Two Investigations into the Causal Link between Child Mortality and Subsequent Fertility using DHS Data from Kenya, Lesotho, Malawi, Tanzania and Zimbabwe

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ABSTRACT

This research performs two investigations into the causal link between childhood mortality and fertility using Demographic and Health Survey data from Kenya, Lesotho, Malawi, Tanzania and Zimbabwe, countries which are at different stages of the demographic transition. The first investigation assesses the effect of the death of a child on the timing of the birth of the next child. Piecewise log-rate models were used to investigate women who had experienced the loss of a child and in all the countries under study these women were found to have shorter birth intervals. The magnitude of the effect was strongest in Lesotho and Zimbabwe. The second investigation assesses the effect of the death of at least one child on insuring against future mortality. Logistic regression models showed that women aged 35-49 years old who had experienced at least one child death were likely to insure against future child mortality. This effect was most pronounced in Malawi.

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Thank You God for walking with me.

1 INTRODUCTION

1.1 Background

The focus of past research investigating the causal link between child mortality and fertility has been on the effect of child mortality on fertility (Knodel 1982). Montgomery and Cohen (1998) argue that child mortality is one of the most important factors affecting fertility. The outcomes of research focussing on the assessment of the effect of child mortality on fertility could contribute towards measures implemented by policy makers to reduce fertility in sub-Saharan Africa.

Child mortality affects fertility through physiological, replacement and hoarding effects and these effects result in an increase in the number of births (Schultz 1978; Olsen 1980; Rizk, Stokes and Nelson 1982; Sah 1991; Palloni and Rafalimanana 1999; Obonyo, Otieno and Muga 2005). The physiological effects on women manifest through the cessation of breastfeeding due to the sudden death of a child. The cessation of breastfeeding triggers ovulation resulting in an increase in the probability of conception. The replacement effect occurs when a couple deliberately decide to replace a dead child, and the hoarding effect occurs when a couple has more children than desired or practicable in anticipation of child mortality in their family. While the physiological effect is a biological response, the replacement and hoarding effects are the intentional behavioural responses to the death of a child.

Several studies by researchers such as Chowdhury, Khan and Chen (1976), Balakrishnan (1978), Knodel (1982), Santow and Bracher (1984), Grummer-Strawn, Stupp and Mei (1998), Palloni and Rafalimanana (1999), Rajbhandary (1999), Kimani (2001), Gyimah and Fernando (2002), Gyimah and Fernando (2004), Obonyo, Otieno and Muga (2005), Tymicki (2005), Hossain (2007) and, Lindstrom and Kiros (2007), have investigated the effect of child mortality on fertility and concluded that the death of a child results in shorter birth intervals and increases the likelihood of a couple's having another child. Different methodologies, such as hazard rate modelling and Ordinary Least Squares, have been used to measure the effect of child mortality on fertility.

Empirical studies focusing on investigating the effects of child mortality on fertility fall into two categories: aggregate-level and individual-level studies. Aggregate-level studies are based on national and sub-national averages, while individual-level studies make use of the reproductive experiences of individual women, based on sample surveys (Obonyo, Otieno and Muga 2005). Aggregate-level studies provide crude information on the rate of the incidence of a particular event at the individual-level, but do not measure the biological and behavioural responses of individuals to that event. Individual-level studies accurately measure the biological and behavioural responses of individuals (Obonyo, Otieno and Muga 2005). Kuate Defo (1998) saw individual-level studies as showing a significant fertility response to the death of a child. Aggregate-level studies show that in sub-Saharan Africa child mortality has no effect, or an unclear effect, on fertility.

Thus, based on the outcomes of previous studies, this research investigates the effect of child mortality on fertility by assessing both the replacement and hoarding effects, using data from the Demographic and Health Survey, and focuses on Kenya, Lesotho, Malawi, Tanzania and Zimbabwe. These countries are at different stages of demographic transition. Lesotho and Zimbabwe are low fertility countries according to African standards, and Malawi and Tanzania are high fertility countries. Kenya is an intermediate fertility country with respect to the low and high fertility countries in this study. Log-rate and logistic models will be used to assess the replacement and hoarding effects respectively.

1.2 Aims and objectives

The overall aim of this research is to investigate, first, the effects of a child death on the risk of closing the birth interval, and second, to see if the experience of a child death by a couple has an effect on their having more children than they had initially desired.

This study has five specific objectives. The first is to determine if there is a fertility response to an infant or child death. This will test the assumption made by Palloni and Rafalimanana (1999), who argue that child mortality has small positive effects on fertility. The second is to determine if the birth interval is shortened after a child death. Tymicki (2005) argues that the birth interval is shortened if couples experience a child loss. The third is to do a comparative analysis of the replacement and hoarding effects in low and high fertility countries, testing the argument of Rizk, Stokes and Nelson (1982) that the magnitude of the replacement effect is higher in low fertility countries and the argument of LeGrand, Koppenhaver, Mondain *et al.* (2003) that the hoarding effect is higher in high fertility countries. The fourth is to determine if the death of a child has a time-varying effect on the subsequent birth interval. The death of the index child (child under study) is time-dependent hence there is an expectation that the death of a child will have a time-varying effect on the subsequent birth interval (Grummer-

Strawn, Stupp and Mei 1998; Park, Islam, Chakraborty *et al.* 1998; Rajbhandary 1999). The fifth is to determine if the death of a male child has a greater effect on the subsequent birth interval relative to the death of a female child. In societies where there exists a preference for male children, the death of a male child may increase the desire to replace the deceased male child, with the expectation of conceiving another male child (Rajbhandary 1999).

1.3 Structure of the dissertation

This dissertation is made up of six chapters. Chapter 2 reviews the literature on fertility and child mortality and the research methods used in previous studies. Chapter 3 provides a commentary on the source and quality of the data used in the study, and the levels and trends of fertility and child mortality in the countries under study. In Chapter 4, the replacement effect is analysed. Chapter 5 analyses the hoarding effect. Chapter 6 provides a summary of the findings, discusses the limitations of the study, offers certain recommendations, and provides a conclusion to the dissertation.

2 LITERATURE REVIEW

This chapter presents a review of the literature on the subject of study. Section 2.1 presents a discussion of the literature on the relationship between fertility and child mortality. Section 2.2 will look at methods used in other studies on the replacement and hoarding effects.

2.1 Child mortality and fertility

Several studies have shown child mortality and fertility as being positively related (Basu 1994; Murthi, Guio and Drèze 1995), and an awareness of this relationship could be valuable in designing policies that influence population change (Chowdhury, Khan and Chen 1976; Gyimah and Fernando 2004).

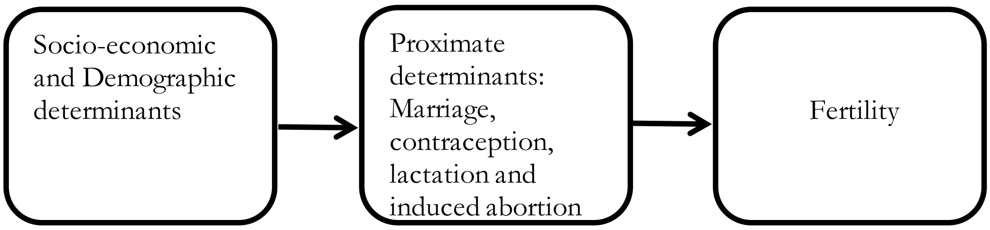
Child mortality and fertility are causally linked in both directions (Rutstein 1974; Knodel 1982; Santow and Bracher 1984; Chowdhury 1988; Palloni and Rafalimanana 1999; Gyimah and Fernando 2002; Obonyo, Otieno and Muga 2005). Fertility can affect child mortality primarily through the influence of the length of the birth interval (Palloni and Rafalimanana 1999; Gyimah and Fernando 2002; Obonyo, Otieno and Muga 2005). Shorter birth intervals result in higher fertility, which in turn can lead to higher child mortality. The effect of child mortality on fertility is primarily as a result of the behavioural and biological factors associated with birth intervals (Knodel 1982; Grummer-Strawn, Stupp and Mei 1998; Palloni and Rafalimanana 1999). There is evidence to support the theory that the death of a child raises subsequent fertility of a woman and is associated with shorter birth intervals.

The socio-economic and demographic determinants of fertility and of childhood mortality operate through proximate determinants that have a direct effect on both fertility and child mortality. These proximate determinants assist in understanding how the determinants function. For example, one determinant might have a negative effect on a proximate determinant and a positive effect on another proximate determinant. The proximate determinants are made up of behavioural and biological factors.

2.1.1 Proximate determinants of fertility

Figure 2.1 shows the relationship between the socio-economic and demographic proximate determinants of fertility. Bongaarts (1978) analysed the eleven proximate determinants of fertility first suggested by Davis and Blake (1956), and argued that seven of them were not important in terms of explaining differences in fertility, leaving four important determinants: marriage, contraception, induced abortion and post-partum infecundability. The delay or disruption of marriage, prolonged breastfeeding, post-partum abstinence and infertility reduce fertility to levels lower than those that would prevail in the absence of these determinants (Bongaarts, Frank and Lesthaeghe 1984). The proximate determinants of fertility change as the fertility rates of a society move from high to low. The physiological, replacement and hoarding effects of child mortality differ according to the stage of the demographic transition of a society.

Figure 2.1. The determinants of fertility



Adapted from Bongaarts, Frank and Lesthaeghe 1984

Marriage (including formal marriages and consensual unions) increases the exposure of women to childbearing. In marriage the exposure to childbearing can be affected by the frequency of coitus although women in arranged and polygamous marriages have a lower frequency of coitus (Bongaarts, Frank and Lesthaeghe 1984). The period of union depends on the age of a woman at first marriage, and this could determine the number of children she will bear. A woman who gets married at a relatively later age is exposed to a shorter period of childbearing than is a woman who gets married at a very young age. Cohen (1998) argues that late age of women at marriage is one of the proximate determinants that has contributed to the decline in fertility in sub-Saharan Africa. Although the dissolution of a marriage through divorce or widowhood limits the period of exposure to child bearing, if a woman does not remarry (Menken 1987), in sub-Saharan Africa the rates of remarriage are high and as a result a significant number of women are in unions (Bongaarts, Frank and Lesthaeghe 1984).

In any society, the total amount of time spent by women in a marriage depends on age at first marriage, the proportion of women who will never get married, and the frequency of widowhood, divorce and remarriage. The possibility of unmarried women, never married women and young women who have never been married being exposed to childbearing should be noted.

The use of contraception reduces the risk of conception and has been mainly responsible for the decline in marital fertility in countries where contraception is available. In countries that are at the end of the fertility transition fertility is low and contraceptive prevalence is high, whilst in countries at the beginning of the transition, fertility is high and the prevalence of the use of contraceptives is low. Contraceptive use and induced abortion have mostly been responsible for the decline in fertility in developing countries (Cohen 1998).

In some parts of sub-Saharan Africa, induced abortion has played a major role in fertility regulation (Garenne and Joseph 2002) although there remains a dearth of data on the frequency of abortions (Mauldin and Ross 1994) as abortion is still illegal in most of sub-Saharan Africa, and thus the data are not available in any official records.

When a woman is breastfeeding, the risk of conception is significantly reduced. Post-partum amenorrhea depends on the duration, intensity and pattern of breastfeeding and abstinence. Long durations of post-partum abstinence are connected to prolonged breastfeeding which is thought by many societies in sub-Saharan countries to be essential for the health of the child. In most sub-Saharan countries the practice of breastfeeding is universal and on average lasts for about 20 months after the birth of a child (Kirk and Pillet 1998). In most societies where prolonged abstinence is practiced, women are exposed to conception after weaning and usually births are spaced at intervals of about four years. Thus one can conclude from these observations that length and intensity of breastfeeding has an influence on exposure to conception, and that the longer the period of breastfeeding, the less likely is conception to occur.

Table 2.1 shows modern contraceptive prevalence, total fertility rate, median age at first marriage, proportion of married women, length of breastfeeding and postpartum period in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe. Modern contraceptive prevalence is higher in low fertility countries, while age at first marriage is lower and length of breastfeeding period is shorter in high fertility countries. The proportion of women married is higher in Malawi and Tanzania.

Table 2.1 Current proximate determinants, women aged 15-49 years

Country	Current modern contraceptive use	Total fertility rate	Median age at first marriage (years)	Proportion married (women aged 15-49 years	Length of breastfeeding (months)	Postpartum amenorrhoea (months)
Kenya	39.4%	4.6	20.0	58.4%	20.7	8.9
Lesotho	45.6%	3.3	19.9	53.1%	16.4	7.4
Malawi	42.2%	5.7	17.8	67.5%	22.9	10.5
Tanzania	27.4%	5.4	18.8	63.3%	20.4	9.8
Zimbabwe	58.4%	3.8	19.3	57.7%	18.7	14.3

Source: 2008-09 Kenya Demographic and Health Survey (KDHS), 2009 Lesotho Demographic and Health Survey (LDHS), 2010 Malawi Demographic and Health Survey (MDHS), 2010 Tanzania Demographic and Health Survey (TDHS), 2005-06 Zimbabwe Demographic and Health Survey (ZDHS).

Note: Median age at first marriage for women aged 25-49 years is weighted; Proportion married includes those formerly married and those living together

2.1.1 Proximate determinants of child mortality

Mosley and Chen (1984) proposed an analytical framework for the study of the determinants of child mortality in developing countries. This framework has been used in this study as a guideline both in understanding child mortality and its determinants and to identify ways to improve child survival and curb child mortality. The analytical framework is based on how the proximate determinants are influenced by the social and economic determinants of child mortality and combines models generated by social science and medical research. Each use different approaches to determining child mortality. While social science research on child mortality focuses on the relationship between socio-economic factors and the levels and trends of mortality, tending to ignore the impact of specific diseases on death, medical research focuses mainly on diseases and the mechanisms and causes of disease transmission, and less frequently on child mortality.

Mosley and Chen (1984) identify a set of proximate determinants that directly influence morbidity and mortality (Figure 2.2). These identified proximate determinants are classified into five categories namely, maternal factors (age, parity, birth interval), environmental contamination (air, food/water/fingers, skin/soil/inanimate objects, insect vectors), nutrient deficiency (calories, proteins, micronutrients), injury (accidental and intentional) and personal illness control (personal preventative measures and medical treatment). Maternal factors, environmental contamination, nutrient deficiency and injury influence the shift of individual's state of health to one of illness, and personal illness control influences the rate and prevalence of illness and recovery.

Maternal factors include the age of the mother, parity, and the length of birth interval. These maternal factors have an effect on infant survival through their effects of the mother's health. Shorter preceding birth intervals are associated with higher mortality due usually to the deterioration of the mother's general state of health from the preceding birth, resulting in low birth weight of the succeeding child and from sibling competition for resources (Knodel and Hermalin 1984; Gupta 1990). In a study conducted in Bangladesh and the Philippines, Miller, Trussell, Pebley *et al.* (1992) found that 60 to 80 per cent of children born soon after a preceding birth were likely to die during the first two years of life. Mothers with large numbers of children tend to have shorter birth intervals and shorter breastfeeding periods, factors which could lead to a higher under five mortality rate (Knodel and Hermalin 1984). Teenage mothers experience higher child mortality due to poor maternal and child health, pre-term births and low birth weight (LeGrand and Mbacke 1993). In sub-Saharan countries, teenage mothers often come from impoverished backgrounds, have had a poor education since they leave school early, and might not have the resources to provide proper healthcare facilities for a child. The biological risks of mortality are higher for older women (Hobcraft, McDonald and Rutstein 1985). For example, older women have a higher chance of having children with Down's Syndrome.

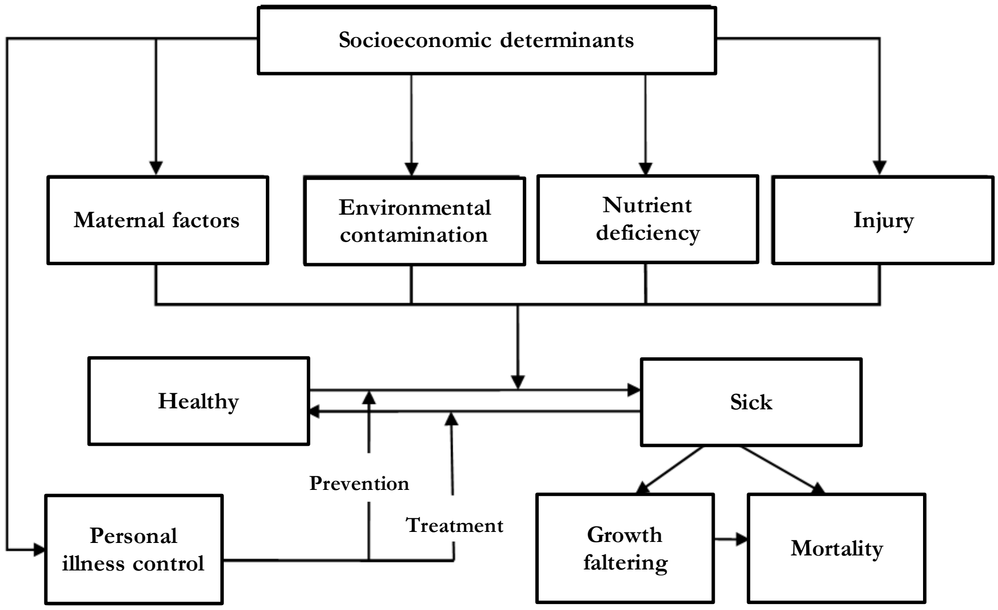
The level of exposure of children to environmental risk factors is determined by the environment in which mothers raise their children and to which they expose them (Folasade 2000). Infections are transmitted through air, food, water, fingers, skin, soil, inanimate objects and insects (Mosley and Chen 1984). Respiratory and contact infections are transmitted through air, and diarrheal and intestinal diseases are transmitted through food, water and fingers. Skin infections are spread through skin, soil and inanimate objects, and parasitic and viral diseases are spread by insects. In most developing countries respiratory and intestinal infections account for most of the childhood diseases caused by environmental contamination (Basu and Stephenson 2005).

