# URBAN RURAL DIFFERENTIALS OF INFANT MORTALITY IN KENYA USING A SHARED FRAILTY MODEL

By

PURITY M. NJAGI

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## Declaration

This project is my original work and to the best of my knowledge has not been presented for a degree in any other university.

CANDIDATE: Purity M. Njagi

SIGNATURE: ____________ DATE 29 | 11 | 2011

This project has been submitted for the award of a Master of Science Degree in Medical Statistics with our approval as university supervisors:

Thaddaeus Egondi DATE

____________ 29-11-2011

DATE

____________ ____________

## Dedication

*This work is dedicated to my loving parents for instilling in me great values that have made me the responsible person I am today. To my mum, I will always be there for you and to my late dad, in my heart you remain forever.*

# Acknowledgements

I would like to extend gratitude to my supervisor and advisor, Mr. Thaddeus Egondi; this project could not have been a success without him. His contributions, detailed comments and insights have been of great value and I am deeply indebted to him.

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## Abstract

Kenya targets to reduce infant mortality to 26/1000 live births by 2015.The Kenya Demographic Health Survey (KDHS) 2008/09 shows that compared to the 2003 KDHS, the Infant Mortality Rate (IMR) improved to 52 from 77 per 1000 live births. However this reduction was achieved with an inverse in the trend whereby infant mortality rate for the first time in Kenya was higher in urban areas than rural areas. Although studies have focused on urban rural differentials in Kenya, most have utilised logistic regression and standard survival models. This study therefore set to examine the implications of unobserved heterogeneity on parameter estimates of urban rural differentials in infant mortality in Kenya.

The study is conceptualised using the Mosley and Chen framework on child mortality. It utilises data from the KDHS 2008/09, the variables analysed include socio economic variables (Mother's education, Wealth quintile and region of residence), demographic variables (Mother's age at birth and birth order) and biological variables (Preceding birth interval and birth size).

Standard Log normal Accelerated Failure Time model was used for analysis, shared frailty model was further fitted to account for unobserved heterogeneity; frailty was considered at household level. Results indicate that although infant mortality was seen to be higher in urban areas compared to rural areas, this difference was not significant. In urban areas birth size was the only significant factor that influenced infant mortality whereas in rural areas region of residence, preceding birth interval, birth order and birth size were significant factors. Consistent with other studies AFT model was seen to underestimate the negative parameters while overestimating the positive parameters.

Recommendations emanating from this study are that, frailty provides a more precise estimate of parameters compared to standard AFT models. In addition, programs or interventions targeted at reducing infant mortality should seek to address factors by urban and rural differentials so as to address specific needs of the population in those regions. It would also be paramount to study other factors that act to influence infant mortality especially in urban areas.

# Table of contents

## Acronyms

| | |
|---|---|
| AFT | Accelerated Failure Time |
| AIC | Akaike's Information Criterion |
| BIC | Bayesian Information Criterion |
| IMR | Infant Mortality Rate |
| KDHS | Kenya Demographic and Health Survey |
| KNBS | Kenya National Bureau of Statistics |
| LnL | Log likelihood |
| PNMR | Post neonatal Mortality |
| UN | United Nations |

# List of tables

# 1 Introduction

## 1.1. Background

Infant mortality rate (IMR) is one of the most important sensitive indicators of the socioeconomic and health status of a community. This is because more than any other age-group of a population, infant's survival depends on the socioeconomic conditions of their environment (Madise et al 2003). It is one of the components of United Nations human development index (UN, 2007). Hence its description is very vital for evaluation and planning of the public health strategies (Park, 2005). Infant and child mortality gained global attention in the millennium development goals number 5, where the target is set at reducing infant and child mortality by two thirds by 2015. Infant mortality is a priority area on any country's public health agenda; it has been recognised in the millennium development goals, and its reduction is a key health milestone for any country. It's thus very important for countries to monitor the progress towards achievement of the MDGs target of reducing infant and child mortality.

In Kenya, there has been a notable decline in infant mortality levels from 77 deaths per 1,000 in 2003 to 52 deaths per 1,000 in 2008.This has been attributed to the various government programmes among them increases in childhood immunization coverage and improvement in key malaria indicators which include ownership and use of treated mosquito nets, preventive treatment of malaria during pregnancy and treatment of childhood fever (KNBS, 2010). Studies on urban-rural mortality differentials in Sub-Saharan Africa show that overall mortality, and infant and child mortality in particular, is generally lower in urban than in rural areas (Akoto and Tabutin, 1989 c.f Eliwo Akoto and Basile O.Tambashe). However, results from the 2008 KDHS depart from this reality-for the first time in Kenya; infant mortality in the urban areas is higher than that in rural areas.

Overall Infant mortality rates have been rising in Kenya until recently when the rate significantly declined. The gap between rural and urban areas has been widening in favor of urban areas until recently. It is not known why the infant mortality rates stayed higher or even increased in urban areas compared to the rural areas despite action plans and interventions made.Studies have shown that policies on health care have benefited urban areas more compared to rural areas. Given that urban areas have been associated with improved health outcomes over time, due to the availability and accessibility of maternal and child health services. It would have been expected that these gains are reflected across all under five mortality rates.

However, Contrary to results observed in previous demographic surveys, in 2008 urban-rural differentials for post neonatal and infant mortality show a reversed pattern, with mortality in urban areas exceeding that in rural areas. Infant mortality is 9 percent higher in urban areas (63 per 1,000) than in rural areas (58 per 1,000). Infant mortality in urban areas remained at the same level as that recorded in the 2003 KDHS; however, infant mortality in rural areas dropped by 27 percent from 79 deaths per 1,000 live births in the 2003 KDHS to 58 deaths per 1,000 live births in the 2008-09 KDHS (KNBS, 2010)

**Table 1: Trends in Urban –Rural differentials of infant mortality in Kenya**

| **Indicator** | **1989** | **1993** | **1998** | **2003** | **2008** |
|---|---|---|---|---|---|
| IMR (Per 1000 deaths) - Urban | 56.8 | 45.5 | 55.4 | 61 | 63 |
| IMR (Per 1000 deaths) - Rural | 58.9 | 64.9 | 73.8 | 79 | 58 |
| Total IMR (Per 1000 deaths) | 59.6 | 61.7 | 73.7 | 77 | 52 |

Source: KDHS 1989, 1993, 1998, 2003 & 2010

This study is aimed at examining the factors associated with urban rural differentials by utilising frailty model to account for the unobserved heterogeneity, which may mask some unobserved factors. Therefore the study seeks to answer the question; Is unobserved heterogeneity significant in accounting for urban – rural differentials in infant mortality in Kenya.

## 1.2 Objective of the study

The general objective of this study was to examine factors associated with urban–rural differentials of infant mortality in Kenya using frailty model.

## 1.3 Specific Objectives

1. To identify the factors associated with urban–rural differentials of infant mortality in Kenya

2. To examine the role of unobserved heterogeneity in urban-rural differentials in infant mortality in Kenya

## 1.4 Justification

Application of parametric and non parametric survival models has often been applied to account for differentials in infant mortality across various socioeconomic and demographic characteristics. This models often assume that the population is homogenous that is there is no heterogeneity and thus can provide a biased hazard estimate. A study of determinants of Infant and child mortality in Kenya using 1998 KDHS examined the extent to which child survival risks continue to vary net of observed factors and the extent to which non frailty models are biased due to violation of the statistical assumption of independence. The study established that Frailty effects are substantial and highly significant both in infancy and in childhood; however the conclusions remained the same (Omariba, 2007).

