College of Natural and Computational Science
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Trend and Determinants of Infant Mortality in East Africa

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Declaration

I declare that this thesis was written by me under the guidance and counsel of my Advisor Bedilu Alamirie (PhD).

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Abstract

Trend and Determinants of Infant Mortality in East Africa.

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Addis Ababa University, 2020

An understanding the risk factors related to infant mortality is to guide the development of focused and evidence-based health interventions to reduce infant mortality. This study aimed to see trend and identify detrminants of infant mortality in East African countries by Demographic Health Surveys. To achieve these objectives, multilevel logistic regression model has been used. The results show that, overall infant mortality was decreasing over-time in East Africa. The average percentage change of infant mortality is significantly decrease by 49.3% in east Africa. Among the East African countries the lowest and highest percentage change of infant mortality observed in Rwanda and Mozambique, respectively. Multilevel analyses shows that child related factors: birth type, birth size, birth order, sex of child, anemia level, breastfed and factors related to mother: mother education, age of mother at first birth, religion, contraceptive use, marital status and finally, factors related to household: family size, residence were found to be statistically significant predictors of infant mortality in East Africa. Survey year's has also statistically significant effect on infant mortality in East African countries. Infant mortality is high in all East African countries in which household members are four and more, also birth type is statistically significant predictor of infant mortality in all East African countries. In order to reduce infant mortality in East Africa, awareness creation efforts have to increase family planning, contraception, improve the education level of parents, encourage breastfeeding, providing availability of toilet and safe water. To this effect, the outcome of reducing infant mortality is achieved by considering those significant factors related to infant birth.

Key words: Infant mortality, Trend, Random intercept model, Random slope model, Intraclass crrelation coefficient, Marginal Quasi Likelihood(MQL), Penalized Quasi Likelihood(PQL).

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Lists of Acronyms

AfDHS	Afghanistan Demographic and Health Survey
DHS	Demographic and Health Survey
ICC	Intra-Class Correlation
IDHS	Indonesian Demographic and Health Survey
IM	Infant Mortality
IMR	Infant Mortality Rate
KDHS	Kenya Demographic and Health Survey
MQL	Maximum Quasi Likelihood
NDHS	Nepal Demographic and Health Survey
NMR	Neonatal Mortality Rate
PDHS	Pakistan Demographic and Health Survey
PQL	Penalized Quasi Likelihood
SDGs	Sustainable Development Goals
UN	United Nations
UNICEF	United Nations Children Funds
WHO	World Health Organization
ZDHS	Zimbabwe Demographic and Health Survey
OR	Odds ratio
EN's	Enumeration area

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CHAPTER ONE

1 Introduction

1.1 Background of the Study

An understanding the risk factors related to infant mortality is to guide the development of focused and evidence-based health interventions to reduce infant mortality. The infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year. The infant mortality rate is the most important sensitive indicator of the socio-economic and health status of a community (WHO, 2011). The high infant mortality rate (IMR) reflects the presence of unfavourable social, economic, and environmental conditions during the first year of life .

The highest rates of child mortality have been still in Sub-Saharan Africa where 1 in 8 children died before age five, which is more than the average for developed regions and Southern Asia. Under-five mortality rates have fallen elsewhere and the disparity between these two regions and the rest of the world has grown. Under-five deaths are increasingly concentrated in Sub-Saharan Africa and Southern Asia, while the share of the rest of the world dropped in 2010 (United Nation, 2011).

According to UNCEF report, poverty is one of the most important factors affecting neonatal mortality rate in Africa (You et al., 2015). Socio-economic, demographic,health care system, cultural practices and technology are also important indirect determinants of neonatal mortality (Rahman et al., 2010).

To reduce child mortality, massive investment has been made to improve access to health-care, nutrition, hygiene and sanitation, and promote exclusive breast-feeding. As a result, all regions of the world have shown reductions in under-five and infant mortality rate (Lawn JE et al; 2005). However, these achievements are challenged by disparities that persist among regions and within countries especially in east Africa (UNICEF's; 2012). Similarly, the past decades have seen rapid developments in reducing under-five mortality; however, neonatal mortality reduction remains a major challenge for most developing countries including East Africa. Between 1990 and 2015, under-five mortality declined by 53%, but the reduction of neonatal mortality in the same period remains slow. Reduction of neonatal mortality would be important to meet both the neonatal and under-five mortality targets of the sustainable development goals (SDGs). The SDGs have two specific targets to reduce the neonatal mortality rate (NMR) and under-five mortality rate to 12 and 25 per thousand live birth within 2030, respectively (UN).