Nutrient deficiency occurs when an individual's nutrient intake falls below the recommended requirements. The three main categories of nutrients are calories, proteins and micronutrients. The survival of children is influenced by the availability of these nutrients to both the mother and child (Mosley and Chen 1984). The diet of the mother during pregnancy has an effect on both birth weight and breastfeeding (Shrimpton 2003), which in turn have an effect on the survival of the child. Nutrition has an effect on the growth of the fetus and on the quality and quantity of breast milk. The lack of adequate micronutrients can result in a compromised immune system and susceptibility to infections, thus affecting the rate of child mortality (Cunningham-Rundles, McNeeley and Moon 2005).

Child injuries include physical injury, burns and poisoning. An injury to a child can be intentional or accidental.

Personal illness control implies a situation where healthy individuals take preventative measures against illness and sick individuals seek medical attention. Immunisation is a measure taken to prevent certain potentially fatal childhood illnesses and is less expensive and more effective than treatment of those illnesses (Foster 1984).

Figure 2.2 Mosley and Chen framework of the proximate determinants of child mortality



Adapted from Mosley and Chen (1984)

Fertility and child mortality are affected by similar demographic and socio-economic variables. The demographic and socio-economic variables that affect both fertility and child mortality that are of interest in the analysis of these two phenomena, and their causal links, are the level of education of the mother, the economic status of the household, the religion of the mother, the age of the mother, place of residence, parity, whether a child was wanted, and the sex of the index child.

2.1.2 Mechanisms linking child mortality to fertility

The death of a child may affect fertility when couples try to replace the child who has died, or to insure against future mortality. Child mortality affects fertility through three mechanisms: physiological, replacement, and hoarding effects (Schultz 1978; Olsen 1980; Rizk, Stokes and Nelson 1982; Sah 1991; Palloni and Rafalimanana 1999). Rizk, Stokes and Nelson (1982) argue that at different stages of the demographic transition of a population the effects of child mortality on parents, and the number of children they have, are different. In low fertility countries, the replacement effect is more evident when compared to high fertility countries.

2.1.2.1 Physiological effect

The physiological effect operates through premature weaning when a child who is breastfeeding dies. The resultant cessation of breastfeeding triggers the resumption of menstruation and ovulation, increasing in the chances of conception and resulting in a shortened birth interval. Breastfeeding prevents conception during the first year after the birth of a child and in the absence of breastfeeding conception is only prevented for about two months (Lindstrom and Kiros 2007).

This mechanism is more evident in populations where breastfeeding is a universally accepted practice, where there is prolonged breastfeeding, and where use of contraceptives is uncommon, that is in pre- or early-transition populations (Palloni and Rafalimanana 1999; Rajbhandary 1999).

2.1.2.2 Replacement effect

The replacement effect occurs when couples intentionally decide to replace a dead child by having another child immediately in order to reach their desired family size as soon as possible. The replacement mechanism does not have a direct effect on the growth of the population (Olsen 1980) since a dead child is replaced by a birth. The death of a child can however affect the birth interval by the cessation of contraceptive use and an increase in coital frequency (Grummer-Strawn, Stupp and Mei 1998; Rajbhandary 1999). This leads to a more rapid transition on the part of a couple to having another child. Gyimah and Fernando (2004), and Rahman (1998) hypothesise that those women who have lost a child are less likely to use contraceptives as they will be attempting to replace the dead child as soon as possible. Gyimah and Fernando (2004) identify a number of studies conducted in sub-Saharan Africa that corroborate this hypothesis.

In populations where sexual abstinence is usually or traditionally practised after the birth of a child, the death of a child may shorten the period of sexual abstinence. The replacement effect is more pronounced in populations that control their fertility (Rajbhandary 1999; Tymicki 2005). Replacing a dead child is usually associated with the family size that the couple desire to have. If parents have not reached their desired family size, the death of a child might motivate them to replace the dead child. As a result, the replacement behaviour of parents is presumed to decline as they reach the number of children they desire to have.

In countries where there is a preference for male children, the death of a male child could have an effect on the parents' decision to replace the male child (Lehrer 1984). In societies where male children are perceived to be more valuable than female children parents are more likely to attempt to replace a dead son. In such societies, male children are preferred because they carry the family name and they are seen to be able to support the family financially or in the form of labour.

Rajbhandary (1999) states that the risk of closing the birth interval after a child's death is time-dependent and declines over time. The effect of a child death on subsequent fertility is stronger in the period immediately following a child's death, but becomes weaker over time. A study conducted in Kenya, Mali, Burundi, Ghana and Zambia by Grummer-Strawn, Stupp and Mei (1998) showed that the effects of a child death are strongest 9 to 24 months after the death of a child in those countries. In a study conducted in Nepal, Rajbhandary (1999) concluded that the chances of replacing a dead child are greatest 9 to 12 months after the death of a child.

Tymicki (2005) argues that physiological and replacement effects can act simultaneously on certain populations. In populations that control fertility the use of female contraceptives can affect the ovarian cycle. The cessation of such contraception can trigger the physiological effect in women. On the other hand, in populations that practice prolonged breastfeeding the replacement effect can be observed when parents deliberately and consciously decide to replace a child. Both physiological and replacement effects operate in populations that are still undergoing fertility transition (Park, Islam, Chakraborty *et al.* 1998).

2.1.2.3 Hoarding effect

The hoarding effect occurs when a couple has more children than they initially planned or desired as an insurance against future child mortality. This effect increases the number of births a woman will have. Couples who use an insurance strategy tend to aim for a specific number of surviving children. In order to achieve the desired number of surviving children they have additional children beyond their target as a buffer against the possible deaths of future children. For example, if the parents desire to have four surviving children, they could aim to have five births so as to insure against the death of a child.

The hoarding effect is common in societies that perceive children as assets (e.g. as old age support) and in high mortality populations (LeGrand, Koppenhaver, Mondain *et al.* 2003). When the certainty or expectation of mortality increases so does the certainty of fertility (Palloni and Rafalimanana 1999). There are two forms of hoarding: the first occurs when a couple experience directly one or more deaths of their children and they may perceive that more of their own children will die and thus they may have more children than they initially desired (Ben-Porath 1976; Rahman 1998). A second form of hoarding occurs when the mortality experience of the community is high and a couple decides to have more children. As a response to high child mortality in the community, females might get married at an early age, and breastfeeding might be prolonged to maximise the survival of children (Notestein 1945 in LeGrand, Koppenhaver, Mondain *et al.* 2003). In this context, women might start having children at an early age, might stop bearing children at a late age, or might have short birth intervals, in attempts to have additional children to insure against future mortality (LeGrand, Koppenhaver, Mondain *et al.* 2003).

2.2 Methods used in analysing the effect of child mortality on fertility

A number of different methods have been applied to individual level data to analyse the effect of childhood mortality on couples' subsequent fertility. The methods used in analyses in previous studies have shown that childhood mortality has an effect on fertility. The methods used range from multivariate regression to event history analysis.

2.2.1 Analysis of the replacement effect using Ordinary Least Squares

Ordinary Least Squares (OLS) is a method used to estimate the unknown parameters of a linear regression equation. This method best describes the relationship between the observed and predicted responses by minimising the sum of squared error. To apply OLS the error terms have to be normally distributed with a constant variance (Neal and Simons 2007). The following paragraphs describe the use of OLS by various authors in their studies analysing the replacement effect.

Ben-Porath (1976) used individual level data in a labour force survey conducted in Israel in 1971 to see if the replacement effect existed at that time. The analysis was of women aged 35 years and older who had been married once, and whose husbands were still alive. He used regression analysis and the dependent variable was the probability that a given birth is a last birth (stopping probability). He found that the stopping probability was lower where a birth was preceded by a child's death, and that the magnitude of the stopping probability decreased as birth order increased. He also applied regression analysis to the logarithm of closed birth intervals. He concluded that replacement of children increases the number of births and reduces the birth intervals.

Olsen (1980) proposed a method to estimate the effect of child mortality on fertility by regressing the number of births on the number of child deaths. When the number of births is regressed on the number of deaths, there is a bias in the OLS replacement coefficient. Child mortality is a covariate of fertility and is correlated with the other covariates of fertility, since these covariates are also determinants of child mortality. This causes the bias in the replacement estimator. Olsen (1980) estimated and corrected for this bias. The regression equation he proposed allows for the estimation of hoarding. He applied this method to data from the 1973 Colombia census and concluded that there was at that time replacement in Colombia, and that, for every ten children who die, two are replaced. Zhang (1990) estimated the replacement effect in China to be 0.6 births per child death using the Olsen (1980) method.

Trussell and Olsen (1983) extended Olsen's (1980) method to accommodate situations where both replacement and hoarding strategies exist. This method is simple, as limited data is needed for the analysis. This technique requires data on the number of deaths and the number of children ever born for each woman. Palloni and Rafalimanana (1999) used this method to investigate the fertility response to child mortality using Demographic and Health Survey (DHS) data from Bolivia, Brazil, Colombia, Ecuador, Guatemala, Mexico and Peru. Their results showed the replacement factors to be in the range 0.02 to 0.4 births per child death. A replacement factor is the rate of replacement, that is, the average number of additional births which occur in response to one child death. They concluded that there was replacement in all of the countries included in the study and the magnitude of replacement varied from country to country. They then pooled the data from the low breastfeeding and high breastfeeding countries. The results they obtained suggested that the replacement effect was more pronounced in low breastfeeding countries. This method estimates the rate at which dead children are replaced, whereas other methods look at the effect of mortality on birth rates or birth intervals. Obonyo, Otieno and Muga (2005), and Palloni and Rafalimanana (1999) have applied this method to assess the effect of child mortality on fertility. Obonyo, Otieno and Muga (2005) used 1993, 1998 and 2003 DHS data from Kenya in their analysis.

A study by Kimani (2001) on the behavioural effects of infant and child mortality on birth intervals in Kenya used OLS regression on closed birth intervals. He captured the physiological, replacement and insurance effects independently of each other. His analysis is based on the effects of deaths in families of previous children on the succeeding birth interval of the index child. The analysis was restricted to Kenyan women who had at least two closed birth intervals. His reasons for analysing closed birth intervals, instead of both closed and open birth intervals, were that there were statistical and theoretical problems related to other measures of fertility when analysing the effects of child mortality on these measures of fertility. The measures that they mentioned were median birth intervals, additional number of children and number of births. It is likely that models fitted using closed birth intervals only are biased towards short birth intervals (Trussell, Martin, Feldman *et al.* 1985) and that coefficients obtained using OLS regression are biased (Olsen 1980). The research showed that couples' sexual and breastfeeding behaviours change when a child dies.

Ben-Porath (1976), Olsen (1980), Trussell and Olsen (1983) and Kimani (2001) assessed the effect of child mortality on fertility using OLS regression methods on different dependent variables. Ben-Porath (1976) used stopping probability and closed birth intervals as the dependent variables in two different investigations. Kimani (2001), like Ben-Porath (1976), used OLS regression with closed birth intervals as the dependent variable. Though this method seems to be flawed, they came to the same conclusion as other researchers who used different methods. Trussell and Olsen (1983) regressed the number of births on the number of deaths and corrected the regression coefficient to obtain a consistent estimate of replacement. Ben-Porath (1976) and Trussell and Olsen (1983) used OLS regression on births, but Ben-Porath (1976) regressed the last birth and Trussell and Olsen (1983) regressed the number of births per woman. One of the limitations of the OLS approach is that it does not tell us about the timing of births and the risk of having a child after the death of the index child.

2.2.2 Analysis of the replacement effect using the proportional hazards model

Proportional hazards models are survival models with proportional hazards functions. Proportional hazards models can be applied to discrete or continuous measures of event time data (Yamaguchi 1991). The coefficients of the proportional hazards model can be estimated without having to make assumptions about the nature or level of the baseline hazard (Yamaguchi 1991). The model assumes that the covariates are not time dependant. When time dependant covariates are incorporated into the proportional hazards model the model is called a piecewise log-rate model.

In a study conducted in Central Java, Santow and Bracher (1984) used proportional hazards models to analyse the effects on a couple of a child death on the length of time before the next birth. They extended the model by adding a time dependant variable and its interaction with the fixed covariates. They defined the variable that captures the replacement effect as the number of surviving children. In their study, birth intervals between the index child and the next birth were analysed. A comparison of birth intervals of women who had experienced a child death and those who had not was done, and from this they concluded that women who have experienced a child loss have shorter birth intervals than women who have not experienced a child death. The model that they used seems to be viable since it accommodates covariates that vary with time, but the model assumes that the baseline hazard is continuous.

Gyimah and Fernando (2002) applied Cox proportional hazards models to model the risk of closing the birth interval after a child death. They performed a comparative analysis using DHS data from Kenya and Ghana, two countries at different stages of the demographic transition. Gyimah and Fernando (2002) treated the survival status of the index child as a time-varying dummy variable. They used the model to estimate the risk of a mother having a second, third, and fourth birth after the death of the index child. In their analysis, they captured the physiological effect by focusing on the index child who died in infancy and on previous children who died as infants. The results they obtained showed that the risk of having another child was higher for couples who experienced a child death when compared to those who did not experience a child death. The physiological effect was more pronounced in Ghana, a country where the proportion of women who exclusively breastfeed is higher than that in Kenya.

The Santow and Bracher (1984) and, Gyimah and Fernando (2002) models have different time-dependent variables which capture the replacement effect. Though their methods are slightly different to the other methods they all came to the same conclusion, that women who have experienced a child loss have shorter birth intervals. Their methods to some extent try to do what the piecewise exponential method does, the difference being that the baseline hazard is not divided into splines.

Grummer-Strawn, Stupp and Mei (1998) modelled birth intervals by using proportional hazards models and assuming the baseline hazard to be piecewise exponential. All births that occurred during the first nine months after the death of the index child were ignored and intervals that began with a multiple birth where excluded from the analysis. They considered different components of the birth interval in that they assessed the effect of the death of a child on the length of the subsequent birth interval, on the interval from birth to menstruation and on the interval from birth of a child to resumption of sexual relations. They analysed births that occurred five years before the survey. They treated the death of the index child as a time-varying covariate. Their analysis was based on 46 DHSs in Africa, Asia and Latin America. Three hazard models were applied, one with the survival status variable, one with covariates added, and the last one where the breastfeeding variable was added. Their results showed that birth intervals in Africa are shorter than those in the other regions if the index child survives, but similar in all the three regions if the index child dies. They estimated the median birth interval to be about 60 per cent longer if the child survives than if the child dies, and the effect of closing the birth interval is stronger if the child dies within 24 months after the death of the index child.

In their study, Palloni and Rafalimanana (1999) applied hazard models to analyse DHS data from five countries in South America, using ideas suggested by Grummer-Strawn, Stupp and Mei (1998). They used the estimates they obtained from the piecewise exponential model to yield estimates of replacement factors. The difference between their method and that used by Grummer-Strawn, Stupp and Mei (1998) lies in the definition of the time-dependent variable that captures the death of a child. They defined a time-dependent variable in terms of three categories: the death of a child, the death of a breastfeeding child that interrupts breastfeeding, and the death of a child after that child stopped breastfeeding. As expected, the results obtained using the piecewise exponential model suggest that the risk of closing the birth interval is greater for couples who lose a child compared to those whose child survives.

In a study conducted in Nepal, Rajbhandary (1999) showed that the risk of having another child is higher if a child dies than if the child survives and the risk is higher if the child who dies is male, using a logistic formulation of the discrete time hazard model. He concluded that the effect of a child death on birth interval declines over time and the age at death of the index child has an effect on replacement. The model that he proposed was extended to allow for time-dependent effects of child death. The death of the index child is the variable of interest in Rajbhandary's (1999) research. A month is taken as a discrete time unit, and each discrete time unit for each subject is modelled. The birth interval is represented by several observations, one for each month. For each observation, the dependent variable takes the value one if there was a birth that month. The fixed covariates were assumed to be the same every month and the time covariates could change every month.