The issue of the homogeneity/heterogeneity of the urban setting shows that within a country, the fact that the urban and rural areas are combined at the national level, and that their mortality level is compared at that aggregate level, may mask certain differences (Akoto, 1991). Likewise, within a city, the study of cause of mortality by type of neighborhood or residence may show that in urban areas there are neighborhoods with higher mortality rates than rural areas; such differences are generally concealed by urban and rural aggregates (Kuaté, 1988; c.f Akoto et al )

Results from several empirical and simulation studies have shown that accounting for unobserved heterogeneity significantly improves overall model fitness (Heckman et al., 1985; Sastry, 1997; Trussell and Rodriguez, 1990; Blossfeld and Hamerle, 1992). There is evidence that the failure to correct for unobserved heterogeneity can lead to hazards that either decline steeply or rise more slowly than the true hazard, and the parameter estimates and their associated standard errors will be biased. Correcting for unobserved heterogeneity in event history models is thus seen as a way of correcting for model misspecification, and the frailty approach is a statistical modeling concept that aims to account for heterogeneity caused by unmeasured factors (Guiterrez, 2002)

Most studies conducted in Kenya focusing on urban – rural differentials in infant mortality have utilised ordinary regression models thus assuming homogenous populations. Identification of unobserved heterogeneity in rural urban differentials in infant mortality can provide useful information to planners to look for definitive predictors to use in determining new entry points for interventions and reducing the health gap in infant mortality in both rural and urban areas and ultimately in Kenya.

### 1.5 Scope and limitation

This study intends to highlight the urban rural differentials in infant mortality in Kenya specifically looking at the significance of unobserved heterogeneity. One of the limitations of this study is that, the study will not analyse all the determinants influencing infant mortality as they many and vary depending on where the area and population of study. The study will focus on the widely documented factors within similar populations.

A potential data quality in this study is the selective omission from the birth histories of the record of births of infants who did not survive, which can lead to underestimation of mortality rates. When selective omission of childhood deaths occurs, it is usually most pronounced for deaths occurring early in infancy. However, evidence from the 2008-09 KDHS data shows for the five years before the survey, the ratio of neonatal deaths is within acceptable levels. This high percentage of neonatal deaths (61percent).implies that there was little if any selective omission of childhood deaths that could compromise the quality of the early childhood mortality rates (KNBS 2010)

The use of frailty models assumes that the unobserved risk factors are the same within clusters, which may not reflect reality. In addition, the dependence between survival times within the cluster is based on marginal distributions of survival times. However, when covariates are present in a proportional hazards model with gamma distributed frailty the dependence parameter and the population heterogeneity are confounded (Clayton, 1985).

# 2 Review of literature

This section reviews various literatures on frailty models especially shared frailty models and factors associated with infant mortality. Presentation of conceptual framework and operational framework will follow, and then hypotheses and definition of key variables will be discussed. Reviews of this literature will cite what is already known about infant mortality and frailty models as well as spell out the gaps from different studies.

## 2.1 Review of literature on Frailty models

The notion of frailty provides a convenient way to introduce random effects, association and unobserved heterogeneity into models for survival data. The frailty approach is a statistical modeling concept which aims to account for heterogeneity, caused by unmeasured covariates. In statistical terms, a frailty model is a random effect model for time-to-event data, where the random effect (the frailty) has a multiplicative effect on the baseline hazard function. The shared frailty model is relevant to event times of related individuals, similar organs and repeated measurements. Individuals in a cluster are assumed to share the same frailty Z, which is why this model is called shared frailty model. It was introduced by Clayton (1978) and extensively studied in Hougaard (2000). The survival times are assumed to be conditional independent with respect to the shared (common) frailty (Wienke, 2003).

In a study by Gymiah O.Stephen in sub Saharan African using 2003 DHS data on effects of infant deaths on timing of second births using Log normal AFT models in a multivariate context with and without frailty, observed that the models that accounted for unobserved heterogeneity fitted with respect to overall model fitness than standard models. The study further concluded that that standard model that do not control for unobserved heterogeneity produced biased estimates by overstating the degree of positive dependence and underestimating the degree of negative dependence (Gymiah n.d).

## 2.2 Review of literature on urban rural differentials

Omariba (2007) conducted a study in Kenya using 1998 Kenya Demographic and Health Survey utilising standard Weibull survival models showed that bio demographic factors are more important in explaining infant mortality, while socioeconomic, sociocultural and hygienic factors are more important in explaining child mortality.

A study on socioeconomic determinants of infant mortality in Kenya using data from 2003 KDHS showed lack of significant socioeconomic association with infant mortality in both urban and rural Kenya. This was attributed to the nature of the occupations available in rural areas which is usually manual (like agriculture), so women are not available for long time to care for their children. While in the urban areas, because of the assumed availability of health services, the survival of the child is determined by his/her mother's awareness and thus educational level. The study showed that biological and demographic variables are more important determinants of infant and post neonatal mortality. In the urban areas, the survival of the child is determined by maternal awareness and level of education (Hisham Elmahdi Mustafa and Clifford Odimegwu)

The notion that there is excess m excess mortality over rural areas supposes that urban populations are living in a more precarious situation than village dwellers. Among other factors such a situation may be attributed to the economic crisis. As shown by several studies, the effects of economic crisis are much more palpable in urban settings than in rural areas (Eloundou-Enyegue P. M., 2000).

Child mortality is especially sensitive to fluctuations in the standard of living. Given the effects of the economic crisis are felt much more in urban than rural areas, there is reason to expect that urban mortality will be higher than rural mortality or, at the very least, that the differences between urban and rural mortality will shrink.

In Luanda, a study by Akoto and Tabutin (1989) quoted by Akoto E and Basile O, found that child mortality has increased since independence (1975) with the war and the considerable deterioration in general living conditions until 1980. The mortality rate among children 0 to 2 years of age rose by nearly 20% in 5 years. Contrary to expectations, this increase in mortality has been much higher in modern neighborhoods than in poor ones, and higher in urban communities than in rural communities in this province. The authors estimate that this is due to the sharp deterioration in living conditions, which may have a much more significant impact in the monetary economy (where the wage-earners are found in central neighborhoods) than in the subsistence economy (rural or semi-rural areas in the outskirts and the ring). This demonstrates how fragile health is, especially children's health, in a very difficult economic and political context such as that of Luanda.

It has been noted that child mortality is much more sensitive to deteriorations in living conditions than infant mortality. It should also be noted that, in Tanzania (1998), contrary to expectations, urban residence is associated with a higher risk of infant mortality. The risk of infant death among urban children was 50% higher than among rural children. This may be a reflection of either the deterioration living conditions in urban settings as compared to rural areas, or the rapid improvement in socioeconomic conditions in rural areas as compared to urban areas.