In difficult situations, adults and the elderly may be able to survive better than infants, whose immune systems may be less able to cope with the environment. For this reason, in developing countries infants are affected the most by the availability of health facilities, a lifestyle of the family, affordability of good food, sanitation, etc. In developing countries, infant mortality accounts for a relatively higher proportion of all deaths, whereas in the developed countries, it represents an increasingly small segment of total mortality (Suwal, J. V. (2001)).

1.2 Statement of the Problem

In 2012, the global infant mortality rate (IMR) was estimated as 35 per 1000 live births, while it was 64 per 1000 live births in Sub-Saharan African countries (UN; 2013). Similarly, Sub-Saharan Africa has seen the least decline in infant mortality rate and under-five deaths including east Africa (UN; 2013 and UNICEF's; 2012). Under-five deaths are increasingly concentrated in Sub-Saharan Africa and Southern Asia, while the share of the rest of the world droped in 2010 (United Nation, 2011).

Even though several researchers have studied the risk factors of infant mortality in different countries of the world, most of them studied the risk factors at the regional level and small areas. Such studies may not demonstrate the exact situation of trend and risk factors in the national level. Mostly there are limited studies that focused on trend and determinants of infant mortality in several countries by using statistical models such as survival analysis and a logistic regression model, but they didn't consider east Africa to see the trend and determinants of infant mortality by using a binary logistic regression model. Therefore, this needs a comprehensive study to attempts to narrow the gap of understanding of trends and the effect of demographic, socio-economic and nutritional factors on infant mortality in east Africa. This study has been highly motivating to see the trend and to identify the major determinants of infant mortality in East Africa by using the multilevel logistic regression model.

1.3 Objectives of the Study

The general objective of this study is to see the trend and to identify determinants of infant mortality in east African countries.
Specifically, we aimed to:

- See the trend and identify determinants of infant mortality using DHSs data.
- Compare the prevalence and trend of infant mortality across East African countries.
- Assess the reduction of infant mortality in East African countries.

1.4 Significant of the Study

Results derived from this study will help to:

- Create awareness on the risk factors of infant mortality and reducing infant mortality.
- Understand how trends of infant mortality look like in East African countries.
- Serve as stepping-stone for those who are interested to undertake in-depth study on issues related to trend and determinants of infant mortality in African countries and the other.

1.5 Limitations of the Study

Although many factors are affecting infant death, this study is undertaken to see the trend and to assess few factors that affect infant death in east African countries. The following are some of the limitations of our study:

- The data used in this study were from DHSs website (https://dhsprogram.com). Thus, we lost several countries data because some countries does't have DHSs dataset and some countries restrict their DHSs data.
- In this study, our trend analysis requires data from at least 3 time-points, so we didn't see the trend for Comoros because it has only two time-points. Therefore, our final trend analysis only utilized data from 11 countries with an adequate number of standard DHSs time-points.

CHAPTER TWO

2 Literature Review

The literature on infant mortality shows that mortality is studied during two periods: neonatal and post neonatal. In this chapter, we use several studies related to neonatal and post neonatal mortality conducted in various countries in the world including East Africa.

A study conducted by Febriyuna, N., (2015) on determinants of infant mortality in Indonesia based on 4th, 5th, and 6th rounds of the IDHS data collected in 2002-2003, 2007, and 2012 respectively. He used a logistic regression model to estimate the effect of a variety of factors on infant mortality. The results of logistic regression showed that bio-demographic factors which include child and maternal traits are key predictors of infant mortality. He found that household's hygiene characteristics such as a source of drinking water, toilet facility, and improving flooring materials were significantly affected infant mortality and some socioeconomic variables such as household members was a highly significant factor. He also found that male sex, birth multiplicity, higher birth rank, shorter birth interval, mother age above 35 years, and complication during pregnancy were positively related to infant mortality while behavioural practices such as institutional delivery, knowledge of Oral Rehydration Solutions, and especially contraceptive practice are important factors that are negatively related to infant mortality.