Tymicki (2005) assessed the relationship between infant mortality and subsequent fertility using the multilevel hazard model in a study done on a small historical population in Poland. The multilevel hazard model he used accounts for the heterogeneity and time dependency at mother and child level. The hazard is assumed to be linear although the slope changes between different intervals. In Tymicki's (2005) research, the death of the previous child is the main covariate and it captures the replacement effect. He looked at two cohorts, one that controlled their fertility, and a natural fertility cohort. Tymicki (2005) estimated the transition from natural to controlled fertility in the small historical population to have started at the beginning of the twentieth century. He defined the cohort born before 1900 as the natural fertility cohort, and the cohort born after 1900 as the cohort that controlled their fertility. The replacement effect was more pronounced in populations that controlled their fertility, and he came to the conclusion that the death of a child speeds up the transition to the next birth.

Grummer-Strawn, Stupp and Mei (1998), and Palloni and Rafalimanana (1999), used piecewise exponential models to estimate the effect of a child death on the risk of closing the birth interval. While their methods are the same, Palloni and Rafalimanana (1999) go on to combine the results obtained from the hazard model so as to get estimates for the replacement factors. Rajbhandary (1999) uses a logistic formulation of the discrete time hazard model, and this model does what the piecewise exponential model does. The multilevel hazard model used by Tymicki (2005) contains unobserved heterogeneity because women and children have underlying differences which need to be accounted for. For example some women are more fertile than others due to their genetic makeup. This model is a piecewise exponential model which has a multilevel structure (woman level and child level).

2.2.3 Analysis of the hoarding effect

While the hoarding effect is very important in assessing the effect of child mortality on fertility it has to date remained largely unstudied (LeGrand, Koppenhaver, Mondain *et al.* 2003). The reason for this could be because any analysis of the hoarding effect must examine people's perceptions of mortality risks and how these perceptions influence their reproductive behaviours. This information can be accessed through asking questions in organized surveys which can be expensive to conduct.

Rahman (1998) conducted a study in a rural area of Bangladesh on the effects of childhood mortality on contraceptive use by testing the replacement and insurance hypothesis. The components of contraceptive use he used were acceptance of and discontinuation of contraception by couples. He used the survival status of the index child before acceptance or discontinuation of contraception to capture the replacement effect, and the death of previous children captured the hoarding effect. From his study, he concluded that the relative risk of accepting and continuing birth control was lower for couples who experienced the death of child or previous children's deaths.

LeGrand, Koppenhaver, Mondain *et al.* (2003) did a qualitative analysis on the insurance effect in Senegal and Zimbabwe. They collected data on reproductive strategies, reproductive behaviour, and child survival. The sources of data were individual men and women interviews, husband and wife interviews, and focus group discussions. Data were collected in high and low infant mortality areas in the urban and rural parts of the countries being studied. They concluded that limited insurance behaviour existed in both countries.

LeGrand and Barbieri (2002) used logistic regression to assess the insurance effect using pooled Demographic and Health Survey data from 21 African countries. They estimated community-level mortality risks in the past 12 years. They concluded that there was an insurance effect on the timing of first births.

The approach used by LeGrand, Koppenhaver, Mondain *et al.* (2003) measures the hoarding effect at the community level, and the approach used by Rahman (1998) measures the hoarding effect at the individual level. A more reliable and fruitful approach would be to measure the hoarding effect both at the individual and community level.

2.3 Summary

The two main statistical methods used in studies analysing the effect of child mortality on fertility are the OLS regression and proportional hazards models. Olsen (1980), and Trussell and Olsen (1983), among others, developed multivariate techniques to avoid the problems encountered in bivariate analysis (Montgomery and Cohen 1998). In the 1970s hazard rate models began to be used in the analysis of child mortality and birth intervals, while at the same time the collection of individual level data started to expand. Grummer-Strawn, Stupp and Mei (1998) were among the first to start using piecewise exponential models to examine the effect of child mortality on the length of the subsequent birth interval.

The causality between child mortality and fertility occurs in both directions and this causes statistical problems. When analysing the effect of child mortality on fertility there is a need to model the data in such a way that the subsequent birth occurs at least 9 months after the death of the index child (Obonyo, Otieno and Muga 2005). This would solve the problem of reverse causality.

Since the physiological, replacement and hoarding effects can coexist in a society (Montgomery and Cohen 1998), a time-dependent variable has to be defined in order to capture the effects and analyse them seperately. For example, the replacement effect is captured by defining the time-dependent variable that indicates the death of a child that opens the interval.

Studies conducted in assessing the physiological and replacement effects using aggregate data are inconclusive in that the findings state that child mortality has no effects, or has unclear effects, on fertility, whereas all the studies conducted using individual level data show that child mortality has a significant effect on fertility at the individual level (Obonyo, Otieno and Muga 2005).

3 DATA

In this chapter, a description of the source of the data used in this study is presented and the quality of the data is assessed.

3.1 Data sources

The data used in this research are from the Demographic and Health Surveys (DHS) of Lesotho (conducted in 2009), Kenya (conducted in 2008-09), Zimbabwe (conducted in 2005-06), Malawi (conducted in 2010) and Tanzania (conducted in 2010). These data were obtained from the Measure DHS website (www.measuredhs.com). The DHS data are collected using women's, men's and household questionnaires. This research uses data obtained from the women's questionnaire. The data are based on the birth histories of women aged 15-49 years. Standard questions are asked in DHS and as a result it is possible to draw comparisons between the countries included in the study.

The DHS of the countries in this study are conducted by the statistical agencies and the Ministries of Health of the countries in collaboration with ICF Macro, and the frequency with which they are conducted varies between countries. Although Measure DHS says the surveys are commonly conducted every five years, in the countries under investigation the interval between surveys varies. Each survey is a follow-up survey from the previous surveys (unless it is the first survey), and the surveys provide updated estimates of population and health indicators. Households are selected for the survey using sampling frames developed by the statistical agencies. The samples for the DHS are designed to provide estimates that represent the provincial and national population. Table 3.1 shows the number of women and households interviewed in each of the five countries. The analysis focuses on women who had had at least one birth. As a result the analysis is restricted to 6102 women in Kenya, 5191 women in Lesotho, 18041 women in Malawi, 7326 women in Tanzania, and 6725 women in Zimbabwe.

Table 3.1 Demographic and Health Survey Sizes

DHS	Country	Households interviewed	Women interviewed	Women with ≥1 birth
2005-2006	Zimbabwe	9285	8907	6725
2008-2009	Kenya	9057	8444	6102
2009	Lesotho	9391	7624	5191
2010	Malawi	24825	23020	18041
2010	Tanzania	9623	10139	7326

Source: Adapted from Zimbabwe, Kenya, Lesotho, Malawi and Tanzania DHS reports

3.1.1 Fertility and child mortality levels and trends in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe

This section presents the fertility and childhood mortality levels and trends in the preceding years before the surveys in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe. The main sources of fertility and childhood mortality are surveys and censuses since vital registrations in sub-Saharan African countries are not complete. The data used in this literature review are from the Demographic and Health Surveys and censuses conducted in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe. Information obtained from these surveys and censuses is assumed to be reliable.

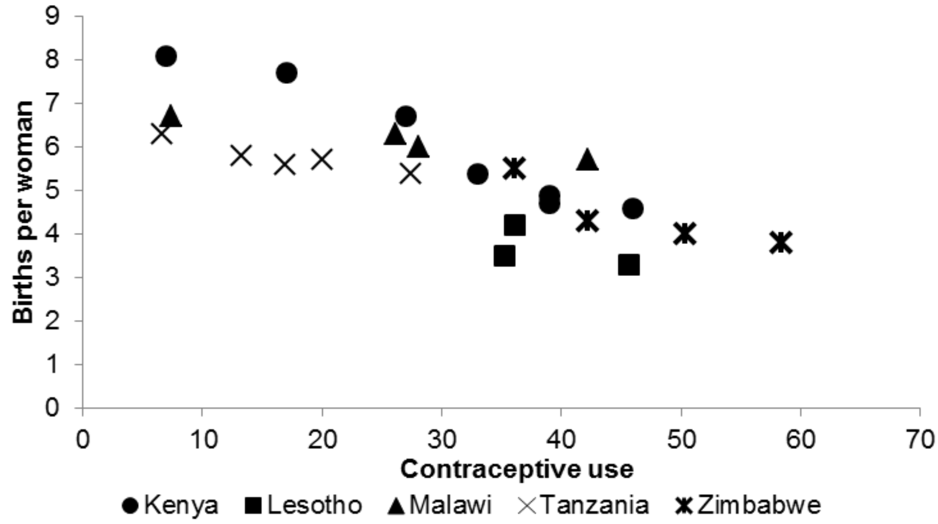
Table 3.2 Fertility, under-five mortality levels and contraceptive prevalence

Country	Year	Total Fertility	Average parity	IMR	U5MR	Contraceptive prevalence
Kenya	1977/78 KFS	8.1		87.3	144.8	7.0%
	1984 KCPS	7.7				17.0%
	1989 KDHS	6.7	7.9	59.6	89.2	27.0%
	1993 KDHS	5.4	8.0	61.7	96.1	33.0%
	1998 KDHS	4.7	7.2	73.7	111.5	39.0%
	2003 KDHS	4.9	6.9	77.0	115.0	39.0%
	2008/09 KDHS	4.6	6.3	52.0	74.0	46.0%
Lesotho	1976 Census	5.4		122.0		
	1986 Census	5.3		84.4		
	1996 Census	4.1		74.0		
	2001 LDS	4.2	5.4	81.0	113.0	36.1%
	2004 LDHS	3.5	5.5	91.0	113.0	35.2%
	2009 LDHS	3.3	4.6	91.0	117.0	45.6%
Malawi	1992 MDHS	6.7	7.7	134.0	234.0	7.4%
	2000 MDHS	6.3	7.1	104.0	189.0	26.1%
	2004 MDHS	6.0	7.2	76.0	133.0	28.1%
	2010 MDHS	5.7	7.3	66.0	112.0	42.2%
Tanzania	1991/92 TDHS	6.3	7.2			6.6%
	1996 TDHS	5.8	7.6	88.0	137.0	13.3%
	1999 TRCHS	5.6	7.1			16.9%
	2002 Census	6.3		95.0	153.0	
	2004 TDHS	5.7	7.1	68.0	112.0	20.0%
	2010 TDHS	5.4	6.1	51.0	81.0	27.4%
Zimbabwe	1984 ZRHS					26.6%
	1988 ZDHS	5.5	7.3	53.0	75.0	36.1%
	1994 ZDHS	4.3	6.9	53.0	77.0	42.2%
	1999 ZDHS	4.0	6.5	65.0	102.0	50.4%
	2005/06 ZDHS	3.8	6.1	60.0	82.0	58.4%

Source: Adapted from Zimbabwe, Kenya, Lesotho, Malawi and Tanzania DHS reports
Note: Average parity is for women 45 to 49 years old

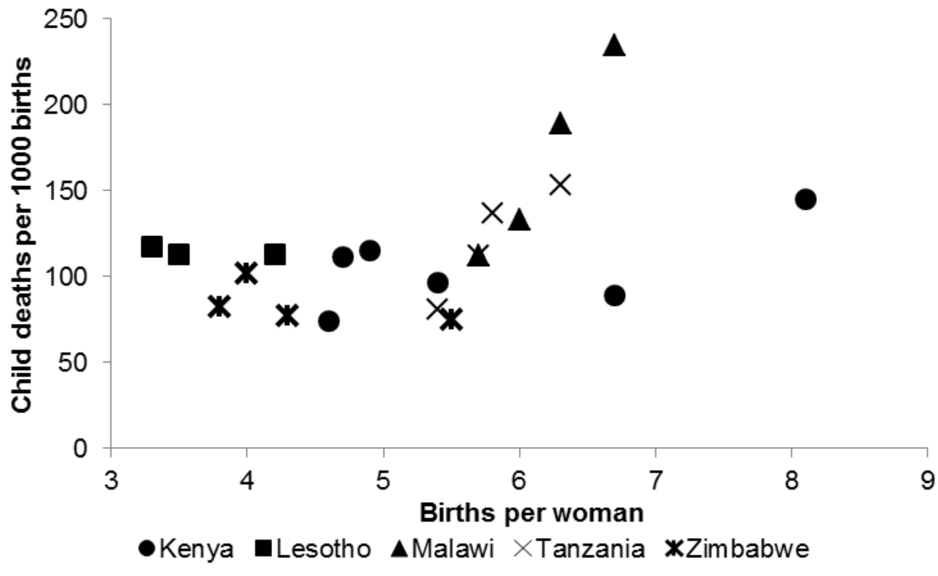
Table 3.2 shows a decline in fertility in the five countries but taking place at different paces. Fertility levels in Malawi and Tanzania are currently high. Recent DHS estimates show that contraceptive prevalence is more than 40 per cent in all five countries except for Tanzania, where the prevalence is estimated at 27.4 per cent. Parities for women aged 45 to 49 years are high in all the five countries, ranging from 6 to 8 births per woman aged 45 to 49 years in Kenya, Malawi, Tanzania and Zimbabwe. Under-five mortality declined from the 1960s and 1970s to the late 1980s. This decline reversed after 1990 when the prevalence of HIV/AIDS started increasing.

Figure 3.1 Relationship between total fertility rate and contraceptive prevalence in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe



As shown in Figure 3.1, total fertility rate and contraceptive prevalence are negatively related. In all five countries there has been a decline in the total fertility rate, which could be the result of an increase in the use of contraception.

Figure 3.2 Relationship between total fertility rate and under-five mortality



Fertility and mortality are positively related (Figure 3.2)

3.2 Data quality

The data collected in DHSs tends to be of a high quality for most of the surveys, but surveys in developing countries are prone to incomplete responses. The quality of the data will be evaluated by examining the completeness of responses giving birth dates, age heaping, displacements and omission of births. There are some problems in DHS data caused by enumerator error and response error (Cleland 1996). Response errors occur when respondents give inaccurate information. Many respondents have difficulty in recalling information on birth or death dates. In DHSs the problem of event dating is a problem which stems also from some interviewers who try to avoid questions about children who were born during the five years before the survey so as to reduce their workload (Cleland 1996). There are supplementary questions in the survey about children under the age of five at interview date. Anthropometric measures of these children also have to be captured and recorded. As a result, interviewers tend to omit or displace births that occurred within the five year period before the survey.

3.2.1 Completeness of age and date of birth of women

In each survey, every woman has to respond to three questions concerning her age in completed years, month of birth, and year of birth. At least two of the three, year of birth and age should be completed. One of the instructions in the DHS interviewer manual (ICF International 2012) used in countries that do the surveys which concerns this information, states that, if the respondent cannot give information on age, year and month of birth the enumerator should ask the respondent for a document that gives the respondent's age. Where there is no document forthcoming the enumerator is instructed to estimate the respondent's age by using information on her children's ages, or by looking at her appearance, although this assessment could contain a bias. Sometimes age, month and year of birth require imputation if there are inconsistencies.

Table 3.3 Completeness of information on date of birth and age in the women's questionnaire (% of respondents)

Completeness of information	Kenya	Lesotho	Malawi	Tanzania	Zimbabwe
Month and year complete	72.55	98.45	89.17	81.77	98.99
Year imputed	1.11		0.03	0.08	
Month imputed	25.15	0.20	10.27	18.06	0.98
Year and age-year ignored		1.22			
Year and month imputed	1.18	0.13	0.53	0.09	0.03
Total	100.00	100.00	100.00	100.00	100.00

Source: Adapted from Zimbabwe, Kenya, Lesotho, Malawi and Tanzania DHS reports

Table 3.3 shows the proportion of respondents who provided information on age, year of birth and month of birth. The highest level of reported birth dates was in Lesotho and Zimbabwe, where over 98% of respondents managed to give externally valid information on the month and year of birth. In Kenya, about 73% of respondents gave information on their date of birth. Kenya has the highest proportion of women (1.18%) who did not give information, or had inconsistencies in terms of the year and month of birth, and this required imputation. In Kenya, Malawi and Tanzania over 10% of the respondents had their month of birth imputed.

3.2.2 Digit preference (women)

There is a particular need to assess the quality of age data for women aged 15-49 years since this affects the age at birth of a child. In reporting on age there is a tendency for individuals to prefer certain digits, or prefer a certain year of birth. This results in age heaping, and where present, can compromise the quality and consistency of age data. Figure 3.3 shows the distribution of women by age in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe. In all of the countries surveyed, the distribution of women by age is not smooth; this is more likely to be random error.