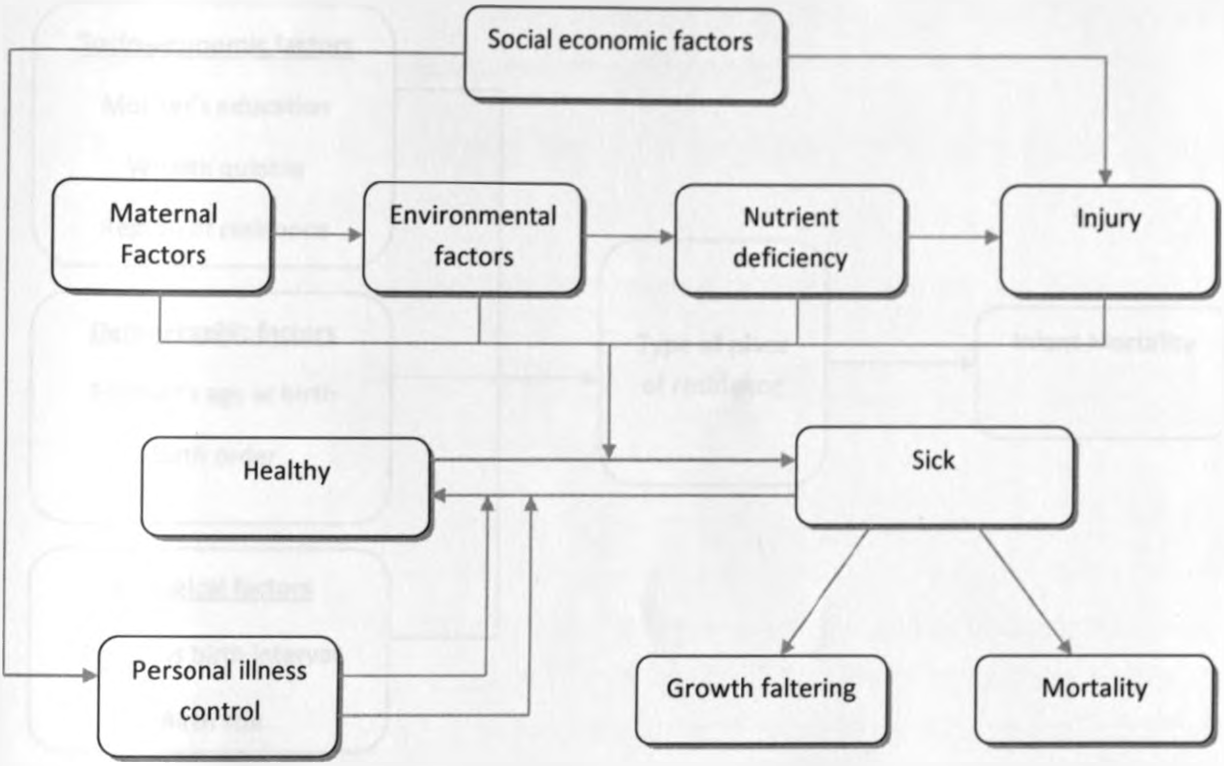
A study in Tanzania has shown lack of infant and child mortality differentials by such socioeconomic factors as maternal education, partner's education, urban/rural residence, and presence of radio in the household. But demographic factors such as short birth interval (less than 2 years), teenage pregnancies (< 20 years) and previous child death were all significantly associated with increased infant and child mortality. There is lack of infant-child mortality differentials by economic status (wealth index), ethnicity and sex of the child. (Mturi and Curtis1995) quoted from (Odimegwu, 2008)

An analytical cross-sectional study conducted using secondary data analysis of the 2003 Kenyan Demographic and Health Survey (KDHS) established the relationship between infant mortality and various socioeconomic and demographic factors. The study found that, In terms of levels and differentials of infant mortality by some socioeconomic and demographic factors, Nyanza province has the highest level of IMR and PNMR while Central province has the least one. Again, Luo children have the highest IMR while it is the least in the Kikuyu group. Urban and rural areas show almost the same level of IMR. Mothers with no education have the highest level of infant mortality than the other categories of education in Kenya.

Poorest households had the highest level of IMR and PNMR, and there were more male infant mortality than females in these households. There is also a significant high risk for dying among infants for mothers whose age at first birth is less than 19 years. Also the probability of infant death is more likely for male infants, those born less than 2 years birth interval or those who were never breastfed by their mothers than otherwise. In the rural areas also, children with maternal education level less than secondary, being from ethnic group other than Kikuyu, being a male, those of fifth or more birth order with less than 2 years birth interval and never breast fed babies were all at a significant higher risk for not surviving their first year of age. In both areas, social and demographic factors showed some association with infant mortality (Odimegwu, 2008).

Size of the child at birth also has a bearing on the childhood mortality rates. Children whose birth size is small or very small have a 50 percent greater risk of dying before their first birthday than those whose birth size is average or larger.(KNBS 2010)

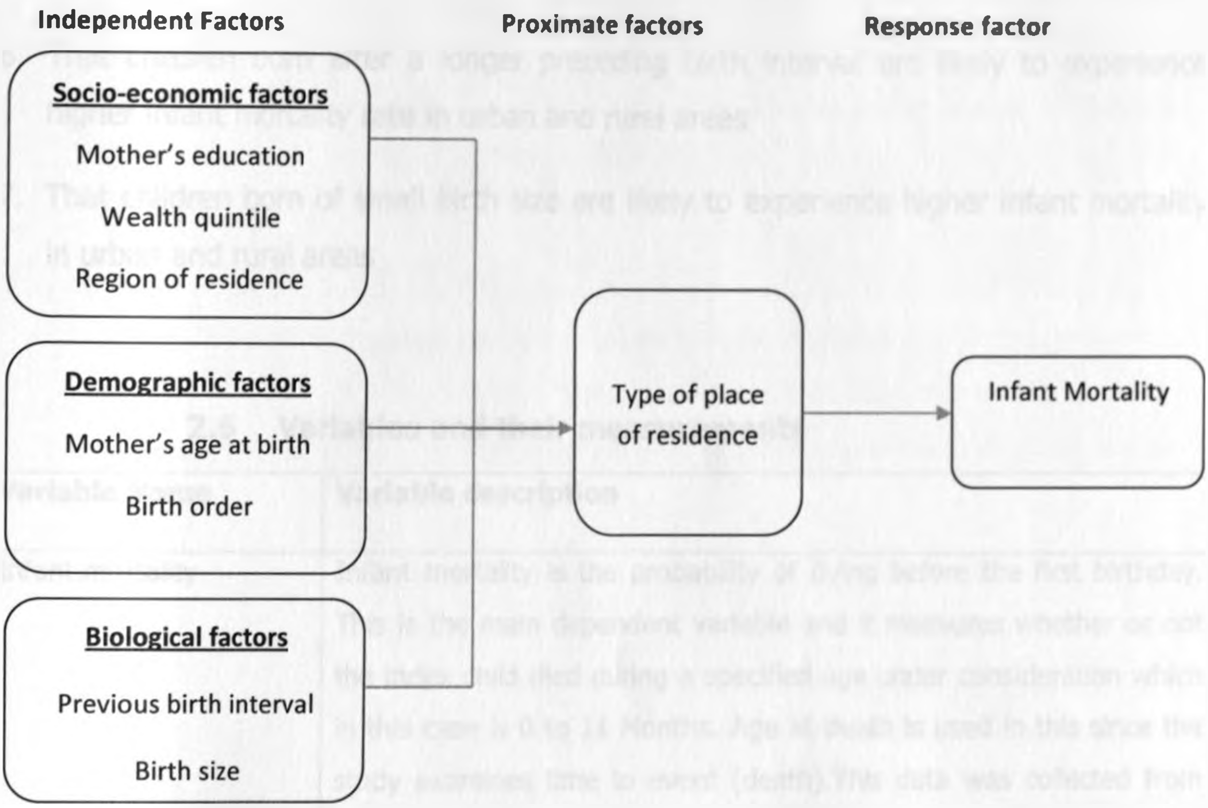
## 2.3 Conceptual framework




Source: Mosley & Chen (1984)

Mosley and Chen (1984) proposed a framework that assesses the determinants where the effects on social and economic factors on mortality are estimated through a common set of intermediate variables (Hill 2003). The framework links the individual child health for this with the underlying socio-economic factors. The approach is based on the premise that all social and economic determinants of child mortality operate through a common set of biological mechanisms or proximate determinants to exert an impact on mortality.