A study conducted by Nisar and Dibley. (2014) on determinants of neonatal mortality in Pakistan based on Pakistan Demographic and Health Survey (PDHS) 2006-07 by using multivariate Cox proportional hazard model. The results of the Cox proportional hazard model showed that the wealth index, male infant, baby's birth rank, birth size, and mother with delivery complications were significantly higher hazards of neonatal death in Pakistan. The other study was done by Mohamood A. (2002) studied the determinants of neonatal and post-neonatal mortality in Pakistan by using the Cox-proportional hazard Regression model. Their findings showed that premature births, baby size at birth and type of birth had a significant effect on neonatal mortality. Premature babies have a 13.6 times higher risk of neonatal mortality than full-term born babies. Babies of very large size also have 8.5 times higher risk of neonatal mortality than normal-sized born babies, and single born babies have a lower risk to die than multiple births. The results also found that neonatal survival is higher for large family members, and babies who had the vaccine at birth were at a significantly lower risk of neonatal mortality than those who did not receive immunization at birth. It also observed that babies delivered at government hospitals had significantly lower neonatal mortality than babies delivered at home.

Lamichhane et al. (2017) studied that factors associated with infant mortality in Nepal, a comparative analysis of Nepal (NDHS) 2006 and 2011 data by using multiple logistic regression. Based on NDHS 2006, they found that region, succeeding birth interval, breastfeeding and type of delivery assistance were significant predictors of infant mortality and based on NDHS 2011, and they also found that birth interval (preceding and succeeding) and baby's size at birth were significantly associated with infant mortality. The other study was done by Suwal, J. V. (2001) on the main determinants of infant mortality in Nepal based on the data from the Nepal fertility, family planning, and Health Survey, 1991, conducted under the Demographic Health Survey (DHS) by using logistic regression analysis. The results showed that the place of residence, parity, ethnicity, and immunization are the main predictors of infant mortality in Nepal. Also, the factors education, occupation, age at marriage, place of work of the mother, place of delivery, religion and access to delivery assistance were significantly affecting infant mortality in Nepal.

Kibrie et al. (2018) studied that the determinants of early neonatal mortality in Afghanistan based on 2015 AfDHS data by using a multiple logistic regression model. They found that antenatal care, sex of neonate, birth rank, birth size and marital status were statistically significant with neonatal death. The study results also revealed that male neonates had a higher likelihood of dying than female neonates; both smaller and larger babies were more likely to die than averaged size babies; neonates delivered by mother with a birth interval of fewer than two years had odds of pregnancy were less likely to experience death of their babies than the women who did not utilize this service. The other study conducted by Rahman and Sarkar. (2009) on determinants of infant and child mortality in Bangladesh by using logistic regression. They used 1999-2000 BDHS data and they found that place of residence, mother education, father education, preceding birth interval, toilet facility, family size, delivery place, and antenatal care were the major factors of infant mortality.

A study was done by Zwi AB, et al. (2018) on determinants of neonatal, infant and under-five mortality in a war-affected country based on 2010 Household Health Survey in South Sudan by using generalised linear latent and mixed models. They found that unimproved source of drinking water, mother who reported a previous child death was a significantly higher risk of neonatal mortality. The other study was done by Kembo and Van Ginneken. (2009) studied the determinants of infant and child mortality in Zimbabwe based on 2005-06 ZDHS data by using a Cox proportional hazards model. The results of the Cox proportional hazards model showed that birth order 6+ with a short preceding interval had the highest risk of infant mortality while socioeconomic variables did not have a distinct impact on infant mortality.

Muluye and Woncheko. (2012) studied the determinants of infant mortality in Ethiopia based on 2005 EDHS data by using Kaplan-Meier and Cox proportional hazards, regression model. The results of Kaplan Meier showed that most infant deaths occurred in the earlier month's immediately after birth and then declined as the age of the infant advanced to 12 months. It was observed that about 47.9% and 58.4% of the deaths, respectively, occurred in the first and second months of the follow-up period. The result of Cox proportional hazards showed that "breast-feeding, age of mother, mother education level, birth order, source of drinking water, and sex of infants significantly affected infant mortality in Ethiopia. The other study was done by Mekonnen et al. (2013) by using the 2005 EDHS survey to examine the determinants of neonatal mortality in Ethiopia. They used Cox proportional hazard model and the results showed that bio-demographic factors such as sex of a child, age of mother, mother education, and birth interval were significantly affected neonatal mortality. Finally, their results showed that neonatal mortality rate was highest among mothers with "no education and lowest among mothers with tertiary education and above.

A study was done by Mustafa E. (2008) on socioeconomic determinants of infant mortality in Kenya based 2003 Kenya Demographic and Health Survey (KDHS) on by using a logistic regression model. The results showed that infant mortality in 2003 was 79.6 per 1000 and breastfeeding, ethnicity, sex of a child, birth order, and birth interval were significantly affect the infant mortality while wealth index, mother occupation, mother education level, religion, and place of residence were insignificant.