Figure 3.3 Distribution of women by age group, Kenya, Lesotho, Malawi, Tanzania and Zimbabwe

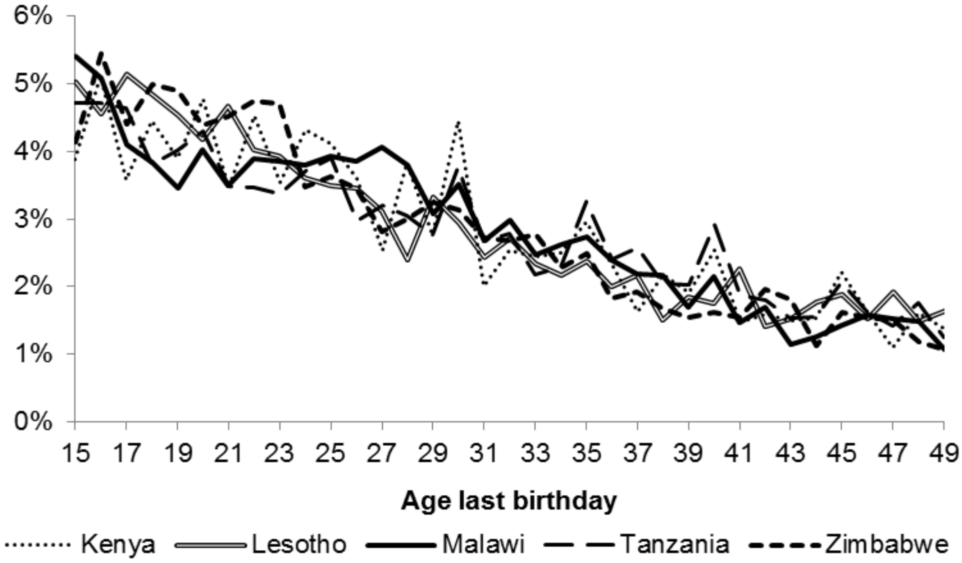


Figure 3.3 shows minimal age heaping in Lesotho, Malawian and Zimbabwean women. Moderate age heaping is observed in Kenyan and Tanzanian women. In the five countries there seems to be a preference for digits ending with 0, 5 and for even numbers, which is as expected since people tend to report digits that are multiples of 2, 5 and 10 (Nagi, Stockwell and Snavley 1973).

3.2.3 Completeness of reporting of age and date of birth of children

The accuracy of information on the date of birth of children is determined by looking at how complete the information that was reported is and if there is any information missing. In the dataset there is a date flag indicating whether the date of birth was imputed and the type of imputation. The frequency of the date flag is used in this study to create Table 3.4 which shows the proportion of children whose date of birth was reported or imputed. There was a high level of date of birth reporting (more than 95%) in all five countries. Generally, information on the date of birth is almost complete in the five countries.

Table 3.4 Percentage of mothers providing complete information on date of birth and age of children

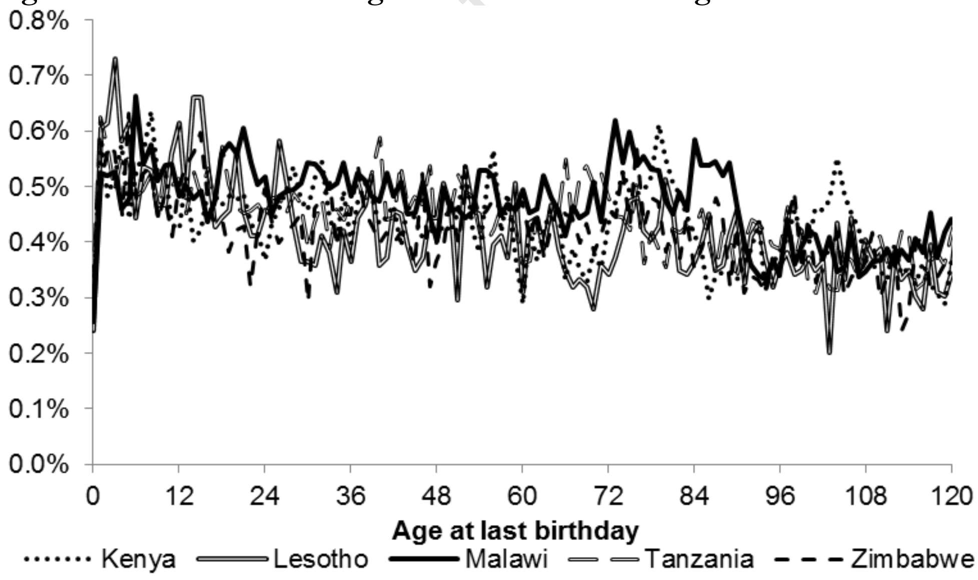
Completeness of information	Kenya	Lesotho	Malawi	Tanzania	Zimbabwe
Month and year complete	95.70	98.93	99.38	99.42	99.36
Year imputed		0.01	0.00		
Month imputed	3.11	0.10	0.28	0.29	0.43
Year and age- year ignored		0.39			
Age and month imputed	0.83	0.42	0.30	0.28	0.12
Year and month imputed	0.28	0.01	0.02		0.02
Age and year imputed	0.00	0.08			0.01
All imputed	0.06	0.05	0.02	0.02	0.06
Total	100.00	100.00	100.00	100.00	100.00

Source: Adapted from Zimbabwe, Kenya, Lesotho, Malawi and Tanzania DHS reports

3.2.4 Digit preference (children)

Figure 3.4 shows the distribution of surviving children by their ages. There is not much age heaping in the children's age data with the exception of Kenya and Malawi, where heaping is evident at ages six and ten. This could be an indication of displacement of year of birth.

Figure 3.4 Distribution of age in months of surviving children



3.2.5 Age at death of deceased children

There are two age at death variables in the DHS data sets: b6 (age at death in days, months and years), and b7 (age at death imputed in months). The age at death variable imputed in months is not used when calculating child mortality because the imputed month is the lower bound of the age interval (Hill 2012).

Figure 3.5 Distribution of age at death in months (children)

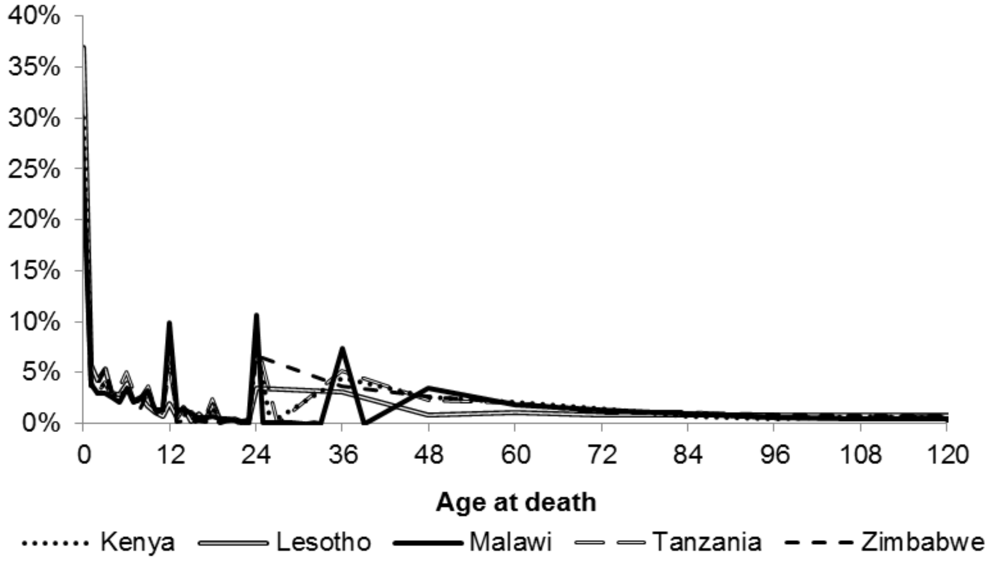


Figure 3.5 illustrates the distribution of age at death in months. Heaping of age at death is common in multiples of six months as expected. Heaping is evident at 12 months, 24 months and 36 months. The heaping at 12 months can affect the infant mortality rate if the age at death was rounded up to 12 months.

3.2.6 Displacement of births

Displacement of births occurs when the exact years of birth are not reported at all, not accurately reported, or when the interviewer does not record the years of birth correctly. This error introduces bias into birth intervals. The preceding birth interval is underestimated for displaced children, and the succeeding birth interval is overestimated. Births are omitted when they are not reported at all in a woman's birth history. In this study, we will examine the number of births per year three to eight years before the survey in order to assess the extent of displacement. In Figure 3.4 age heaping was identified at age 6. In this section, we will interrogate this finding to establish whether there is displacement. Displacement of births from age four to age five is observed if the survey was conducted early in the year (Arnold 1990). The average birth intervals by year of birth before the survey will be plotted to see if there was any significant effect on birth intervals.

Figure 3.6 Number of surviving births by years before the survey

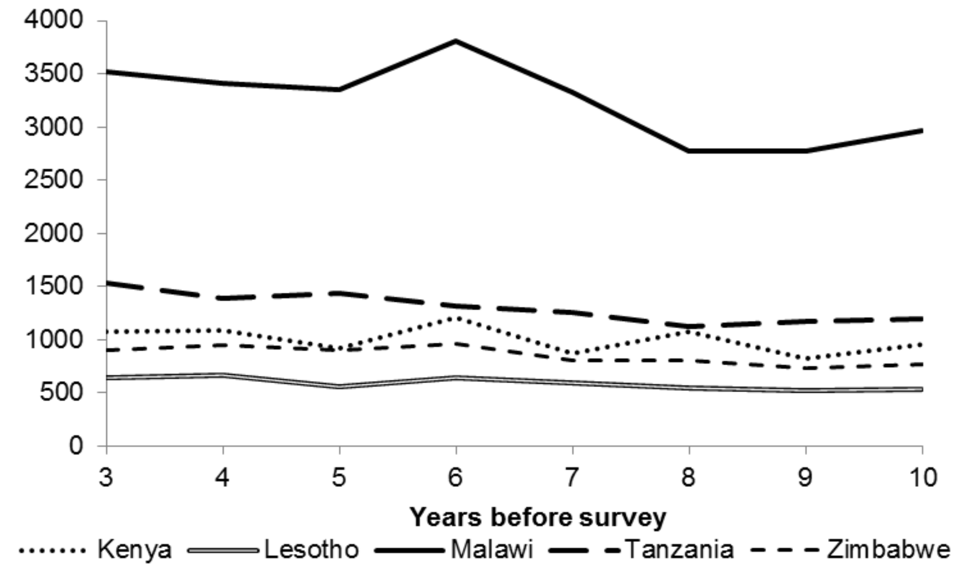
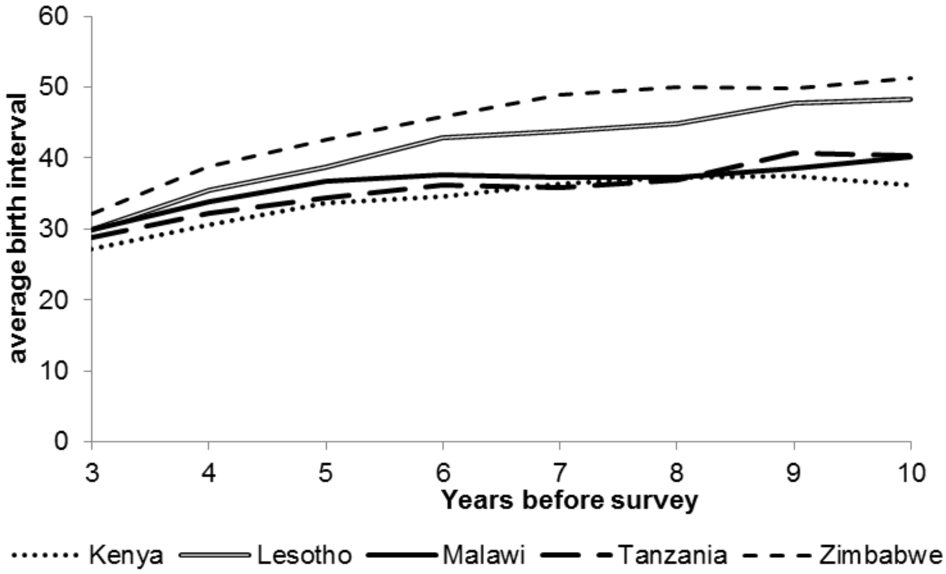


Figure 3.6 shows evidence of moderate displacement from age five to six in all the countries except Tanzania. In Tanzania, the displacement is from age four to age five, as expected as the survey was conducted early in 2010. This displacement could have an effect on the succeeding birth intervals.

Figure 3.7 Number of births of children who died before the survey by years before the survey

There is displacement of birth dates (5 years before the survey) to an earlier date (6 years before the survey) for deceased children in Kenya, Lesotho and Malawi (Figure 3.7).

Figure 3.8 Average birth interval (in months) by years prior to survey



The displacement of births shown in Figure 3.6 is as a result of the overestimation of birth intervals in Malawi and Tanzania as seen in Figure 3.8, although the extent of the overestimation is minimal. The displacement of births observed in Kenya, Lesotho and Zimbabwe has no effect on the length of the succeeding birth interval.

An assessment of the quality of the data shows that there are errors in the data, such as age heaping for women, and displacement of births. The data on the response of women to information on the date of birth and age for both mothers and children is almost complete. In general, the errors do not appear to be substantial and should have only minor effects on the results of the analysis.

4 ANALYSIS OF THE REPLACEMENT EFFECT

This chapter presents the response variable, the succeeding birth interval (Section 4.1) and the descriptive statistics of the covariates (Sections 4.2 and 4.3). The piecewise log-rate model is discussed in Section 4.4, and the risk of closing the birth interval is established in Section 4.5 using the piecewise log-rate model.

4.1 Succeeding birth interval

The variable under investigation is the birth interval that commences with the birth of an index child, and which is either closed by a subsequent birth, or truncated by the survey date. Event history analysis is used to analyse these data since time to the next birth for some of the births is truncated.

Since there is a possibility of child mortality affecting birth intervals, and birth intervals affecting child mortality, there is need to ensure in the study that the birth of the child that closes the birth interval occurs at least 9 months after the death of the index child. In this study, the death of a child can only affect the subsequent birth if the birth occurs at least nine months after the death of the index child and the death of a child is relevant to the study if it has an effect on the birth of another child. Thus the death of a child is treated as a time-varying covariate. Observations with births that occur less than 9 months after the death of a child were dropped from the analysis.

4.1.1 Descriptive statistics of the succeeding birth interval

Table 4.1 shows the descriptive statistics of closed birth intervals. Zimbabwean and Lesotho women have the longest median birth intervals in comparison to women from the other three countries and this was also shown by Moultrie, Sayi and Timæus (2012). This is as expected since the total fertility rates of the two countries are lower. When fertility falls, some women may stop traditional birth spacing methods (as some of them might start using modern contraceptives) resulting in longer birth intervals. It should be noted that low fertility does not mean long birth intervals Malawian and Tanzanian women have the shortest length of median birth intervals.

Table 4.1 Descriptive statistics of closed birth interval

Country	N (weighted)	Median	Mean	Std. Dev.
Kenya	16119	35	35.44	22.06
Lesotho	9035	37	44.01	25.34
Malawi	52852	32	35.73	18.64
Tanzania	21931	31	36.15	20.24
Zimbabwe	12252	40	45.47	24.80

In Kenya, Lesotho, Malawi, Tanzania and Zimbabwe the distribution of the length of the birth interval is skewed to the right as expected. As seen in Figure 4.1, the patterns of heaping in each of the five countries are different.

Figure 4.1 Distribution of the length of the succeeding birth interval

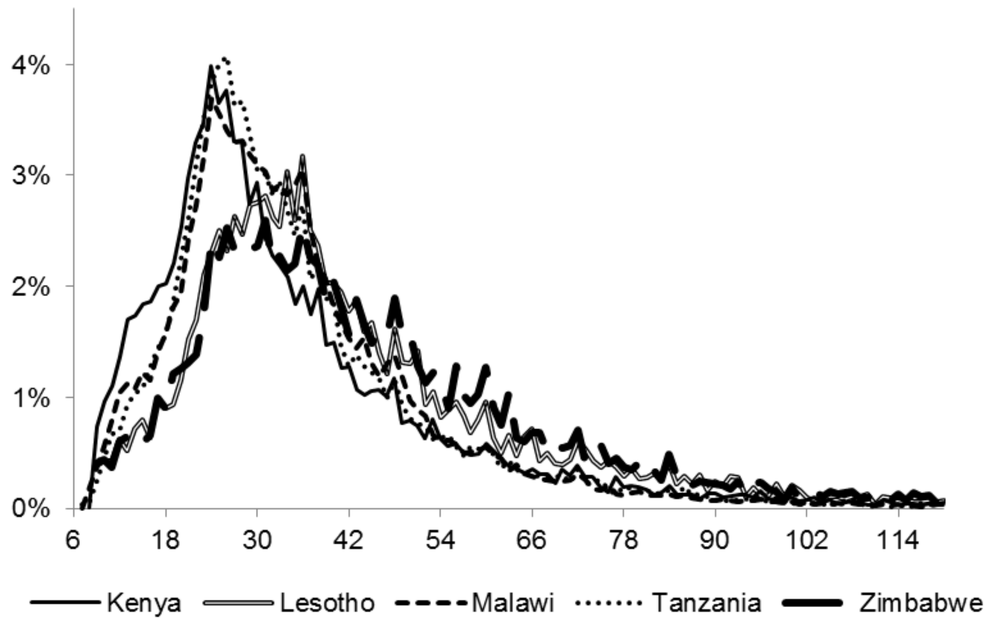


Figure 4.1 shows the distribution of the length of the succeeding birth interval in all five countries. In Kenya, heaping is minimal. It is likely that women in Kenya reported the date of birth of the child who opens the interval as exactly 24, 36, 48 or 60 months after the birth of the child who closes the previous interval.

