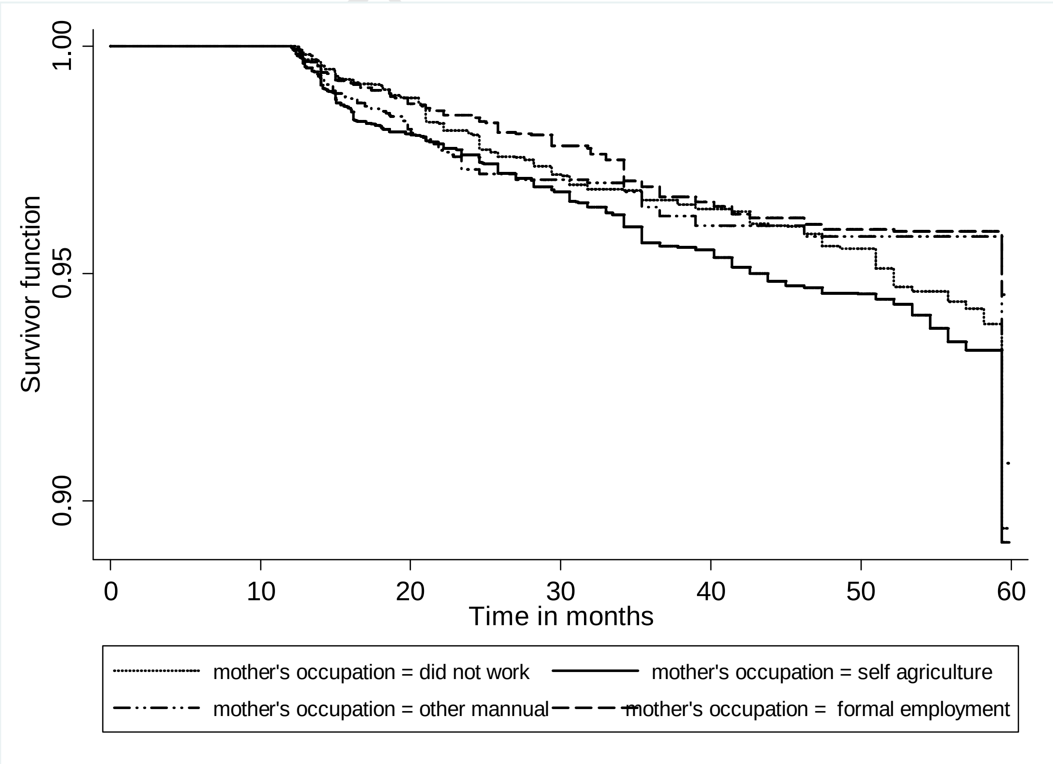


Figure 49. Kaplan-Meier survival curves for children by mothers' marital status using 2004 survey data

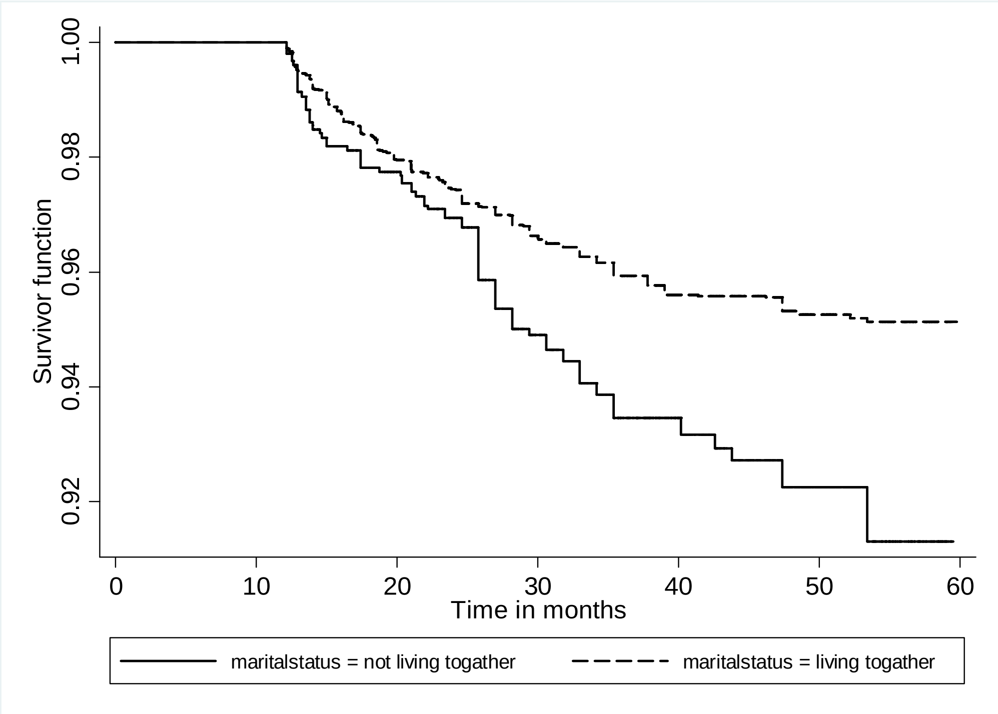


Figure 50. Kaplan-Meier survival curves for children by mothers' marital status using 2010 survey data