## 2.4 Operational framework




Source: Mosley & Chen (1984)

## 2.5 Operational Hypothesis

1. That mothers with low education are likely to experience higher infant mortality rate in urban and rural areas
2. That children born from higher wealth quintile are likely to experience lower infant mortality in urban and rural areas
3. That children from Nyanza and Cast regions are likely to experience higher infant mortality rate in urban and rural areas
4. That older mothers at birth are likely to experience higher infant mortality in urban and rural areas

5. That children of higher birth order are likely to experience higher infant mortality in urban and rural areas

6. That children born after a longer preceding birth interval are likely to experience higher infant mortality rate in urban and rural areas

7. That children born of small birth size are likely to experience higher infant mortality in urban and rural areas

## 2.6 Variables and their measurements

| Variable Name | Variable description |
|---|---|
| Infant mortality | Infant mortality is the probability of dying before the first birthday. This is the main dependent variable and it measures whether or not the index child died during a specified age under consideration which in this case is 0 to 11 Months. Age at death is used in this since the study examines time to event (death).This data was collected from KDHS age at death was calculated from the reported information in completed months. |
| Mother's education | This variable is derived from the highest year of education which gives the years of education completed.This variable Mother's education is then recoded to reflect four education categories as follows; No Education, Primary incomplete, primary complete, secondary+ |
| Wealth quintile | This is variable is an index created from several other variables from the DHs data. It has been recoded from the original; poorest, poorer, Middle, richer, richest into Low (Poorest & poorer), Middle (Middle) and high (richer & richest). |
| Region of residence | This refers to the *De facto* region of residence that is the region in which the respondents was interviewed. The regions refer to the 8 |

| | |
|---|---|
| | main regions/provinces in Kenya. They are as follows; Nairobi , Central , Eastern, Western, Nyanza, Rift Valley, Coast, North Eastern |
| Mother's age at birth | This variable has been created by using the date of birth of the child and the date of birth of the birth to give age at time of birth. Its then recoded as follows; Below 20 Years, 20-29 years , 30-39 years, 40-49 years |
| Birth order | Birth order number gives the order in which the children were born, from the DHS data this data is presented from order 1 to order 13.This has thus been recoded into four categories that is first birth order, second and third birth order, four and five birth order and six and above birth order. |
| Previous birth interval | Preceding birth interval is calculated as the difference in months between the current birth and the previous birth, counting twins as one birth.It thus refers to the time duration between the previous birth and the study birth. This is divided into; Below 2 years, 2 years, 3years,4+ years |
| Birth size | Birth size refers to the Size of child as reported subjectively by the respondent. Its thus recoded into two categories as follows;Small/very small, Average/Large |

# 3 Data and methodology

This section represents the description of the source of data including the sample utilised for this study. It further describes the methods of data analysis both exploratory and advanced analysis that lead to the conclusions of this study.

## 3.1 Source of data

The data used in this study is from the KDHS carried in 2008, the 2008-09 Kenya Demographic and Health Survey (KDHS) is a population and health survey that Kenya conducts every five years. The survey collected information on demographic and health issues from a sample of 8,444 women at the reproductive age of 15-49 and a sample of 3,465 men age 15-54 years in a one-in-two subsample of households.

The survey is household-based, and therefore the sample was drawn from the population residing in households in the country. A representative sample of 10,000 households was drawn for the 2008-09 KDHS. This sample was constructed to allow for separate estimates for key indicators for each of the eight provinces in Kenya, as well as for urban and rural areas separately. Compared with the other provinces, fewer households and clusters were surveyed in North Eastern province because of its sparse population. A deliberate attempt was made to oversample urban areas to get enough cases for analysis. As a result of these differing sample proportions, the KDHS sample is not self-weighting at the national level

The data for mortality estimates was collected in the birth history of the women interviewed. Women gave information on date of birth of every child born, and if the child is dead the age at which the child died is given. KDHS also collected information from all regions (provinces) on child health outcomes (mortality & incidence of illnesses) women's (respondents) demographic, social and economic (Wealth) characteristics.

This study uses data on births during 5 year period preceding the 2008 survey whose sample is 6,079(1,467 Urban and 4,612 deaths).Data on deaths is that of children who died before their first birthday which is by the $11^{th}$ month, whose sample is 299 deaths. STATA version 10 is used for data processing and analysis

## 3.2 Data Analysis

### 3.2.1 Parametric Models

This study uses parametric approach in modeling the hazard of dying before celebrating first birth day. Unlike the Cox model which is semi-parametric because the form of the baseline hazard is not specified, except the form of the effect of covariates. The parametric model, on the other hand, has all parts of the model specified, that is both the hazard function and the effect of any covariates. The strength of this is that estimation is easier and estimated survival curves are smoother as they draw information from the whole data. The parametric models assume a continuous parametric distribution for the probability of failure over time. There are many types of parametric models, which differ in the assumed distribution of the timing function.

In this study, several models have been explored in order to choose the appropriate model. Various tests have been employed, however this study utilizes the one of the widely used tests that is the; Akaike's Information Criterion (AIC), The AIC or likelihood ratio tests allow us to assess relative model goodness of fit, but not absolute model goodness of fit.

Smaller AICs and BICs generally indicate better-fitting models.

$$AIC = -2\,(\ln L) + 2(k)$$

Where k is the total number of parameters estimated in the model (including a constant term, if any).

**Table 2: AIC for Five Parametric Models for Urban**

| Model | Hazard shape | AIC |
|---|---|---|
| Exponential | Constant | 935.472 |
| Weibull | Monotone | 643.958 |
| Gompertz | Monotone | 892.694 |
| Log-Normal | Variable | 638.553 |
| Log-Logistic | Variable | 643.195 |

**Table 3: AIC for Five Parametric Models for Rural**

| Model | Hazard shape | AIC |
|---|---|---|
| Exponential | Constant | 3434.953 |
| Weibull | Monotone | 2406.454 |
| Gompertz | Monotone | 3205.013 |
| Log-Normal | Variable | 2394.144 |
| Log-Logistic | Variable | 2405.668 |

From table 2 and 3 above, the log normal parametric model has the lowest AIC in both Urban and rural data.

The log-normal distribution assumes that the log of the timing function follows a normal distribution

The survivor function for the Lognormal is;

$$s(t) = 1 - \varphi\{\frac{\ln(t) - \mu}{\sigma}\}$$

Where $\varphi$ is the standard Normal cdf and $\mu = X\beta$

### 3.2.2 Shared frailty model

Parametric specification plus covariates can only go so far in explaining the variability in observed time to failure. Excess unexplained variability is known as over dispersion caused either by misspecification or omitted covariates not addressed. As such, current model cannot adequately account for why subjects with shorter times to failures are more "frail" than others. A frailty model attempts to measure this over dispersion by modeling it as resulting from a latent multiplicative effect on the hazard function. (Gutierrez,R 2002)

The study utilizes the shared frailty model with log normal distribution. Shared frailty models for multivariate data have the added appeal that the frailty can be used to model intragroup correlation. The notion of frailty provides a convenient way to introduce random effects, association and unobserved heterogeneity into models for survival data. The frailty approach is a statistical modeling concept which aims to account for heterogeneity, caused by unmeasured covariates or dependence among study subjects. In this study, infants from the same household are said to share certain characteristics (genetic or environment) which are masked and can be accounted for using a shared frailty model.

In statistical terms, a frailty model is a random effect model for time-to-event data, where the random effect (the frailty) has a multiplicative effect on the baseline hazard function. The shared frailty model is relevant to event times of related individuals, similar organs and repeated measurements. Studies have shown that the frailty parameter might be correlated across individuals who share certain genetic or environmental characteristics (Oeppen J 2011). This study considers frailty at the child household level , whereby children born from the same mother and who reside in same household are likely to be exposed to similiar risk due to genetic composition or environmental exposure therefore sharing the same frailty value.

Individuals in a cluster are assumed to share the same frailty Z, which is why this model is called shared frailty model. It was introduced by Clayton (1978) and extensively studied in Hougaard (2000). The survival times are assumed to be conditional independent with respect to the shared (common) frailty (Wienke, 2003).

The hazard rate for the $j^{th}$ individual in the $i^{th}$ subgroup is:

$$h_{ij}(t)=h_o(t)e^{X_{ij}\beta + W_{i\varphi}}$$

Where $W_i$ are the subgroup frailties which are assumed to be independently distributed with a mean of 0 and a variance of 1.