There is moderate heaping on the length of the subsequent birth interval for Lesotho women. Heaping can be seen at interval lengths 27, 31, 34 and 36 months. This could have been caused by imputation of dates of birth of the children. The heaping of birth intervals is minimal in Malawi and evident at interval lengths of 24, 36 and 48 months. In Tanzania, the heaping of birth intervals is minimal and evident at lengths of

26 and 36 months. Compared to the other four countries, Zimbabwe has extensive heaping, evident at length intervals of 24, 26, 31, 36, 48 and 60 months.

4.2 Childhood mortality

The key covariate of birth interval in this investigation is the survival status of the index child (child mortality). This variable is binary, with two response categories: 'yes' (child died) and 'no' (child survived), where 'child survived' is the reference category. This variable is of interest as one hypothesises that couples who lose a child try to replace the dead child, and therefore the succeeding birth intervals for couples who lose a child between births and those who do not are different.

4.2.1 Kaplan-Meier method

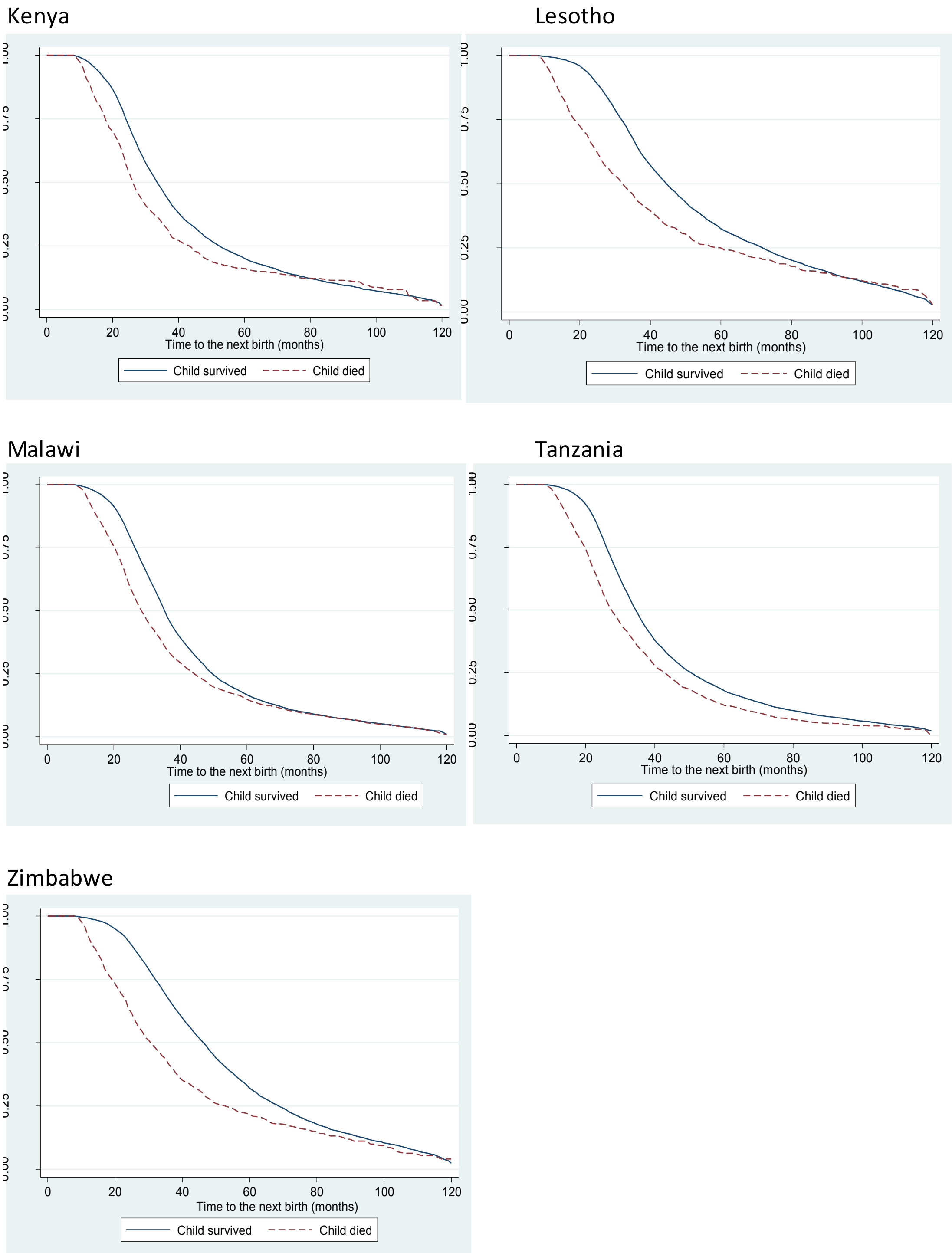
The Kaplan and Meier (1958) method is also known as the product limit method (Reid 1981) and is used to estimate the survival of a population for a certain amount of time even when there are censored observations. The estimate obtained by using this method can be used to plot a survival curve and estimate the survivor function of time to the next event data. This method has an advantage over the Life Table method in that it does not group the survival times of the individuals in a sample, but instead uses exact survival times. The Life Table method is a non-parametric method that can be used to estimate the survivor function, and the survival times are grouped into intervals. In this research we use the Kaplan and Meier (1958) estimator to estimate the proportion of women who have another birth after the death of the index chid.

Let $S(t)$ be the probability that no event occurs before time t. From a population size N, let the observed time until an event be $0 \leq t_1 \leq t_2 \leq \ldots \leq t_N$; for each t_i the number at risk prior to time t is n_i. The time between t_i and t_j might not be the same. Let d_i be the number of events at time t_i. The Kaplan and Meier (1958) estimator is the non-parametric maximum likelihood estimate of the survival function $S(t)$ and it is of the form:

$$\hat{S}(t) = \prod_{t_i < t} \frac{n_i - d_i}{n_i}$$

The Kaplan and Meier (1958) curve is a plot of the Kaplan and Meier (1958) estimate and is a step function (a series of horizontal steps). On the curve the times of the censored data are seen as vertical lines.

Figure 4.2 Kaplan-Meier survival curves of succeeding birth intervals by survival status of index child



The survival plots in Figure 4.2 inform us about the proportion of women who progress to the next birth in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe by the survival status of the index child. There are differences in the transition to the next birth between those women whose child died and those women whose child survived. The differences are stronger in the low fertility[1] countries, Lesotho and Zimbabwe. Women who experienced a child death progress to the next birth faster than those women who did not experience a child death.

Table 4.2 Length of median birth interval in months by survival status of index child based on Kaplan-Meier survivor function

	Kenya	Lesotho	Malawi	Tanzania	Zimbabwe
Child survived	36	50	36	36	49
Child died	28	36	30	29	34
Difference in birth interval	22.2%	28.0%	16.7%	19.4%	30.6%

The median birth interval is the time by which half of the women in the sample have had another child after an index birth. The length of the median birth interval in months with respect to the survival status of the index child is presented in Table 4.2 which shows statistically significant differences between the duration of the median birth intervals for women who experienced a child loss and those who did not experience a child loss. The median birth interval is shorter for women who experienced a child death compared to those who did not.

The length of the median birth intervals for women whose child survived or died in Lesotho (50 and 36) and Zimbabwe (49 and 34) are longer than in the other three countries. Since the birth intervals under analysis are for the period 1970 to 2010, the possibility exists that they have changed during that period. In Lesotho and Zimbabwe, the birth interval is 28% and 30.6% shorter when a child dies than when the child survives. In the other three countries, the length of the birth interval is shorter by 22.2% (Kenya), 16.7% (Malawi), and 19.4% (Tanzania). The reduction in the birth interval is much lower for high fertility countries than that for low fertility countries as expected.

4.3 Covariates

The covariates that affect the succeeding birth interval used in the analysis are chosen based on previous work done in this area by Palloni and Rafalimanana (1999), Rajbhandary (1999), Tymicki (2005), and Grummer-Strawn, Stupp and Mei (1998). The covariates identified in this literature are: education of mother, age of mother at birth of the index child, residential area, religion, socio-economic status of household, previous birth interval, birth order, and sex of index child, and whether the index child was wanted or not. The variables mentioned above affect both fertility and childhood

[1] Low fertility according to African standards

mortality and were chosen so as to avoid possible simultaneity biases. There are unseen variables that also affect both and this further complicates matters as these unseen variables are not controlled for. It should be noted that the chosen covariates that affect both are not sufficient to fully avoid possible simultaneity biases.

The two variables, residence of mother and socioeconomic status of mother, might be affected by the 'current status variable' problem. A current status variable problem occurs when information collected during a DHS is different from the time of the actual occurrence of the event. Information collected based on these variables is collected at the time of the survey and might be different from the time the woman gave birth to her child. Interpretation of results concerning these variables should be done with caution.

To assess the effect of childhood mortality on fertility the factors that affect both phenomena have to be controlled so as to see how the effect varies within the categories of the covariates (Gyimah and Fernando 2002). In our research the factors that were excluded were religion, whether the index child was wanted, and residential area. The reason for this is that religion had no effect on fertility in the countries analysed. The variable, whether the index child was not wanted, was not considered in this analysis as it only applied to children who were born five years before the survey. Residence of the mother was not considered because the mother could have changed place of residence subsequent to the time the child was born. There was an attempt to add ideal number of children as a covariate of succeeding birth interval in order to see if this has an effect on the replacement effect. Since the covariate was insignificant, it was excluded from the analysis.

4.3.1 Education

The education of the mother was grouped into three categories: no education, primary education and secondary or higher education. The third category merged secondary and tertiary education since there were only a few women with tertiary education in the surveys. The effect of the mother's education on fertility is negative (Lehrer 1984), but in some African countries women with low education might have higher fertility than women with no education (Basu 1994). Women without an education usually stay at home and look after their children. Women with a low level of education are usually employed in low paying jobs and do not have time to look after their children. Education and child mortality are strongly related and they have an inverse relationship

(Martin, Trussell, Salvail *et al.* 1983), an increase in education being associated with a decline in child mortality. According to Gyimah and Fernando (2002), the risk of a subsequent birth is lower for women with an education than for those with no education. The effect of education on birth interval is complex. The length of the birth interval can decrease with an increase in the level of a woman's education. An educated woman may have her first child at a late age and for her to attain her desired number of children she can decrease the period between births. The effect of education can be explained in terms of high contraceptive usage, labour force participation, and late age at marriage or at first birth (Kimani 2001).

4.3.2 Age

The age of the mother at birth of the index child was coded in conventional five year age groups from the age of 10 years to 49 years. This variable is used to control for the fecundity of women at different ages and the change of fecundity over time. Older women tend to have longer birth intervals due to reduced fecundity, and children of very young mothers tend to experience noticeably higher child mortality.

4.3.3 Wealth

The relative socio-economic status of the household (in this analysis regarded as a proxy for wealth) is categorised into five categories of equal size: poorest, poorer, middle, richer and richest. The higher the socioeconomic status of the household the longer the birth interval will be (Obonyo, Otieno and Muga 2005). The association between wealth and fertility is explained by the access to and affordability of contraceptives of wealthier women.

4.3.4 Previous birth interval

The previous birth interval is grouped into four categories; no previous interval, short (less than 30 months), medium (30 to 47 months) and long (48 or more months) birth intervals. For the first births the previous interval is defined as no previous interval. Other studies measure the previous interval as being between the date of the first birth and the date of first union of the parents. This is not a reliable measure of the preceding birth interval for first births, as those first unions that last a short time are usually omitted or displaced to earlier periods. Some of the couples whose unions have lasted a long time tend not to remember the exact dates of their first union while others find it difficult to define 'first union', to distinguish between the time they got married and first the time they had sexual relations. The previous interval is a proxy for the effect of proximate determinants, for example, length of abstinence and contraceptive use, among others (Gyimah and Fernando 2004). It is assumed that shorter preceding birth intervals are associated with shorter succeeding birth intervals, hence a higher risk of a subsequent birth (Gyimah and Fernando 2002).

4.3.5 Birth order

The birth order of the index child is coded into five categories, birth order 1, birth order 2-4, birth order 5-7, birth order 8-10, and birth order 11 or more. The risk of progressing to the next birth is lower if the birth order number is higher. This is common in women who control their fertility (Tymicki 2005). Older women with higher parities have a lower risk of progressing to the next birth due to reduced fecundity. This variable can be used to analyse the effect of a child death with respect to birth order by the interaction between birth order and child death.

4.3.6 Sex

The sex of the index child is categorical by nature. If the index child is female, there is less chance of her dying, since female child mortality has been found to be lower than male child mortality. The succeeding birth interval after a female child will tend to be shorter as couples will desire to have another child, preferably a son (Grummer-Strawn, Stupp and Mei 1998). It is hypothesised that if the index child who died is male, the risk of a subsequent birth is higher than if the child were female (Lehrer 1984). This is usually observed in societies where there is a preference for sons.

4.4 Piecewise log-rate model

The Kaplan and Meier (1958) method is used in this study for the first exploratory data analysis. The estimates obtained in Section 4.2 give an approximation of the replacement effect. The piecewise log-rate model is used to estimate the replacement effect, using the hazard model with the control variables. The Kaplan and Meier (1958) survival curve is a step function, whereas the piecewise log-rate model is a continuous curve.

4.4.1 Choice of model

In this research, we might have analysed the data using a proportional hazards model which allows the coefficients to be estimated without the researcher having to make assumptions about the nature or level of the baseline hazard. However the assumption this model carries that the hazard rate of different subjects is not time-dependent (Yamaguchi 1991) makes it less attractive to use. An alternative to the proportional hazards model is the piecewise log-rate model, which is a semi-parametric continuous time duration model that accommodates covariates that change with time. This model can be used to estimate the hazard function of different distributions and as a result can be used to model time to event data in a range of different kinds of studies, such as clinical studies, reliability engineering and economics studies. It is not necessary to make the assumption that the hazard rate of different subjects not being time-dependent when the piecewise log-rate model is used.

We chose to model the data using the piecewise log-rate model because there is no need to determine the distribution of the hazard rate in advance. Since the piecewise log-rate model can be used to measure time dependant covariates, it can be used to examine how the hazard rate differs with time. This model is used to assess the effects of time-varying covariates and time-varying interactions. In the proportional hazards model, time dependence is not specified. In the log-rate model, the hazard rate is assumed to be a step function of time that is constant within specified time periods, whereas a proportional hazards model is constant over time. Some of the births have open intervals, and for these births the time until another birth is censored. Birth interval affects child mortality and child mortality affects birth intervals; there is need to account for the reverse causality of birth intervals and child mortality and therefore child mortality must be accounted for as a time-varying variable.

4.4.2 The basic model

The piecewise log-rate model, known as the piecewise exponential model (Yamaguchi 1991), is applied in this study to investigate the risk of a birth interval closing, conditional on whether the death of the index child occurred during the time between birth of the index child and the subsequent birth, but more than nine months before the interval was closed after a child death. The analysis was done on women aged 15 to 49 years who had had at least one birth.

The piecewise log-rate model allows duration time that is being investigated to be split up into several intervals (Holford 1976). The appropriate number of intervals needs to be determined. If the number of intervals chosen is large, there will be a more accurate approximation of the unknown baseline hazard rate, but there will be a large number of coefficients to be estimated. If a small number of time periods is chosen, there will be a poor approximation of the baseline hazard rate, but fewer problems in terms of estimating coefficients (Blossfeld, Golsch and Rowher 2007; Demarqui, Loschi and Colosimo 2008).

When choosing the number of intervals there should be events that fail within each of the intervals in order to obtain sensible estimates. If an adequate (not too large or too small) number of intervals is chosen, a better approximation of the unknown baseline hazard is determined (Demarqui, Loschi and Colosimo 2008). The influence of the fixed covariates is the same in the different intervals. The piecewise log-rate model can be specified as follows:

$$h(t, X) = h_{0i}(t)\exp(X\beta), t \in T_i$$

where

$i=1,\ldots,k$ and k is the number of intervals

T_i is the interval

h_{0i} is the baseline hazard in interval T_i

X is the vector of covariates

β is the coefficient of the covariates

The baseline hazard is assumed to be constant within an interval, may differ between each interval, and is exponentially distributed within each interval (Holford 1976; Friedman 1982). Intervals can be of different lengths.

The piecewise log-rate model can be estimated by creating variables that refer to the split time intervals and by including these intervals in the model. The estimated coefficients of these time dummy variables indicate the baseline hazard in each period. It is not possible to include all the time dummy variables as well as the constant in the model. Either the constant is excluded, or one of the time dummy variables. The coefficients of the time dummy variables, and the constant, will vary, depending on whether the constant, or one of the time dummy variables, is included or excluded. This does not have an effect on the coefficients of the covariates.