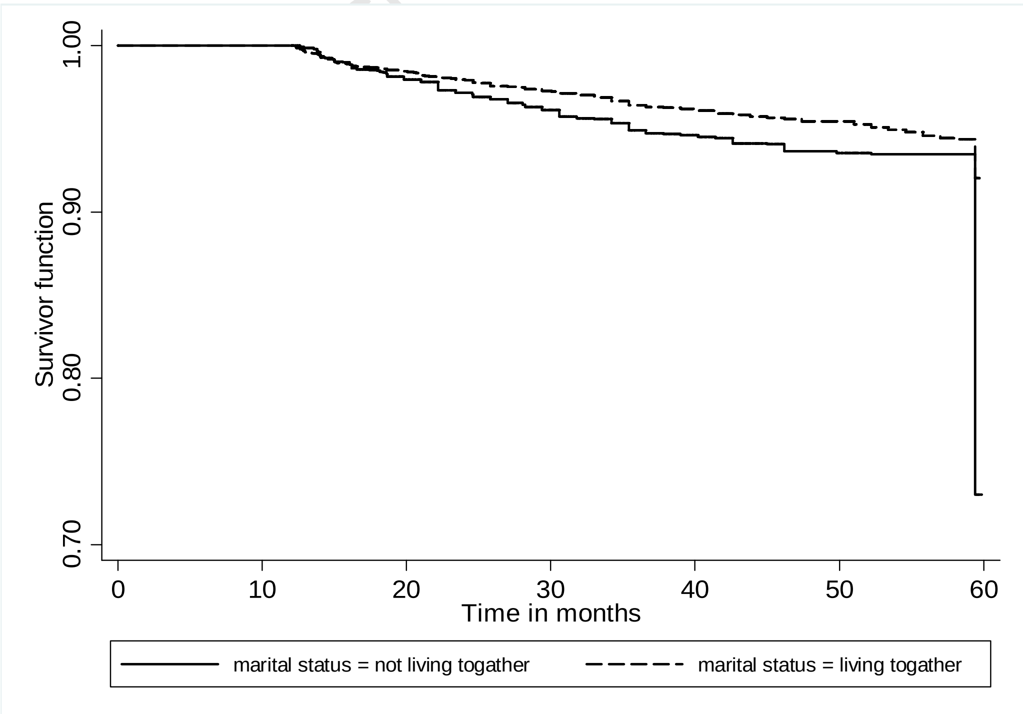


Figure 51. Kaplan-Meier survival curves for children by mothers' age using 2004 survey data

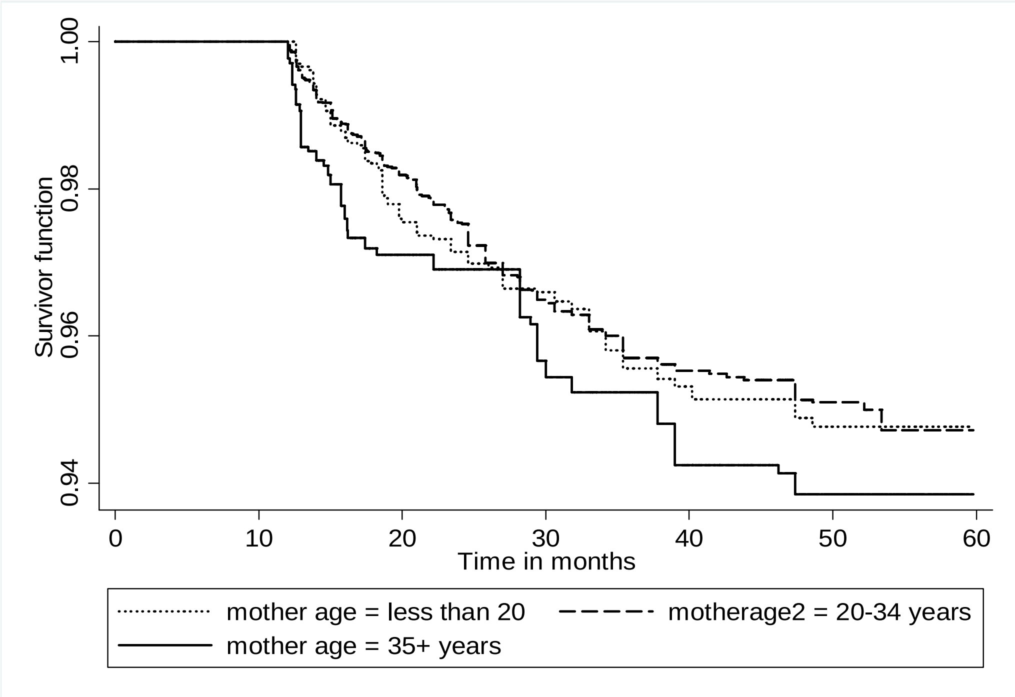


Figure 52. Kaplan-Meier survival curves for children by mothers' age using 2010 survey data