# 4 Results

## 4.1 Characteristics of study population

This chapter presents the characteristics of the study population by socio-economic, biological factors and demographic factors. Further it discusses the distribution of children who died before their first birthday and those who survived beyond their first birthday by socio-economic, biological factors and demographic factors. In addition the section explains the association between the study characteristics and the survival status of the child by residence (rural and urban).

## 4.2 Background characteristics of study respondents

Table 2 below shows the percentage distribution of study respondents by background characteristics. This study utilised a sample population of 6,079 of which 24.1 percent were from urban residents while 75.9 percent were from rural residents. Of the sample births used for analysis 4.9 percent did not survive beyond their 1st birthday whereas 95.1 percent survived beyond their 1st birthday.

Distribution of the respondents by mothers education indicated that 21.4 percent had no education, 31.5 percent had not completed primary education, 24.9 percent had completed primary education while 22.2 percent had attained secondary education or higher. The distribution of the respondents by wealth index revealed that majority were in the low wealth index and they accounted for 46.9 percent, those in the medium and high wealth indexes were 16.2 and 36.8 percent respectively.

Respondents distribution by region of residence showed that most of the respondents were from Nyanza with 18.2%, followed by Rift Valley with 17.4%, then Coast with 14.5% and closely followed by western which had 13%, then Eastern with 12.2%, North eastern with a percentage of 9.5%, then Central with 8.16% and lastly Nairobi had the least with 2.0% of the respondents.

More than half of the study births were born of mother's aged between 20 to 29 years at 55.2 percent, 32.2% were born of mother's aged between 30 to 29 years whereas 6.65% were born from mother's aged 40-49 years and 5.8%. Of the study births 51 % were male births whereas 49% were female births.

Of the study births 22.8% were of birth order 1, 37.5% were births of order between 2 to 3, 21.1% were births of order 4 to 5 and finally 18.5% were births of order 6 and above. Additionally of the study births 2.4% were born in less than 2 years after a previous birth,24.5% were born 2 years after a previous birth whereas 32.8% were born 3 years after a previous birth and 40.6% were born 4 and above years after a previous birth. Distribution by size of the birth shows that 81.9% of the births were born of average or large size whereas 17.2% of the births were born of small or very small size.

The table further outlines the distribution of the study characteristics by type of place of residence (Urban or rural) of the study respondents. Of the study births used for analysis, 95.3 percent of those residents in urban areas survived beyond their first birthday whereas 4.6 percent didn't survive beyond their first birthday. Those from rural residence, 94.9 percent survived beyond the first birthday while 5 percent did not survive beyond the first birthday.

Distribution by mothers education in urban areas indicated that majority of the respondents had attained secondary education and above with 41.8%, followed by those that had completed primary education at 25.2%, those with incomplete primary education were 21.4% and finally 11.4% had no any form of education. Among those resident in rural areas most had not completed their primary education with 34.6%, those that had completed primary education and those that had no education had almost similar proportion with 24.8% and 24.5% respectively. Those with more than secondary education were the least with 15.4%.

Respondent's distribution by wealth quintile revealed that in urban areas majority of the respondents were in the high wealth quintile with 90.6% and small proportions were of low and middle wealth quintile with 4.7% and 4.5% respectively. Nevertheless, among the rural respondents majority were in the low wealth quintile with 60.4% whereas those in middle and high quintile were 19.9% and 19.6% respectively.

Region distribution indicates that most of the urban respondents were from the regions that are home to the three main cities in Kenya, Nairobi region had the majority with 28.2%, followed by coast with 22.9% and Nyanza by 14.1%.Other regions that followed include western with 10.2%, Rift valley with 8.1%, North Eastern with 7.2%, Central with 6.7% and finally Eastern with 2.2%.Distribution among respondents in rural areas indicated that Nairobi did not have rural respondents, majority of the rural respondents were from Rift valley with 20.4%,followed by Nyanza with 19.5%, Eastern 15.4%, Western with 13.8%.The regions with least rural respondents were central 8.6% ,Coast 11.8% and western with 10.3%.

Distribution of the respondents by mother's age at birth reveal that of the respondents resident in urban areas majority were aged between 20-29 years with 61.5%, followed by those aged between 30-39 years with 27.6%, then those below 20 years with 6.88 and the least were aged between 40-49 years with 3.8%.Similarily among the respondents from rural areas majority were aged between 20-29 years with 53.2%, followed by those aged between 30-39 years with 33.7% and least were those age below 20 years and those aged between 40-49 years with the 5.4% and 7.5% respectively.

The distribution by birth order among urban respondents indicate that majority of the births were second and third order with 43.6% ,this was followed by first order births with 34.9% and then fourth to fifth order and sixth order and above with 14.8% and 6.6% respectively. Among the rural respondents analysis reveal that most births were of second and third order with 35.6%, this was followed by fourth and fifth order births with 23.1% and then sixth order and above births and finally first order birth with 22.2% and 18.9% respectively.

Urban respondents distribution by preceding birth interval indicates that more than half of the births were born 4 years and above after a previous birth with 51.3%, followed by those born 3 years after a previous birth with 24.4% and then those born 2 years and less than 2 years after a previous birth with 21.3% and 2.8% respectively. Similarly births from rural respondents reveal that majority were born 4 years and above after a previous birth with 37.9%, followed by those born 3 years after a previous birth with 34.4% and then those born 2 years and less than 2 years after a previous birth with 25.3% and 2.3% respectively.

Distribution by size of the birth among urban residents show that majority of the births, 83.7% were born of average or large size whereas 16% of the births were born of small or very small size. Among births from rural respondent's majority, 81.4% were born of average or large size whereas 17.6% of the births were born of small or very small size.

**Table 4: Percentage distribution of study respondents by background characteristics**

| Characteristics | Urban | | Rural | | Total | |
|---|---|---|---|---|---|---|
| | Frequency (n) | Percent (%) | Frequency (n) | Percent (%) | Frequency (n) | Percent (%) |
| **Residence** | | | | | | |
| Urban | - | - | - | - | 1,467 | 24.13 |
| Rural | - | - | - | - | 4,612 | 75.87 |
| **Survival status** | | | | | | |
| Survived | 1,399 | 95.36 | 4,381 | 94.99 | 5,780 | 95.08 |
| Dead | 68 | 4.64 | 231 | 5.01 | 299 | 4.92 |
| **Household characteristics** | | | | | | |
| **Wealth Quintile** | | | | | | |
| Low | 70 | 4.77 | 2,786 | 60.41 | 2,856 | 46.98 |
| Middle | 67 | 4.57 | 918 | 19.9 | 985 | 16.2 |
| High | 1,330 | 90.66 | 908 | 19.69 | 2,238 | 36.82 |
| **Region** | | | | | | |
| Nairobi | 414 | 28.22 | | | 414 | 6.81 |
| Central | 99 | 6.75 | 397 | 8.61 | 496 | 8.16 |
| Coast | 337 | 22.97 | 546 | 11.84 | 883 | 14.53 |
| Eastern | 33 | 2.25 | 711 | 15.42 | 744 | 12.24 |
| Nyanza | 208 | 14.18 | 901 | 19.54 | 1,109 | 18.24 |
| Rift valley | 119 | 8.11 | 941 | 20.4 | 1,060 | 17.44 |
| Western | 151 | 10.29 | 639 | 13.86 | 790 | 13 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Northeastern | 106 | 7.23 | 477 | 10.34 | 583 | 9.59 |
| **Mothers Characteristics** | | | | | | |
| **Mothers education** | | | | | | |
| No education | 168 | 11.45 | 1,132 | 24.54 | 1,300 | 21.39 |
| Incomplete primary | 315 | 21.47 | 1,600 | 34.69 | 1,915 | 31.5 |
| Complete primary | 370 | 25.22 | 1,145 | 24.83 | 1,515 | 24.92 |
| Secondary + | 614 | 41.85 | 735 | 15.45 | 1,349 | 22.19 |
| **Mothers age at birth** | | | | | | |
| Below 20 years | 101 | 6.88 | 252 | 5.46 | 353 | 5.81 |
| 20-29 years | 903 | 61.55 | 2,456 | 53.25 | 3,359 | 55.26 |
| 30-39 years | 406 | 27.68 | 1,557 | 33.76 | 1,963 | 32.29 |
| 40-49 years | 57 | 3.89 | 347 | 7.52 | 404 | 6.65 |
| **Birth Order** | | | | | | |
| 1 | 512 | 34.9 | 875 | 18.97 | 1,387 | 22.82 |
| 2-3 | 640 | 43.63 | 1,644 | 35.65 | 2,284 | 37.57 |
| 4-5 | 218 | 14.86 | 1,065 | 23.09 | 1,283 | 21.11 |
| 6 + | 97 | 6.61 | 1,028 | 22.29 | 1,125 | 18.51 |
| **Preceding birth interval*** | | | | | | |
| Below 2 years | 27 | 2.84 | 86 | 2.31 | 113 | 2.42 |
| 2 years | 203 | 21.37 | 946 | 25.37 | 1,149 | 24.56 |
| 3 years | 232 | 24.42 | 1,283 | 34.41 | 1,515 | 32.38 |
| 4 and above years | 488 | 51.37 | 1,414 | 37.92 | 1,902 | 40.65 |
| **Birth size** | | | | | | |
| Average/Large | 1,218 | 83.71 | 3,735 | 81.43 | 4,953 | 81.98 |
| Small/very small | 233 | 16.01 | 811 | 17.68 | 1,044 | 17.28 |
| Don't Know | 4 | 0.27 | 41 | 0.89 | 45 | 0.74 |
| Missing | 12 | | 25 | | 37 | |
| **Total (n)** | **1,467** | | **4,612** | | **6,079** | |