In this study, the baseline hazard is modelled with a piecewise exponential over the following intervals in periods of months: 0-8, 9-17, 18-23, 24-29, 30-35, 36-41, 42-47, 48-53, 54-59, and 60+ months. Using this model the outcome variable is the succeeding birth interval, and the main covariate is the death of the index child. The following covariates that are controlled are the previous birth interval, age of mother at the birth of the index child, level of education of mother, birth order, and wealth. In this analysis the period of time to the next birth is split into ten segments, and nine of these are included in the model. Other studies by Grummer-Strawn, Stupp and Mei (1998), and Palloni and Rafalimanana (1999), have used a similar model but with different step functions for the baseline hazard. Their studies are examined and discussed in section 2.2.2. Interaction effects are modelled and tested for significance.

4.4.3 Interaction effects

Based on theoretical evidence, the following variable interactions are tested: death together with education, and birth order with sex. Education is presumed to reduce the effect of child mortality on the chances of having a subsequent child, and birth order increases the effect of child mortality on the risk of having a subsequent birth. It is important to establish whether and to what extent there is sex preference in low and high fertility countries.

An educated woman earns more money and has a superior socio-economic status than an uneducated woman (Benefo and Schultz 1996). A superior socio-economic status affords a woman access to better health facilities and better nutrition for her children and this in turn increases the chances of the survival of her children. An increase in the chances of survival of a child can reduce the demand for more children (Benefo and Schultz 1996). The results of the interaction between child death and maternal education are important because the higher the education of a woman the greater the risk of replacing a dead child. Women with higher education may have fewer children compared to those with a lower education as a result they are more likely to replace a dead child.

Tymicki (2005), and Grummer-Strawn, Stupp and Mei (1998), hypothesise that women with higher parities experience higher child mortality, and this in turn causes the risk of the birth interval closing to be greater. It is likely that women with fewer children (most probably educated women) are more likely to have another child after the death of a child.

If the index child who died is male, the sex variable will increase the risk of having another child. Interactions of sex of child, birth order and mother's education with child mortality, between sex and birth order, sex with education, and birth order with education where attempted and are shown in Table A1 and Table A2

The significance of the covariate is tested in this study by using the p-value of the coefficient. If the p-value of the coefficient is less than the level of significance, then the covariate is statistically significant. The level of significance used in this study is 5 per cent, but in some instances, 10 per cent is used.

4.5 Descriptive statistics for the covariates

Table 4.3 shows the descriptive statistics of the covariates of birth intervals for the five countries in this study. At most 16 per cent of women aged 15-49 years who had had at least one birth experienced a child death. Malawi had the highest proportion of women (15.2%) who had lost a child. In Kenya (37%), Malawi (32.3%) and Tanzania (32.3%) more than 31 per cent of the births had short preceding intervals (less than 30 months), that is, the births preceded by short intervals. In Lesotho 36 per cent of children under study are first births, and 33 per cent of children under study in Zimbabwe are first births. A small portion of births was preceded by long birth intervals in all five countries.

In the sample, the majority of women (more than 50 per cent) had had a child when aged between 20 and 29 years. This is due to the shape of the fertility curve. The proportion of women aged 10 to 14 years, 40 to 44 years, and 45 to 49 years who had given birth, is small because at those ages few women are having children.

A high proportion of women in Kenya (76.2%), Lesotho (97.4%), Malawi (75.3%), Tanzania (72.2%) and Zimbabwe (89.4%) have at least a primary education. At least one in five women in Kenya (20.5%), Lesotho (30.9%), and Zimbabwe (42.7%) has a secondary education. As expected, about 50% of the women in all five countries have 2-4 children. The proportion of women in the five wealth categories is not exactly 20%, because samples are not selected according to the characteristics of individuals.

Table 4.3 Descriptive statistics of the covariates of succeeding birth intervals

Variable	Category	2008-09 KDHS		2009 LDHS		2010 MDHS		2010 TDHS		2005-06 ZDHS	
		Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N
Death	No	90.6	20 123	90.5	12 869	84.8	60 120	88.5	25 897	92.6	17 754
	Yes	9.4	209	9.5	1 357	15.2	10 773	11.5	3 361	7.4	1 413
Sex	Female	48.9	10 860	48.4	6 889	49.7	35 208	49.7	14 538	49.6	9 498
	Male	51.1	11 361	51.6	7 337	50.3	35 685	50.3	14 720	50.5	9 669
Previous Interval	No previous interval	27.7	6 102	36.8	5 191	25.7	18 041	25.7	7 326	33.1	6 281
	<30	37.0	8 152	18.4	2 603	32.3	22 641	32.3	6 377	22.7	4 313
	30-47	21.4	4 714	24.8	3 499	28.6	20 083	28.6	16 013	25.1	4 759
	48+	14.0	3 091	20.0	2 823	13.5	9 441	13.5	6 274	19.1	3 633
Age at birth	10-14	2.2	478	0.6	79	1.9	1 361	1.0	304	1.0	187
	15-19	22.5	5 003	21.2	3 012	24.8	17 551	20.8	6 073	24.3	4 609
	20-24	32.9	7 309	35.5	5 056	32.4	22 984	31.8	9 291	34.7	6 580
	25-29	22.8	5 059	22.5	3 194	21.4	15 194	23.0	6 722	22.3	4 224
	30-34	12.6	2 801	12.5	1 784	12.2	8 678	14.4	4 203	11.9	2 258
	35-39	5.6	1 239	6.0	853	5.5	3 911	7.1	2 071	4.8	903
	40-44	1.4	311	1.7	236	1.5	1 094	1.9	545	1.0	196
	45-49	0.1	21	0.1	12	0.2	120	0.2	49	0.1	20
Education	No education	23.9	5 304	2.7	381	24.7	17 525	27.8	8 137	10.6	2 028
	Primary	55.7	12 371	66.5	9 454	66.3	46 978	61.4	17 967	46.7	8 952
	Secondary & higher	20.5	4 546	30.9	4 391	9.0	6 390	10.8	3 154	42.7	8 187
Birth order	1	27.5	6 102	36.5	5 191	25.5	18 041	25.0	7 326	32.8	6 281
	2-4	50.1	11 133	50.9	7 235	50.5	35 799	49.0	14 340	50.9	9 751
	5-7	17.8	3 944	11.0	1 560	19.3	13 672	19.8	5 790	13.6	2 609
	8-10	4.2	923	1.6	225	4.4	3 083	5.6	1 632	2.5	475

Variable	Category	2008-09 KDHS		2009 LDHS		2010 MDHS		2010 TDHS		2005-06 ZDHS	
		Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N
	11+	0.5	119	0.1	15	0.4	298	0.6	170	0.3	51
Wealth	Poorest	27.7	6 151	26.9	3 829	22.2	15 703	20.2	5 909	24.9	4 776
	Poorer	18.8	4 185	21.0	2 988	21.2	15 038	21.5	6 283	21.7	4 157
	Middle	18.7	4 148	18.2	2 593	21.0	14 905	21.2	6 189	19.7	3 780
	Richer	17.6	3 900	17.6	2 508	20.6	14 621	21.4	6 254	18.2	3 487
	Richest	17.3	3 837	16.2	2 308	15.0	10 626	15.8	4 623	15.5	2 967

4.6 Results of the piecewise log-rate model

The three effects co-exist and may operate at the same time. As a result it is usually difficult to analyse an effect independent of the other effects. In this study we tried to ensure that the variables that specify these effects were analysed separately but we might have been unable to separate them. It should be noted that the replacement effect is the overall effect as the physiological and hoarding effects may have also been operating.

Table 4.4 shows the risks of closing the birth interval for women who have experienced a child death, controlling for demographic and socio-economic variables for the five countries. In all five countries, child death has a statistically significant effect on the risk of a woman having another birth. Generally, for all five countries, women who have experienced a child loss have a higher risk of having another child compared to those with a surviving child. Zimbabwe has the highest risk, followed by Lesotho, Tanzania, Malawi and Kenya.

Zimbabwe and Lesotho are relatively low fertility countries and the replacement effect in these countries is more pronounced. In countries such as those under study, when a couple lose a child, they tend to attempt to replace the child so that they attain their desired number of children. Kenyan women who have experienced a child death have the lowest relative risk of closing the birth interval compared to women in the other four countries. The reason for this could be that fertility control is lower in Kenya, where about 39.4 per cent of married women currently use modern contraceptives. Malawi and Tanzania are high fertility countries, and the replacement effect is lower than in low fertility countries. A less pronounced replacement effect could be an indicator of the hoarding effect.

The highest probability of having another child in Kenya is between 24 to 29 months after the birth of the index child, in Lesotho, Malawi and Tanzania 30 to 35 months, and in Zimbabwe 54 to 59 months. Succeeding birth intervals in Kenya are shorter in length compared to succeeding birth intervals in Lesotho, Malawi Tanzania and Zimbabwe.

The length of the succeeding birth intervals varies according to the survival status of the index child. The interaction between duration since the birth of the index child with survival status of the index child is statistically significant. In all five countries, women who have experienced a child death are highly likely to replace the child within 18 months after the death of the index.

In Lesotho and Tanzania, the risk of another birth is not affected by the sex of the index child. The interaction between the sex and the death of the index child is statistically significant, except in Kenya and Malawi. The chances of having another child are greater if the index child who has died is male than if the child was female.

There is an association between the previous birth interval and the subsequent birth interval. Generally, the risk of a woman having a subsequent birth reduces with an increase in the length of the previous birth interval. Index births with shorter preceding birth intervals are more likely to result in shorter succeeding birth intervals, thus increasing the risk of a subsequent birth. In Lesotho and Zimbabwe, the chances of having another child are higher for preceding birth intervals of less than 30 months, 30 to 47 months, and greater than 47 months, compared to births with no previous interval. A different pattern is observed in Kenya, Malawi and Tanzania, where the chance of having another child is lower for preceding birth intervals less than 30 months, 30 to 47 months and longer than 47 months, compared to births with no previous interval.

In Lesotho and Zimbabwe, women aged 15 to 19 years have a higher probability of having another child compared to women aged 20-24. The opposite is true for women aged 10 to 14 years, since not many women in that age group are having children as they are still in school. Generally, women in the age groups 25 to 29 years, 30 to 34 years, 35 to 39 years, 40 to 44 years, and 45 to 49 years, have a lower risk of conception resulting in a live birth compared to women aged 20 to 24. At the age 20 to 24, most women in countries such as those under study are in unions and this increases their chance of having children. The risk of having a subsequent birth reduces with an increase in the age of the mother at the birth of a child. In the five countries, the transition to the next birth is shorter for women who had their children at a younger age. The births of children to older women are followed by longer birth intervals because of the reduced fecundity of older women.

The probability of having a subsequent birth differs according to the level of education of the mother. In Lesotho, a primary education has no effect on the chance of a woman having another child after the birth of the index child. The risk of having another child is lower for women who are educated in comparison to those who are uneducated in all five countries. Women who are educated tend to have fewer children than women who are not educated. This could be because there is higher use of modern contraceptives, greater labour participation, late age at marriage and more spousal communication among educated women.

Lesotho and Zimbabwean women with higher parities tend to have lower relative risk of a subsequent birth compared to women with first births. In Kenya, Malawi and Tanzania the instantaneous risk of giving birth is higher as a result within a set time interval if the risk remains constant, the likelihood of a higher parity having another birth is higher. Generally, the risk decreases as the birth order increases. Couples with higher parities tend to have a lower likelihood of a subsequent birth as they might have attained their desired family size.

The chances of having another birth reduce with an increase in wealth and the effect is significant. Women who come from wealthy households tend to have access to and knowledge of contraceptive use and it is highly likely that they are educated.

Table A1 shows the interaction between women who have experienced the death of a child and maternal education. As shown in Table A1 women with secondary education have the greatest risk of having a subsequent birth. Educated women are more likely to replace a dead child.

Table 4.4 A piecewise log-rate model associated with the risk of closing the birth interval

		2009-08 KDHS	2009 LDHS	2010 MDHS	2010 TDHS	2005-06 ZDHS
Variable	Category	exp(β)	exp(β)	exp(β)	exp(β)	exp(β)
Death	No	ref.	ref.	ref.	ref.	ref.
	Yes	1.26*	2.40*	1.58*	1.73*	2.89*
Sex	Female	ref.	ref.	ref.	ref.	ref.
	Male	1.04	1.00	1.02**	1.00	1.02
Previous interval	No prev. interval	ref.	ref.	ref.	ref.	ref.
	<30	0.86	3.25*	0.52*	0.56*	1.66*
	30-47	0.76	3.21*	0.47*	0.44*	1.36*
	48+	0.58*	2.42*	0.37*	0.30*	0.96*
Age at birth	10-14	1.01	0.89	0.83*	0.73*	0.82*
	15-19	1.06	1.01	0.96*	0.99*	1.08*
	20-24	ref.	ref.	ref.	ref.	Ref
	25-29	0.85*	0.80*	0.88*	0.94*	0.76*
	30-34	0.67*	0.58*	0.71*	0.75*	0.56*
	35-39	0.48*	0.34*	0.53*	0.46*	0.32*
	40-44	0.25*	0.08*	0.33*	0.24*	0.14*
	45-49	0.14*	0.00*	0.49*	0.14*	0.00*
Education	No education	ref.	ref.	ref.	ref.	ref.
	Primary	0.88*	1.00	0.91*	0.94*	1.01*
	Secondary & higher	0.72*	0.80*	0.59*	0.85*	0.85*
Birth order	1	ref.	ref.	ref.	ref.	ref.
	2-4	1.08	0.28*	1.72*	1.92*	0.61*
	5-7	1.07	034*	1.57*	2.09*	0.65*
	8-10	1.00	0.58*	1.39*	2.07*	0.72*
Wealth	Poorest	ref.	ref.	ref.	ref.	ref.
	Poorer	0.89*	0.76*	0.98	1.02	0.93*
	Middle	0.79*	0.70*	0.95*	0.99	0.84*
	Richer	0.67*	0.54*	0.91*	0.79*	0.66*
	Richest	0.48	0.46*	0.81*	0.57*	0.57*
Interval	0-8	0.01*	0.02*	0.01*	0.00*	0.02*
	9-17	0.36*	0.24*	0.28*	0.22*	0.29*
	18-23	ref.	ref.	ref.	ref.	ref.
	24-29	1.45*	1.95*	1.68*	1.82*	1.82*
	30-35	1.36*	2.68*	2.12*	2.06*	2.25*
	36-41	1.38*	2.67*	2.06*	1.90*	2.40*
	42-47	1.13*	2.47*	2.03	1.72*	2.57*
	48-53	1.02	2.26*	1.81*	1.40*	2.62*
	54-59	0.89**	2.23*	1.55*	1.35*	2.66*
	60+	0.42*	0.92	0.66*	0.58*	1.38*
Death*Interval	Death*0-8	0.00*	0.00*	0.00*	0.00*	0.00*
	Death*9-17	2.15*	4.16*	2.09*	2.47*	3.07*
	Death*24-29	0.80	1.92*	0.39*	0.34*	1.03*
	Death*30-35	0.49*	1.36*	0.25*	0.21*	0.66*

		2009-08 KDHS	2009 LDHS	2010 MDHS	2010 TDHS	2005-06 ZDHS
Variable	Category	exp(β)	exp(β)	exp(β)	exp(β)	exp(β)
	Death*36-41	0.40	0.88*	0.18*	0.16*	0.42*
	Death*42-47	0.79	0.42*	0.49*	0.78*	0.50*
	Death*48-53	0.53*	0.47*	0.51*	0.69*	0.30*
	Death*54-59	0.23*	0.10*	0.43*	0.73*	0.20*
	Death*60+	0.26*	0.15*	0.33*	0.39*	0.14*
Death*Sex	Death*male	1.17	2.03**	1.52	1.54*	2.10*
Constant		0.05*	0.02*	0.03*	0.02*	0.02*

*Significant at 5 per cent, **significant at 10 per cent

5 ANALYSIS OF THE INSURANCE EFFECT

In Chapter 4, an investigation of the effect of childhood mortality on birth intervals was undertaken to determine whether birth intervals are shorter when the index child dies, using data from Kenya, Lesotho, Malawi, Tanzania and Zimbabwe. In this chapter, we examine the impact of childhood mortality on couples having more children than desired (a dimension of reproductive behaviour) by testing the insurance effect, also called the hoarding effect.

5.1 Hoarding

The hoarding effect occurs when couples have more children than desired in anticipation of future child mortality, or due to the experience of a child loss in the later phase of their reproductive lives (Ben-Porath 1976). Studies by Angeles (2010), Lehrer (1984), Rahman (1998), and Rutstein (1974) define hoarding as having more children than the desired number, the definition which will be used in this study. This chapter investigates the extent to which those women who are nearing the end of their reproductive lives change their reproductive behaviour in response to the death of a child. The sample is restricted to these women on the assumption that they have stopped bearing children. The chapter will investigate whether the experience of the death of a child results in women having more children than they desired.

5.2 Child mortality

The key covariate used to assess the hoarding effect in this study is the death of at least one child and it is grouped into two categories: at least one child death, and no child death. The study will attempt to establish whether child mortality causes a woman to attempt to have more children than she desired. It is hypothesised that, due to the loss of a child, a woman will increase the number of children she will have in order to achieve a couple's desired number of surviving children.

Table 5.1 shows the mean number of children ever born by survival status of children and age of the mother. The average number of children ever born differs with the experience of child death. Women who have experienced a child death have more children on average than those women who have not experienced a child death. There is a problem of reverse causality, where women with more children experience higher child mortality due to sibling competition for family resources, transmission of infections due to overcrowding, and short birth intervals (Rosero-Bixby 1998). Women with high fertility are probably not educated, live in rural areas or are very poor, and this could increase the risk of having higher mortality (Basu 1994). Rutstein (1974) measured the effect of child mortality on subsequent fertility at a given parity level in order to get around the problem of reverse causality. As expected, the average number of children ever born increases with the age of the mother, whether the woman experienced a child death or not. As shown in Table 5.1, the average number of children ever born increases as the number of child deaths experienced by a woman increases and this is true for all the age groups. Women who have experienced higher child mortality show higher rates of fertility.

Table 5.1 Mean number of children ever born by the number of child deaths and age of mother

Number of children who died	2008-09 KDHS			2009 LDHS			2010 MDHS			2010 TDHS			2005-06 ZDHS		
	35-39	40-44	45-49	35-39	40-44	45-49	35-39	40-44	45-49	35-39	40-44	45-49	35-39	40-44	45-49
no death	4.76	4.93	5.96	3.71	4.67	4.79	5.30	5.96	6.35	5.63	6.01	6.67	4.34	5.24	5.83
1 death	5.84	6.57	6.95	4.71	5.01	5.74	6.01	6.72	7.47	6.45	6.99	7.61	5.27	6.25	7.37
2 deaths	7.09	7.73	8.56	5.46	5.54	7.10	6.58	7.52	7.75	6.81	7.78	8.45	5.92	7.05	8.17
3 deaths	6.97	9.03	9.50	6.40	8.26	8.58	7.28	8.05	8.58	8.16	8.55	8.55	5.72	9.33	8.79
4 deaths	7.84	8.22	9.44	7.10		7.80	8.13	9.00	9.56	7.69	8.60	8.93		8.28	9.75
5 or more	8.47	10.40	8.66				9.43	9.58	10.28	10.71	10.19	9.91			11.58

5.3 Covariates

The covariates included in this study are those used by LeGrand, Koppenhaver, Mondain *et al.* (2003) in their qualitative study of the hoarding effect in Senegal and Zimbabwe: marital status of the mother, age of the mother, residence, wealth, religion, proportion of surviving males, and education of partner.

Marital status is chosen as a covariate because reproductive decision-making is usually made by a couple. We would like to control the marital status of a woman as it has an effect on hoarding. LeGrand, Koppenhaver, Mondain *et al.* (2003) say that married women in developing countries such as those included in their study, tend to have more births so as to strengthen their marriages. Women who are married have greater exposure to childbearing and marriage provides stability in terms of family and household strategies and resources. In this researcher's study, marital status is grouped into three categories: currently married, never married and formerly married. The 'currently married' category includes those women who are living with a partner, and the 'formerly married' category includes widows, divorcees and those not living with their partner. In the countries under study, as Table 5.2 shows, there are more women who are currently married than those who are not married.

The death of at least one child is the covariate of interest in this study. More than half the women in Malawi and Tanzania reported that at least one of their children had died. This is an indicator of high childhood mortality in the two countries. In Kenya, Lesotho and Zimbabwe on average one in three women aged between 35 and 49 years had experienced the loss of a child. LeGrand and Phillips (1996) found that fertility is high in countries that have high infant and child mortality; and fertility is low in countries that have low infant and child mortality.

LeGrand, Koppenhaver, Mondain *et al.* (2003) hypothesise that couples in rural areas have many children so as to gain respect in the community, and that they view children as their support in old age, while women who live in rural areas are more likely to insure against future mortality than are women in urban areas. Couples in urban areas invest financially in their children and thus have fewer children. According to the DHSs of the countries under study, a higher proportion of the respondents reside in rural areas than in urban areas. Approximately 90 per cent of the respondents in Malawi reside in rural areas, and about 70 per cent of the respondents in Zimbabwe reside in rural areas. The categories for education of the mother and father, and wealth are covered in Section 4.3.

Age is coded into three age groups, 35 to 39 years, 40 to 44 years and 45 to 49 years. The older a woman is the higher the chances of having more children. In high child mortality conditions, women insure against future child mortality when they are younger as it will be more difficult to have children at an older age. According to Ben-Porath (1976), having children at an older age is also a form of hoarding (Ben-Porath 1976). As expected in all the countries except in Zimbabwe, there are more women aged 35 to 39 years than those aged 40 to 44 years and 45 to 49 years. In Zimbabwe, the number of women aged 35 to 39 years is less than the number of women aged 40 to 44 years.

Table 5.2 Descriptive statistics of the selected covariates (Women aged 35-49 years who have attained their desired family size)

Variable	Category	2008-09 KDHS		2009 LDHS		2010 MDHS		2010 TDHS		2005-06 ZDHS	
		Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N
Death	No	62.9	913	64.8	784	34.6	1 439	45.0	670	70.1	786
	Yes	37.1	539	35.2	426	65.4	2 724	55.0	819	29.9	335
Age	35-39	38.4	558	35.2	426	43.1	1 796	36.8	548	33.4	374
	40-44	31.3	455	32.4	392	30.2	1 259	34.0	506	35.2	395
	45-49	30.2	439	32.4	392	26.6	1 108	29.2	435	31.4	352
Residence	Urban	21.5	312	22.6	274	10.3	429	19.7	294	30.8	345
	Rural	78.5	1 140	77.4	936	89.7	3 734	80.3	1 195	69.2	776
Wealth	Poorest	16.1	233	23.6	286	21.3	885	20.0	298	20.2	226
	Poorer	19.7	286	17.7	214	20.0	831	19.4	289	18.2	204
	Middle	22.4	325	18.5	224	19.5	812	20.9	311	21.6	242
	Richer	20.6	299	19.2	232	21.4	889	22.0	328	18.7	210
	Richest	21.3	309	21.0	254	17.9	746	17.7	263	21.3	239
Marital status	Never married	3.4	49	3.9	47	0.1	6	0.8	12	1.3	14
	Currently married	76.4	1 109	69.8	844	80.3	3 344	80.8	1 203	72.5	813
	Formerly	20.3	294	26.4	319	19.5	813	18.4	274	26.2	294
Education of mother	No education	13.0	189	2.4	29	31.5	1 310	24.5	364	13.7	154
	Primary	55.8	810	65.8	796	62.3	2 593	64.7	963	50.8	569
	Secondary or higher	31.2	453	31.8	385	6.3	260	10.9	162	35.5	398
Education of father	No education	10.1	147	33.8	409	14.9	620	18.5	275	7.4	83
	Primary	45.3	658	45.0	544	65.7	2 735	65.8	979	46.6	522
	Secondary or higher	44.6	647	21.2	257	19.4	808	15.8	235	46.0	516
Religion	Traditional	21.1	307	38.8	470	21.1	879			2.8	31

Variable	Category	2008-09 KDHS		2009 LDHS		2010 MDHS		2010 TDHS		2005-06 ZDHS	
		Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N	Weighted %	Weighted N
	Christian	69.3	1 006	58.4	707	67.0	2 788			87.5	981
	Muslim	6.7	97	0.1	1	10.7	445			1.1	12
	Other religion	1.1	16	1.6	19	0.4	17			0.2	2
	No religion	1.8	26	1.1	13	0.8	33			8.5	95

5.4 Logistic regression model

Logistic regression is a form of regression used to model binary outcomes (Pagano and Gauvreau 2000). It describes the relationship between a binary variable and continuous or categorical covariates. The probabilities of an event are modelled as a function of explanatory variables using a logistic function:

$$p_i = \frac{e^{\beta_{0i} + \boldsymbol{X}_i' \boldsymbol{\beta}_i}}{1 + e^{\beta_{0i} + \boldsymbol{X}_i' \boldsymbol{\beta}_i}}$$

where

i is the *i* th individual

$0 \leq p_i \leq 1$

β_{0i} is the intercept

$\boldsymbol{\beta_i}$ is a vector of coefficients of the covariates $\boldsymbol{X_i}$

$\boldsymbol{X_i}$ are the determinants

The advantage of logistic regression models is that model assumptions are less strict regarding homoscedasticity, normality and linearity (DeMaris 1995). There is no need for the error term to be normally distributed and the dependent and independent variables do not need to have a linear relationship. The value one represents the outcome of interest (success) and the value zero represents a failure.

This study investigates whether and to what extent there is a hoarding effect in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe. The data are drawn from the birth histories of women aged 35 to 49 years who had attained their desired number of children in the 2008-09 Kenya Demographic and Health Survey (KDHS), the 2009 Lesotho Demographic and Health Survey (LDHS), the 2010 Malawi Demographic and Health Survey (MDHS), the 2010 Tanzania Demographic and Health Survey (TDHS), and 2005-06 Zimbabwe Demographic and Health Survey (ZDHS). Table A3 shows the number of women who gave non-numeric, "up to God" and no responses to the ideal number of children they expected to have. In all the four countries except in Kenya (almost 10 per cent) less than 4 per cent gave non-numeric "up to God" and no responses. Women who have attained their desired number of children are assumed to have completed their reproductive career but some have additional children due to hoarding, unwanted pregnancies or change of mind. Having more children than the desired number of children is a proxy for hoarding. The desired number of children is the number of children a woman would like to have in the course of her whole life. This variable is used to measure the demand for children in surveys.

In DHSs some women might not respond to the question on their desired number of children, some will give non-numeric responses, and some exceed the number of children a woman can ever realistically have (Bongaarts 1990). In this study, women who gave non-numeric responses to the desired number of children question were excluded from the analysis. As a response to the question on desired number of children it is likely that women respond in terms of their surviving children and not the number of births. A significant number of women who have unwanted births tend to adjust the desired number of children so that it is closer or equal to the number of children that they have.

Bongaarts (2010) used the variable 'desired family size' in his research on the effect of desired family size on the demand for contraceptives, and concluded that, in countries where fertility had declined, desired family size was lower. His research shows that the measure is a good predictor of the number of children a woman will have. He emphasised the fact that women were likely to adjust their desired number of children closer to their actual number of children. Bhargava (2007), and Freedman, Hermalin and Chang (1975) agree that desired family size is an important variable in predicting the number of children a woman will give birth to.

Though the variable, 'desired number of children' has its limitations, the measure is a valid one to use for measuring the hoarding effect. The experience of a child death can cause a woman to either replace a child or insure the replacement of the child by having additional births. This can cause the actual number of children a woman has to exceed her desired number of children (Bongaarts 1990). Ibisomi, Gyimah, Muindi *et al.* (2011) argue that those women who have more children than their desired number among women, who have experienced the loss of a child, see this as an insurance against future child mortality. A woman with more than her desired number of children is denoted as one and zero otherwise. Because the outcome variable hoarding is binary, logistic regression is used to model the effects of covariates on this outcome. The mean of the outcome p_i, is the probability of a woman hoarding and $1-p_i$ is the probability of a woman not hoarding

Logistic regression is used to predict the odds of the outcome we are interested in based on the independent variables. The probability of hoarding, p_i is modelled with a logistic function, and this is a linear function of the covariates. The odds ratio (OR) is used to compare the odds of the outcome of interest of one group relative to the odds of the outcome of interest of another group. The odds ratio is

$$OR = e^{\beta_i}$$

The odds ratio tells us how likely it is for the outcome of interest to be exposed to the identified determinants compared to the unexposed determinants. If the odds ratio is equal to one, the outcome of the variable of interest of each of the two groups is the same, and if the odds ratio is greater than one, the outcome of interest is more likely to occur in the one group than in the other group. Maximum likelihood estimation will be used to estimate the coefficients of the covariates. The significance of the coefficient will be evaluated by comparing the p-value of the coefficient and the chosen significant level.

5.5 Results of the logistic regression

Results from the fitted regression models are presented in Table 5.3 and show that women who have experienced at least one child death are more likely to have more children than they desired than those women who have not experienced a child death. In Kenya, Lesotho, Malawi, Tanzania and Zimbabwe the odds of having more children than desired for women who have experienced at least one child death are 114 per cent, 77 per cent, 140 per cent, 79 per cent and 59 per cent, respectively, more than the odds of having more children than desired for women who have not experienced a child death. It is likely that there is hoarding in all five countries among women aged 35 to 49 years old, and the odds are greater when a woman experiences the death of a child (using the definition of hoarding in section 5.1). Insurance by women who have experienced a child death against future child mortality is likely evident in the countries under study, but the odds are lower for Lesotho, Tanzanian and Zimbabwean women. Women in Malawi are likely to have the highest odds of hoarding compared to women in the other four countries. This is as expected, since Malawi is a high fertility country and research has shown that women in that country tend to have many children. Interaction between the death of at least one child and the other covariates was attempted and there was found to be no effect on hoarding.

With the exception of Zimbabwe, the age of the mother is significant in terms of having more children than desired for the age group 45 to 49 years. Women aged 45 to 49 years are more likely than women aged 35 to 39 years to have insured against future mortality. The older women have more children than the younger women.

In Lesotho, women in the other wealth groups are less likely to insure against future mortality relative to the poorest women. The chances of insuring against future mortality decrease with an increase in wealth. The wealthier the people the less they view children as old age support. Malawian women who are in the poorer and middle wealth categories are more likely to insure against future mortality compared to women in the poorest category.

In Tanzania, a unit increase in the percentage of surviving sons decreases the odds of having more children than desired by 55 per cent. If the surviving child is male, the odds of having more children than desired are lower than if the surviving child is female. From the figures for this category, a high preference for male children is observed in Tanzania.

Married women in Malawi are likely to have greater odds of insuring against child mortality than do women who have never been married. A possible reason could be married women are expected to have many surviving children for the marriage to be recognized.

An unexpected pattern is observed in Zimbabwe, where the odds of having more children than desired are greatest among women whose partners have both a primary and higher education. This could be because educated men can afford to have more children. We would have expected the level of education of the partner to reduce the odds of having more children than desired. Malawian women whose partners have a secondary education are 28 per cent less likely to insure against child mortality.

In Lesotho and Zimbabwe, secondary or higher educated women have the lowest odds of having more children than desired compared to women who are not educated. Primary educated women in Tanzania have the greatest odds of having more children than desired compared to uneducated women. A reason for this could be uneducated women usually stay at home and look after their children.

In Kenya, women affiliated to the Muslim religion, and other non 'indigenous' religions, are less likely to insure against mortality compared to women who are affiliated to Traditional (African) religion. Thus, Muslim and Christian women in Malawi are less likely to have more children than they desired compared to women affiliated to Traditional religion. Zimbabwean women who are not affiliated to any religion are more likely to hoard children compared to women affiliated to Traditional religion.

Thus, from the literature and the DHS data, it can be seen that the experience of a child death is likely to have an effect on hoarding (using the definition of hoarding in section 5.1) and it appears hoarding might exist in all the five countries assuming the women did not have unwanted pregnancies or change of mind. Couples might insure against child mortality in order to retain their desired number of surviving children in case some die.

Table 5.3 Odds ratio of hoarding by selected covariates

Variable	Category	2008-09 KDHS	2009 LDHS	2010 MDHS	2010 TDHS	2005-06 ZDHS
Death	No	ref.	ref.	ref.	ref.	ref.
	Yes	2.14*	1.77*	2.41*	1.79*	1.59*
Age	35-39 years	ref.	ref.	ref.	ref.	ref.
	40-44 years	1.04	1.39**	1.15	1.04	1.30
	45-49 years	1.46*	1.70*	1.47*	1.31**	1.30
Residence	Urban	ref.	ref.	ref.	ref.	ref.
	Rural	1.51	0.98	1.05	0.78	1.71*
Wealth	Poorest	ref.	ref.	ref.	ref.	ref.
	Poorer	1.26	0.48*	1.27**	1.06	0.85
	Middle	0.73	0.29*	1.28**	0.91	0.68**
	Richer	0.58*	0.36*	1.12	0.85	1.16
	Richest	0.59	0.20*	1.24	0.38*	0.82
Marital status	Never married	ref.	ref.	ref.	ref.	ref.
	Currently married	1.48	1.54	4.96**	1.17	0.93
	Formerly	1.38	1.07	3.12	0.87	0.70
Education of mother	No education	ref.	ref.	ref.	ref.	ref.
	Primary	1.08	0.29	1.16	1.38**	0.72
	Secondary or higher	0.69	0.17*	0.84	1.20	0.59**
Proportion of surviving male children		1.24	1.32	0.87	0.45*	0.99

Variable	Category	2008-09 KDHS	2009 LDHS	2010 MDHS	2010 TDHS	2005-06 ZDHS
Education of partner	No education	ref.	ref.	ref.	ref.	ref.
	Primary	1.13	0.62*	1.07	0.89	1.92**
	Secondary or higher	1.23	0.85*	0.72**	1.69	2.01**
Religion	Traditional	ref.	ref.	ref.		ref.
	Christian	0.98	0.98	0.79**		1.74
	Muslim	0.47*	1.00	0.58*		1.20
	Other religion	0.13**	0.42	1.47		1.00
	No religion	2.09	1.43	0.99		2.58*

6 DISCUSSION AND CONCLUSION

In Chapter 4 and Chapter 5, two investigations were conducted to assess the replacement and hoarding effects on fertility in five African countries. This chapter discusses the results obtained from these investigations. The results obtained from the preceding chapters are compared with other studies conducted in developing countries. Section 6.1 and section 6.2 examine the results obtained in assessing the replacement and hoarding effects respectively. Section 6.3 presents the limitations of the study and section 6.4 presents the conclusions drawn from the study.