* Total (n) Urban 950 Rural 3,729

## 4.3 Urban rural differentials of infant deaths by study characteristics

Table 5 below summaries the proportion of infant deaths by the study covariates. In this table births are cross classified with the key socio-economic, biological factors and demographic factors and disaggregated by urban and rural residence.

In rural areas, region of residence and infant mortality were associated unlike among the urban residents. Mothers from Nyanza region experienced the highest deaths with 7.4% followed by those from central and Nyanza with 6.1% and 6% deaths respectively.

Western had 5%, Northeastern 4.8%, Rift valley region with 3.5% and Eastern with 2.7%. This association was significant at 0% level.

Mother's age at birth had an association with infant deaths among urban respondents unlike the rural respondents. Mothers aged between 40-49 years experienced the highest deaths with 10.5% ,followed by those aged between 30-39 years with 6.2%, then those aged between 20-29 years with 3.9% and finally mothers aged below 20 years experienced the least deaths with 2%.This association was significant at 2% level.

In addition there was an association between birth order and infant deaths among urban respondents unlike their rural counterparts. Mothers whose births were of sixth and above order experienced the highest deaths with 9.3%, followed by those whose births were fourth and fifth order 6.4% ,then those whose births were second and third order with 4.5% and finally those of first order had the least deaths with 3.1%.This association was significant at 3% level.

Preceding birth interval and infant deaths had an association among rural respondents unlike among their counterparts in urban areas. Mothers whose births were less than 2 years after a previous birth experienced the highest deaths with 12.8%, followed by those whose births were 2 years after a previous birth with 6.3%, then those whose births were 3 years after a previous birth with 4.1% and finally those of 4 years and above after their previous births with 4.4%. This association was significant at 0% level.

There was an association between infant deaths and birth size of the child both among urban and rural respondents. Among the urban respondents births whose size was large or average experienced less deaths with 3.2% compared to those of small or very small size with 9.4%.This association was significant at 0% level. Among the rural respondents , those of average or large size had experienced lowest deaths with 4.4% compared to those of small or very small size with 7.2%.This associations were significant at 0% level.

**Table 5: Distribution of infant deaths by study characteristics differentiated by urban rural residence**

| Characteristics | Urban | | | Rural | | |
|---|---|---|---|---|---|---|
| | Counts | Percent | Total(n) | Counts | Percent | Total(n) |
| **Mothers education** | | | | | | |
| No education | 13 | 7.7 | 168 | 56 | 5 | 1,132 |
| Incomplete primary | 18 | 5.7 | 315 | 83 | 5.2 | 1,600 |
| Complete primary | 15 | 4.1 | 370 | 55 | 4.8 | 1,145 |
| Secondary + | 22 | 3.6 | 614 | 37 | 5 | 735 |
| | $X^2$=6.3092 df=3 sig=.097 | | | $X^2$=0.2189 df=3 sig=.947 | | |
| **Wealth Quintile** | | | | | | |
| Low | 3 | 4.3 | 70 | 137 | 4.9 | 2786 |
| Middle | 4 | 6 | 67 | 57 | 6.2 | 918 |
| High | 61 | 4.6 | 1330 | 37 | 4.1 | 908 |
| | $X^2$=0.2966 df=2 sig=.862 | | | $X^2$=4.4934 df=2 sig=0.106 | | |
| **Region** | | | | | | |
| Nairobi | 15 | 3.6 | 414 | | | |
| Central | 8 | 8.1 | 99 | 24 | 6.1 | 397 |
| Coast | 15 | 4.5 | 337 | 33 | 6 | 546 |
| Eastern | 2 | 6.1 | 33 | 19 | 2.7 | 711 |
| Nyanza | 8 | 3.9 | 208 | 67 | 7.4 | 901 |
| Rift valley | 6 | 5 | 119 | 33 | 3.5 | 941 |
| Western | 6 | 4 | 151 | 32 | 5 | 639 |
| Northeastern | 8 | 7.6 | 106 | 23 | 4.8 | 477 |
| | $X^2$=6.316 df=7 sig=0.503 | | | $X^2$=25.939 df=6 sig=0.000 | | |
| **Mothers age at birth** | | | | | | |
| Below 20 years | 2 | 2 | 101 | 14 | 5.6 | 252 |
| 20-29 years | 35 | 3.9 | 903 | 115 | 4.7 | 2456 |
| 30-39 years | 25 | 6.2 | 406 | 75 | 4.8 | 1557 |
| 40-49 years | 6 | 10.5 | 57 | 27 | 7.8 | 347 |
| | $X^2$=9.392 df=3 sig=0.025 | | | $X^2$=6.4336 df=3 sig=0.092 | | |
| **Birth Order** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 16 | 3.1 | 512 | 44 | 5 | 875 |
| 2-3 | 29 | 4.5 | 640 | 78 | 4.7 | 1644 |
| 4-5 | 14 | 6.4 | 218 | 56 | 5.3 | 1065 |
| 6 + | 9 | 9.3 | 97 | 53 | 5.2 | 1028 |
| | $X^2$=8.9626 df=3 sig=0.03 | | | $X^2$=0.4279 df=3 sig=0.934 | | |
| **Preceding birth interval** | | | | | | |
| Below 2 years | 1 | 3.7 | 27 | 11 | 12.8 | 86 |
| 2 years | 12 | 5.9 | 203 | 60 | 6.3 | 946 |
| 3 years | 9 | 3.9 | 232 | 53 | 4.1 | 1283 |
| 4 and above years | 30 | 6.2 | 488 | 62 | 4.4 | 1414 |
| | $X^2$=1.8067 df=3 sig=0.613 | | | $X^2$=17.7848 df=3 sig=0.000 | | |
| **Birth size** | | | | | | |
| Average/Large | 39 | 3.2 | 1,218 | 163 | 4.4 | 3,735 |
| Small/very small | 22 | 9.4 | 233 | 58 | 7.2 | 811 |
| | $X^2$=18.9107 df=1 sig=0.000 | | | $X^2$=11.1945 df=1 sig=0.001 | | |

### 4.4 Results of Log normal Parametric Model

Table 8 (Attached appendix) summarizes the results of the log normal parametric model on individual effects of the study covariates on infant deaths, each variable is fitted separately and differentiated by place of residence (Urban and rural).