6.1 Analysis of the replacement effect

The results from Chapter 4 demonstrate that there are differences in the transition from the birth of the index child to the subsequent birth between women who have experienced the death of a child and those who have not. These differences relate to the duration between the birth of the index child and the next birth. Lesotho and Zimbabwean women who had experienced the death of a child had shorter birth intervals compared to those of Kenyan, Malawian and Tanzanian women. The median birth intervals were about 30 per cent shorter for those Lesotho and Zimbabwean women who had experienced the loss of a child. This suggests that women who have experienced the loss of a child in general have shorter birth intervals. This is consistent with the findings from other studies, for example those by Chowdhury, Khan and Chen (1976), Grummer-Strawn, Stupp and Mei (1998), Gyimah and Fernando (2002), and Obonyo, Otieno and Muga (2005).

In addition, the results show that women who have experienced the death of a child tend to have a higher risk of having a child after the index child has died. These findings are similar to those of other studies, such as those done by Grummer-Strawn, Stupp and Mei (1998), Rajbhandary (1999), Palloni and Rafalimanana (1999), Gyimah and Fernando (2002), Tymicki (2005), and Lindstrom and Kiros (2007), studies which used data from moderate to high fertility countries. The effects of a child death on birth intervals and on fertility are greater in Zimbabwe and Lesotho than in Tanzania, Malawi and Kenya. The findings show that there is replacement occurring in all five countries but it is more pronounced in countries that have lower fertility rates, such as Zimbabwe and Lesotho. This is as expected, since the replacement effect is likely to differ according to the demographic transition of a country (Rizk, Stokes and Nelson 1982). In high fertility and high mortality countries such as Malawi and Tanzania, few effects of replacement are observed.

The use of contraceptives in Lesotho and Zimbabwe is higher so one would expect the replacement effects of child mortality to be higher: women in Lesotho and Zimbabwe who use contraception, consciously and deliberately may discontinue use of contraception in order to replace a deceased child. Rahman (1998) showed that contraceptive users who have not attained their desired number of children are more likely to discontinue use of contraceptives when they experience a child loss.

The results of this study also reveal the sex-specific effect of replacement to be present in Lesotho, Tanzania and Zimbabwe. The sex of the deceased child has an effect on the parents' decision to replace the child. The results show a stronger preference for replacing a deceased male child in these three countries. The findings on sex preference are consistent with the findings of a study done by Gyimah and Fernando (2002), where they used DHS data from Ghana and Kenya.

The results show that in all five countries the effects of a child death are strongest 9 to 17 months after the death of the index child, and that this effect declines over time. Women who have experienced a child death are highly likely to replace the deceased child within the first 18 months after the death of a child. The results are consistent with those obtained by Grummer-Strawn, Stupp and Mei (1998) who found that the effects of a child death are stronger 9 to 24 months after the death of a child in Kenya, Mali, Burundi, Ghana and Zambia.

Various factors affect the likelihood of having another child. These include the level of education of the mother, the age of mother at the birth of the index child, the socio-economic status of a household, the length of the previous birth interval, and the birth order. These findings are similar to those obtained by Rajbhandary (1999) and Gyimah and Fernando (2002). The risk of having another birth is lower for women who are educated, older and wealthier. This is because educated women tend to possess more knowledge about family planning, and wealthier women, who are usually educated, can afford family planning services. Older women have reduced fecundity compared to younger women. Therefore, it can be concluded that socio-economic factors have a significant impact on fertility.

6.2 Analysis of the hoarding effect

The findings from Chapter 5 suggest that the experience of a child loss by women in these countries might have an effect on their insuring against future child mortality. Women who experience the death of a child are more likely to insure against child mortality than women who have not experienced the death of a child, controlling for the covariates that have an effect on hoarding. This means that an increase in childhood mortality results in an increase in fertility, since hoarding increases the number of births. The results are consistent with those obtained by Syamala (2001), who found that women who had experienced the death of at least one child had higher fertility. He defined the hoarding effect as fertility response to expected or experienced mortality.

Malawian women have the highest odds of insuring against future mortality relative to women from the other countries investigated. The findings of this study are consistent with the hypothesis of LeGrand, Koppenhaver, Mondain *et al.* (2003) that the hoarding effect is more pronounced in high mortality societies. Malawi is still in the early stages of the demographic transition and as such is expected to show a higher hoarding effect. Evidence from 2010 MDHS suggests that the use of contraceptives is low in Malawi, women get married early and the under-five mortality rate is amongst the highest in sub-Saharan Africa.

6.3 Limitations of the study

While the results show that the loss of a child has an effect on fertility, the study has several limitations. Contraceptive use and coital frequency are important factors in affecting birth intervals. The effects of contraceptive use and coital frequency relating to each birth could not be controlled. The main reason for this is that DHS data on these variables only covers the five year period before the survey.

In addition, the data used to assess the replacement effect requires the use of current information; some of the variables could not be controlled for as they might not have remained constant from the time the index child was born to the date or period during which the survey was conducted. The data may not necessarily have been current at the time of the study. Although the place of residence of the mother was important to the analysis, we could not control for it because information on place of residence might be different from that at the time the woman gave birth. The variable whether the child was wanted could not be controlled for because it only applied to children who were born five years before the survey. Grummer-Strawn, Stupp and Mei (1998) hypothesise that this variable has an effect on the death of the child, as children who are unwanted tend to have a higher mortality rate.

This research was limited to conceptions resulting in live births because miscarriages, still births and termination of pregnancies are not recorded or reported properly or accurately in developing countries. Therefore, the time period between a still birth, miscarriage or abortion, and a subsequent birth is not included in the analysis.

Measurement of the hoarding effect may require information on how couples perceive the mortality conditions in their communities (Gyimah and Fernando 2004). This research was limited to information collected on the experience of child deaths by individuals.

It is difficult to establish intent using DHS data because most women cannot accurately predict their future fertility, as a result this concept has to be used with caution. It is also important to note that there are women in high fertility countries who space their births so that they get back to full health before bearing another child and there are women who use contraception after the death of a child so as to ensure the survival of the next birth (Bledsoe, Banja and Hill 1998).

Studying the physiological, replacement and hoarding separate from each other, rather than in relation to each other, can be difficult as they co-exist and influence each other. In this study, we tried to ensure that the variables that specify these effects were analysed separately by defining the variables as they were defined in other studies.

6.4 Conclusions and Recommendations

The findings confirm our hypothesis that child mortality is associated with higher subsequent fertility. The results show that women who have experienced the death of a child have shorter birth intervals and women who have lost a child are more likely to insure against future mortality. Child mortality has an effect on fertility levels through replacement and insurance effects, and the magnitude of the effects depends on the stage of demographic transition a society has reached. The replacement and hoarding effects curtail the potential reduction of fertility in Kenya, Lesotho, Malawi, Tanzania and Zimbabwe since the replacement and hoarding effects result in an increase in the number of births. Both replacement and hoarding effects were evident in low fertility countries (Lesotho and Zimbabwe), in moderate fertility country (Kenya) as well as in high fertility countries (Malawi and Tanzania). The replacement effect dominates in low fertility countries and the hoarding effect in high fertility countries. This is an indicator that mortality has not fallen to sufficiently low levels for the replacement effect to operate as the only effect.

Our results indicate that efforts to reduce fertility rates in the five countries under study would benefit from an improvement in child health and survival programs. For example, an increase in the coverage of immunisation in all five countries can help eradicate the six childhood killer diseases.

The results of the study show that the chances of a couple replacing a dead child are highest 18 months after the death of a child in all five countries. Implementation of family planning programs that encourage women who have lost a child to plan and space their births could help reduce fertility.

The results also suggest that in Lesotho, Tanzania and Zimbabwe a deceased male child is more likely to be replaced than is a female child. This indicates that these societies place more significance and value on the male child. Higher male child mortality could increase the number of children a couple will have, thus leading to an increase in fertility levels. Population management interventions need to take this into consideration.

The findings concerning the hoarding effect have prompted questions on the effect of a couple's perception of child mortality risks on fertility. While some studies have been conducted on the hoarding effect, future studies need to explore this effect further by investigating couples' perceptions of child mortality conditions in their communities, and how this affects their reproductive behaviour. Information on how couples perceive child mortality conditions in their communities can be obtained through qualitative research.

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APPENDIX

Table A1 A piecewise log-rate model associated with the risk of closing the birth interval, interaction between education and survival status of index child

		Kenya	Lesotho	Malawi	Tanzania	Zimbabwe
Variable	Category	exp(β)	exp(β)	exp(β)	exp(β)	exp(β)
Death	No	ref.	ref.	ref.	ref.	ref.
	Yes	0.97	1.54	1.45*	1.56*	1.88*
Sex	Female	ref.	ref.	ref.	ref.	ref.
	Male	1.03	0.99	1.02	0.99	1.02
Previous interval	No prev. interval	ref.	ref.	ref.	ref.	ref.
	<30	0.87	3.35*	0.52*	0.56*	0.90
	30-47	0.77	3.31*	0.47*	0.44*	0.73
	48+	0.59*	2.50*	0.37*	0.30*	0.51*
Age at birth	10-14	1.01	0.89*	0.83	0.74*	0.78
	15-19	1.06	1.02	0.96*	0.98*	1.00
	20-24	ref.	ref.	ref.	ref.	ref.
	25-29	0.85*	0.80*	0.88*	0.94*	0.84*
	30-34	0.67*	0.58*	0.71*	0.75*	0.57*
	35-39	0.48*	0.34*	0.53*	0.46*	0.39*
	40-44	0.25*	0.08*	0.33*	0.24*	0.24*
	45-49	0.15**	0.00*	0.49	0.14*	0.26*
Education	No education	ref.	ref.	ref.	ref.	ref.
	Primary	0.86*	0.98*	0.90*	0.93*	0.92
	Secondary & higher	0.71*	0.78*	0.57*	0.81*	0.71*
Birth order	1	ref.	ref.	ref.	ref.	ref.
	2-4	1.07	0.27*	1.71*	1.92*	1.11
	5-7	1.06	0.33*	1.56*	2.09*	1.13
	8-10	0.99	0.56*	1.39*	2.07*	1.01
Wealth	Poorest	ref.	ref.	ref.	ref.	ref.
	Poorer	0.89*	0.76*	0.98	1.02	0.92*
	Middle	0.79*	0.70*	0.95*	0.99	0.85
	Richer	0.67*	0.54*	0.91*	0.79*	0.66*
	Richest	0.48*	0.46*	0.81*	0.57*	0.58*
Interval	0-8	0.01*	0.02	0.01*	0.00*	0.01*
	9-17	0.36*	0.24	0.28*	0.22*	0.27*
	18-23	ref.	ref.	ref.	ref.	ref.
	24-29	1.45*	1.94*	1.68*	1.82*	1.75*
	30-35	1.36*	2.68*	2.12*	2.06*	2.12*
	36-41	1.38*	2.67*	2.06*	1.90*	2.18*
	42-47	1.13*	2.47*	2.03*	1.72*	2.15*
	48-53	1.02*	2.26*	1.81*	1.40*	2.02*
	54-59	0.89*	2.24*	1.55*	1.35*	1.81*
	60+	0.42	0.02	0.66*	0.58	0.89
Death*Interval	Death*0-8	0.00*	0.00*	0.00*	0.00*	0.00*
	Death*9-17	2.00*	6.42*	2.98*	3.83*	4.93*
	Death*24-29	0.90*	0.91*	1.10*	0.95*	1.16*
	Death*30-35	0.61*	0.65*	0.79*	0.74*	0.95*
	Death*36-41	0.67*	0.56*	0.70*	0.84*	0.61*
	Death*42-47	0.74*	0.57*	0.61*	0.90*	0.54*
	Death*48-53	0.52	0.64*	0.61*	0.78*	0.48*
	Death*54-59	0.26**	0.16*	0.58*	0.88*	0.40
	Death*60+	0.39*	0.34*	0.56*	0.58*	0.26*
Education*death	Primary*yes	1.31*	2.13	1.57*	1.64	2.13
	Secondary & higher*yes	1.23	2.70**	2.07*	2.95*	2.58

Table A2 A piecewise log-rate model associated with the risk of closing the birth interval, interaction between birth order and survival status of index child

		Kenya	Lesotho	Malawi	Tanzania	Zimbabwe
Variable	Category	exp(β)	exp(β)	exp(β)	exp(β)	exp(β)
Death	No	ref.	ref.	ref.	ref.	ref.
	Yes	1.33*	2.35*	1.64*	1.72*	2.26*
Sex	Female	ref.	ref.	ref.	ref.	ref.
	Male	1.04	0.98	1.02	0.99*	1.02
Previous interval	No prev. interval	ref.	ref.	ref.	ref.	ref.
	<30	0.91	6.68*	0.54*	0.58*	0.97
	30-47	0.80	6.60*	0.48*	0.45*	0.79
	48+	0.61*	4.97*	0.38*	0.31*	0.55**
Age at birth	10-14	1.01	0.89	0.82	0.73	0.77*
	15-19	1.06	1.01	0.96	0.98*	1.00
	20-24	ref.	ref.	ref.	ref.	ref.
	25-29	0.85*	0.80*	0.88*	0.94*	0.84*
	30-34	0.67*	0.58*	0.71*	0.75*	0.57*
	35-39	0.48*	0.34*	0.53*	0.46*	0.39*
	40-44	0.25*	0.08*	0.33*	0.25*	0.24*
	45-49	0.14**	0.00*	0.49	0.14*	0.26*
Education	No education	ref.	ref.	ref.	ref.	ref.
	Primary	0.88*	1.00	0.91	0.94	0.93
	Secondary & higher	0.73*	0.81*	0.59*	0.85	0.73*
Birth order	1	ref.	ref.	ref.	ref.	ref.
	2-4	1.04	0.13*	1.67*	1.89*	1.04
	5-7	1.03	0.17*	1.53*	2.05*	1.05
	8-10	0.96	0.29*	1.38*	2.10*	0.91
Wealth	Poorest	ref.	ref.	ref.	ref.	ref.
	Poorer	0.89*	0.76*	0.98	1.01	0.92*
	Middle	0.79*	0.70*	0.95*	0.99	0.85*
	Richer	0.67*	0.54*	0.91*	0.79*	0.66*
	Richest	0.48*	0.46*	0.81*	0.57*	0.58*
Interval	0-8	0.01*	0.02*	0.01*	0.00*	0.01*
	9-17	0.36*	0.24*	0.28*	0.22*	0.27*
	18-23	ref.	ref.	ref.	ref.	ref.
	24-29	1.45*	1.95*	1.68*	1.82*	1.75*
	30-35	1.36*	2.68*	2.12*	2.06*	2.12*
	36-41	1.38*	2.67*	2.06*	1.90*	2.18*
	42-47	1.13*	2.47*	2.03*	1.72*	2.14*
	48-53	1.02	2.26*	1.81*	1.40*	2.02*
	54-59	0.89**	2.23*	1.55*	1.35*	1.81*
	60+	0.42*	0.92	0.66*	0.58	0.89
Death*Interval	Death*0-8	0.00*	0.00*	0.00*	0.00	0.00*
	Death*9-17	2.73*	9.82	3.35*	4.25*	5.93*
	Death*24-29	1.23	1.39*	1.24*	1.06*	1.40*
	Death*30-35	0.85*	0.99*	0.89*	0.82*	1.15*
	Death*36-41	0.93*	0.86*	0.80*	0.93*	0.73*
	Death*42-47	1.01	0.87*	0.70*	1.00*	0.65*
	Death*48-53	0.72*	0.99*	0.70*	0.88*	0.59*
	Death*54-59	0.36*	0.25*	0.66*	1.00*	0.49*
	Death*60+	0.53*	0.52*	0.64*	0.66*	0.31*
Birth order*death	2-4*yes	1.18	2.17	1.53**	1.60	2.20
	5-7*yes	1.11	2.08	1.50	1.67	2.05
	8-10*yes	1.35	2.05	1.63**	1.17*	4.33*
	11+*yes	0.91*	0.00*	1.28	1.16	0.67*

* Significant at 5 per cent, **significant at 10 per cent

Table A3 Number and proportion of women who gave non numeric responses to the ideal number of children question

Response	Kenya	Lesotho	Malawi	Tanzania	Zimbabwe
Up to God	188(8.27%)		92(1.57%)		
Non-numeric response	26(1.14%)	10(0.51%)	111(1.89%)	96(3.24%)	5 (2.4%)
Missing	1(0.04%)	1 (0.5%)	6 (0.1%)	1 (0.03%)	
Any number			57(0.97%)		