The results indicate that in urban areas the survival time for infant among mothers with secondary plus education increases 75.37 times than that of mother with no education. The results also indicate that the survival time for infant was lower for older mothers compared to young mothers. In addition, the survival time at infancy reduces with increase in birth order, while the survival time at infancy is reduces among births born of small or very small size compared to births born with average or large size.

In rural areas results indicate that, the survival time at infancy in Eastern and Rift valley region is longer than that in Central region by 132.7 and 38.47 times respectively. The survival time for children whose preceding birth interval is 2 years is 202.76 times longer than those whose preceding birth interval is below 2 years, while survival time for those with a preceding birth interval of 3 years is 2908.1 times longer than those whose preceding birth interval is below 2 years and the survival time for those with a preceding birth interval of 4 years and above is 2001.1 times longer than those whose preceding birth interval is below 2 years. Finally, the survival time at infancy among births born of small or very small size reduces by 0.04 times than that of births born with average or large size.

Table 6 shows the results of the multivariate log normal parametric model, for urban and rural areas. The respective LR chi-square tests suggest that the overall models are statistically significant.The results indicate that in urban areas the survival time at infancy among births born of small or very small size reduces by 0.007 times longer than that of births born with average or large size.

In rural areas, results indicate that survival time at infancy in Eastern and Rift valley region reduces by 0.04 and 0.01 times respectively compared to that in Central region. In addition the survival time for children of birth order 6 and above is 29.97 times longer than those of 1st birth order. The survival time at infancy among children with a preceding birth interval of 3 years is 465.8 times longer than those whose preceding birth interval is below 2 years, while the survival time for those with a preceding birth interval of 4 years and above is 669.09 times longer than those whose preceding birth interval is below 2 years. Finally, the survival time at infancy among births born of small or very small size reduces 0.02 times compared to that of births born with average or large size.

**Table 6: A log normal model (multivariate) of factors associated with infant mortality in urban and rural areas**

| Characteristic | Urban | | Rural | |
|---|---|---|---|---|
| | Time ratio | p-value | Time ratio | p-value |

| | | | | |
|---|---|---|---|---|
| **Mothers Education** | | | | |
| No education | 1.00 | | 1.00 | |
| Incomplete primary | 0.08 | 0.456 | 1.71 | 0.711 |
| Complete primary | 1.14 | 0.970 | 4.21 | 0.368 |
| Secondary + | 0.55 | 0.869 | 2.74 | 0.586 |
| **Wealth Quintile** | | | | |
| Low | 1.00 | | 1.00 | |
| Middle | 0.00 | 0.119 | 0.19 | 0.161 |
| High | 0.01 | 0.298 | 3.41 | 0.379 |
| **Region** | | | | |
| Nairobi | 1.00 | | | |
| Central | 0.01 | 0.140 | 1.00 | |
| Coast | 0.96 | 0.986 | 0.03 | 0.162 |
| Eastern | 0.08 | 0.604 | 0.04* | 0.106 |
| Nyanza | 0.37 | 0.748 | 7.25 | 0.364 |
| Rift valley | 0.09 | 0.464 | 0.01** | 0.019 |
| Western | 87.79 | 0.256 | 2.85 | 0.592 |
| Northeastern | 0.98 | 0.548 | 0.44 | 0.708 |
| **Mother's age at birth** | | | | |
| Below 20 years | 1.00 | | 1.00 | |
| 20-29 years | 2.11 | 0.922 | 4.25 | 0.676 |
| 30-39 years | 0.08 | 0.753 | 0.41 | 0.804 |
| 40-49 years | 0.01 | 0.559 | 0.01 | 0.200 |
| **Birth Order** | | | | |
| 1 | 1.00 | | 1.00 | |
| 2-3 | 10.71 | 0.433 | ## | ## |
| 4-5 | 2.15 | 0.791 | 1.93 | 0.567 |
| 6 + | ## | ## | 29.67** | 0.026 |
| **Preceding birth Interval** | | | | |
| Below 2 years | 1.00 | | 1.00 | |
| 2 years | 3.22 | 0.833 | 51.16* | 0.105 |
| 3 years | 18.90 | 0.598 | 465.8** | 0.012 |
| 4 and above years | 1.08 | 0.988 | 669.09** | 0.008 |
| **Birth size** | | | | |
| Average/Large | 1.00 | | 1.00 | |
| Small/very small | 0.0006*** | 0.000 | 0.02*** | 0.007 |
| Sigma | 11.547*** | 0.000 | 12.399*** | 0.000 |
| Log likelihood | -304.81 | | -1169.44 | |
| Likelihood Ratio chi | 39.95 | | 61.51 | |
| Prob>chi2 | 0.011 | | 0.000 | |

Significance association ***p<0.01; **p<0.05; *p<0. ## dropped because of collinearity

## 4.5 Results of the Shared Frailty Model

Table 7 below shows results of the Accelerated Failure Time (AFT) log normal model with shared frailty. The models for both urban and rural areas reveal presence of heterogeneous factors; that is shared frailty at household level has expected effects on parameters of estimates in both urban and rural. The results of the log normal frailty model indicate that the standard log normal model underestimates the negative parameters while increasing the positive parameters example in urban areas, the survival time at infancy among births born of small or very small size reduces by 0.0006 times while with shared frailty model the survival time is reduced by 0.0007 times. Another example of overestimation of the positive parameter is that in rural areas the survival time for births with preceding birth interval of 3 years is increased by 465.8 compared to that of preceding birth interval of 2 years and below, while with shared frailty the survival increases by 104.45 times.

**Table 7: A log normal model with Shared frailty for factors associated with infant mortality in urban and rural areas**

| Characteristic | Urban | | Rural | |
|---|---|---|---|---|
| | Time ratio | p-value | Time ratio | p-value |
| **Mothers Education** | | | | |
| No education | 1.00 | | 1.00 | |
| Incomplete primary | 0.03 | 0.411 | 1.56 | 0.769 |
| Complete primary | 0.42 | 0.840 | 4.65 | 0.360 |
| Secondary + | 0.02 | 0.405 | 2.61 | 0.623 |
| **Wealth Quintile** | | | | |
| Low | 1.00 | | 1.00 | |
| Middle | 0.00 | 0.162 | 0.17 | 0.149 |
| High | 0.08 | 0.590 | 2.92 | 0.447 |
| **Region** | | | | |
| Nairobi | 1.00 | | | |
| Central | 0.45 | 0.839 | 1.00 | |
| Coast | 5.71 | 0.522 | 0.05 | 0.212 |
| Eastern | 9.39 | 0.677 | 0.06 | 0.178 |
| Nyanza | 12.26 | 0.464 | 7.42 | 0.378 |
| Rift valley | 1.21 | 0.959 | 0.01** | 0.039 |
| Western | 1613.38* | 0.071 | 3.63 | 0.527 |

| | | | | |
|---|---|---|---|---|
| Northeastern | 0.95 | 0.993 | 0.51 | 0.772 |
| **Mother's age at birth** | | | | |
| Below 20 years | 1.00 | | 1.00 | |
| 20-29 years | 0.18 | 0.856 | 4.84 | 0.699 |
| 30-39 years | 0.01 | 0.631 | 0.45 | 0.834 |
| 40-49 years | 0.01 | 0.606 | 0.01 | 0.248 |
| **Birth Order** | | | | |
| 1 | 1.00 | | 1.00 | |
| 2-3 | 56.45 | 0.284 | ## | ## |
| 4-5 | 3.83 | 0.701 | 2.38 | 0.461 |
| 6 + | ## | ## | 36.27** | 0.022 |
| **Preceding birth Interval** | | | | |
| Below 2 years | 1.00 | | 1.00 | |
| 2 years | 0.11 | 0.647 | 15.47 | 0.272 |
| 3 years | 0.22 | 0.757 | 104.45* | 0.065 |
| 4 and above years | 0.01 | 0.306 | 156.2** | 0.045 |
| **Birth size** | | | | |
| Average/Large | 1.00 | | 1.00 | |
| Small/very small | 0.0004*** | 0.001 | 0.05*** | 0.007 |
| Sigma | 8.428*** | | 0.000 | |
| Log likelihood | -295.41 | | -1162.9246 | |
| Likelihood Ratio chi | 40.31 | | 51.79 | |
| Prob>chi2 | 0.0100 | | 0.002 | |

Significance association ***p<0.01; **p<0.05; *p<0.1 ## dropped because of collinearity

# 5 Discussions, conclusions and recommendations

## 5.1 Discussions

This study seeks to examine the urban rural differentials of infant mortality in Kenya. Although the KDHS reported that the infant mortality in urban areas is greater than in the rural areas, this study establishes that this difference in infant mortality is not statistically significant.

At bivariate level mother's education was a significant determinant of infant mortality in urban areas but not in rural areas, high education is seen to prolong the survival time at infancy. While region of residence was a significant determinant of infant mortality in rural areas this was not the same in urban areas. Mother's age was a significant determinant of infant mortality in urban areas unlike in rural areas. While birth order was not an influencing factor of infant mortality in rural areas the case was different in urban areas whereby as birth order increased the survival time at infancy increases. Preceding birth interval was a significant determinant of infant mortality in rural areas unlike in urban areas, as preceding birth interval increased the survival time at infancy is prolonged. Birth size was a significant determinant of infant mortality in both urban and rural areas, with births born of small size reducing the survival time.

At multivariate level, socio economic factors didn't yield any differentials in infant mortality in both urban and rural areas. This is consistent with other studies on determinants of infant mortality in Kenya (Odimegwu, C. a. (2008). In urban areas, birth size was the only significant determinant of infant mortality; however the estimate parameter is underestimated without frailty. In rural areas region of residence was a significant determinant of infant mortality, with Rift valley province having a reduced infant survival time compared to central province. The parameter for Rift valley remains the same with and without frailty. Birth order, preceding birth interval and birth size are significant determinants of infant mortality; however the parameter of estimate changes with frailty. This is consistent with (Mutunga*, 2007) whose study found that child survival was better for those who were of birth order 2-3, birth interval more than 2 years, not outcomes of multiple births, living in wealthier households, had a access to drinking water and sanitation facilities, and users of low polluting fuels as their main source of cooking.

## 5.2 Conclusions and recommendations

Findings from this study indicate that there is presence of unobserved factors, although there was no much difference in results in both models with and without frailty. This is similar to a study by (Omariba 2007) that Frailty effects are substantial and highly significant both in infancy and in childhood, but the conclusions remain the same as in the none frailty models. Consistent with other studies (Gymiah n.d) there was evidence that the standard models underestimated the degree of positive dependence and overestimated the degree of negative dependence. Further to this the model indicates that birth size was the only significant determinant of infant mortality in urban areas while in rural areas region of residence, birth order, preceding birth interval and birth size emerged as important predictors of infant mortality. These results are similar to those of other studies where infant mortality determinants were seen to be breastfeeding, ethnicity and sex of the child while birth order and intervals are significant variables in the rural areas (Odimegwu, C. a. (2008).

Programs or interventions targeted at reducing infant mortality should seek to address specific factors aimed at reducing urban and rural differentials. It would also be important to study other factors that influence infant mortality especially in urban areas at household level.

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## Appendix

**Table 8: lnL, AIC, and BIC for Five Parametric Models for Urban**

| Model | Hazard shape | lnL | AIC | BIC |
|---|---|---|---|---|
| Exponential | Constant | -459.736 | 935.472 | 974.188 |
| Weibull | Monotone | -312.979 | 643.958 | 687.513 |
| Gompertz | Monotone | -437.347 | 892.694 | 936.249 |
| Log-Normal | Variable | -310.276 | 638.553 | 682.109 |
| Log-Logistic | Variable | -312.597 | 643.195 | 686.750 |

**Table 9: lnL, AIC, and BIC for Five Parametric Models for Rural**

| Model | Hazard shape | lnL | AIC | BIC |
|---|---|---|---|---|
| Exponential | Constant | -1709.477 | 3434.953 | 3484.600 |
| Weibull | Monotone | -1194.227 | 2406.454 | 2462.306 |
| Gompertz | Monotone | -1593.506 | 3205.013 | 3260.865 |
| Log-Normal | Variable | -1188.072 | 2394.144 | 2449.996 |
| Log-Logistic | Variable | -1193.834 | 2405.668 | 2461.520 |

**Table 10: A log normal model (bivariate) of factors associated with infant mortality in urban and rural areas**

| Characteristic | Urban | | Rural | |
|---|---|---|---|---|
| | Time Ratio | p-value | Time Ratio | p-value |
| **Mothers Education** | | | | |
| No education | 1.00 | | 1.00 | |
| Incomplete primary | 8.10 | 0.372 | 0.89 | 0.919 |
| Complete primary | 74.06* | 0.074 | 1.51 | 0.726 |
| Secondary + | 75.37* | 0.052 | 0.98 | 0.993 |
| **Wealth Quintile** | | | | |
| Low | 1.00 | | 1.00 | |
| Middle | 0.06 | 0.555 | 0.21 | 0.123 |
| High | 0.84 | 0.962 | 4.21 | 0.201 |
| **Region** | | | | |
| Nairobi | 1.00 | | | |
| Central | 0.01 | 0.096 | 1.00 | |
| Coast | 0.41 | 0.673 | 0.96 | 0.983 |
| Eastern | 0.03 | 0.450 | 132.7*** | 0.007 |
| Nyanza | 1.84 | 0.809 | 0.41 | 0.558 |
| Rift valley | 0.15 | 0.501 | 38.47* | 0.027 |
| Western | 1.73 | 0.849 | 5.52 | 0.313 |
| Northeastern | 0.02 | 0.170 | 4.64 | 0.396 |
| **Mother's age at birth** | | | | |
| Below 20 years | 1.00 | | 1.00 | |
| 20-29 years | 0.03 | 0.377 | 4.34 | 0.408 |
| 30-39 years | 0.00 | 0.104 | 3.28 | 0.514 |
| 40-49 years | 0.00** | 0.028 | 0.19 | 0.444 |
| **Birth Order** | | | | |
| 1 | 1.00 | | 1.00 | |
| 2-3 | 0.09 | 0.182 | 1.59 | 0.687 |
| 4-5 | 0.02* | 0.067 | 0.94 | 0.959 |
| 6 + | 0.00*** | 0.008 | 0.95 | 0.966 |
| **Preceding birth Interval** | | | | |
| Below 2 years | 1.00 | | 1.00 | |

| | | | | |
|---|---|---|---|---|
| 2 years | 0.14 | 0.741 | 202.76** | 0.020 |
| 3 years | 2.03 | 0.906 | 2908.1*** | 0.001 |
| 4 and above years | 0.14 | 0.734 | 2001.1*** | 0.001 |
| **Birth size** | | | | |
| Average/Large | 1.00 | | 1.00 | |
| Small/very small | 0.00*** | 0.000 | 0.04*** | 0.002 |

Significance association ***p<0.01; **p<0.05; *p<0.1   ## dropped because of collinearity