CHAPTER THREE

3 Data and Methodology

3.1 Data Source

The dataset considered in this study obtained from DHSs website (https://dhsprogram.com) after granting permission to access DHSs data to see trend and determinants of infant mortality in East African countries. We were consider data from DHSs conducted in 17 East African countries, but due to several limmitations our final analysis includes DHSs data from 11 countries:

Table 1: Description of data source

Country	Survey years							
Burundi	1987	2010	2012	2016-17				
Ethiopia	2000	2005	2011	2016				
Kenya	1989	1993	1998	2003	2008-09	2014	2015		
Madagascar	1992	1997	2003-04	2008-09	2011	2013	2016		
Malawi	1992	1996	2000	2004	2010	2012	2014	2015-16	2017
Mozambique	1997	2003	2011	2015	2018				
Rwanda	1992	2000	2007-08	2010	2013	2014-15	2017		
Tanzania	1991-92	1996	1999	2004-05	2007-08	2010	2011-12	2015-16	2017
Uganda	1988-89	1995	2001-02	2006	2009	2011	2014-15	2016	2018-19
Zambia	1992	1996	2001-02	2007	2013	2018			
Zimbabwe	1988	1994	1999	2005-06	2010-11	2015			

3.2 Study Area

The study area of this study were East African countries. East African countries are located in the Eastern part of Africa and includes: Burundi, Comoros, Djibuoti, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Seychelles, Tanzania, Uganda, Zambia, Zimbabwe, Mayotte(France) and Reunion (Walmsley, R., 2003).

3.3 Variables in the Study

The dependent variable of this study is infant status. Here Infant status is described as binary (infant death/not). Therefore, to see the trend and to identify the effect of explanatory variables on infant mortality, the dependent variable for the i^{th} individual in the j^{th} enumeration area Y_{ij} is dichotomized as follows:

$$Y_{ij} = \begin{cases} 1, & if\ the\ i^{th}\ infant\ in\ the\ j^{th}\ enumeration\ \ area\ \ is\ died. \\ 0, & otherwise \end{cases}$$

An independent variable was selected based on: expertise discussions and literature review. We were consider the following child related factors, factors related to mother, and household related factors as an independent variables.

Table 2: Description of independent Variables

No	**Variables**	**Category**	No	**Variables**	**Category**
1	Residence	0 = Urban 1 = Raral	10	Mother education level	0 = No education 1 = Primary 2 = Secondary 3 = Higher
2	Family size	0 = 1-3 1 = 4-6 2 = 7 and more	11	Religion	0 = Catholic 1 = Muslim 2 = Chirstian 3 = Others
3	Wealth	0 = Poor 1 = Middle 2 = Rich	12	Sex of infant	0 = Male 1 = Female
4	Marital status	0 = Married 1 = Widowed 2 = Divorced 3 = Single	13	Age of mother at firt birth	0 = 11-19 1 = 20-29 2 = 30-39 3 = 40 and more
5	Birth order	0 = 1 1 = 2-3 3 = 4 and more	14	Birth type	0 = Single 1 = Multiple
6	Breastfed	0 = Yes 1 = N0	15	Birth size	0 = Large 1 = Average 2 = Midium 3 = Small
7	Contraceptive use	0 = Yes 1 = No	16	Toilet	0 = Yes 1 = No
8	Water	0 = Protected water 1 = Otherwise	17	Delivery	0 = Health facility 1 = Not
9	Mother occupation	0 = Yes 1 = No	18	Sex of household head	0 = Male 1 = Female
19	Mother current age	0 = 11-19 1 = 20-29 2 = 30-39 3 = 40 and more			

3.4 Statistical Methodology

3.4.1 Introduction

Typically, different surveys contain multiple levels of nesting. When analysing such datasets, without any doubt, a multilevel logistic regression model is generally more appropriate than an ordinary single-level logistic regression model because it enables one to deal with the hierarchical structure of variables. In the multilevel study, a structure of the data in population is hierarchical, and a sample from such a population can be viewed as a multistage sample. In our case, the units at a lower level (level-1) are infants nested within units at a higher (level-2). Thus, we were use two-level logistic regression models to take into account the hierarchical structure of the data and to provide a flexible framework for analysing the hierarchical structure of the data (Leeuw and Meijer, (2008))(Goldstien, H. (2003)). To analyse such data type, the statistical analyses were performed using STATA version 15.1 and R version 3.5.0.

3.4.2 Test of Hetrogeneity

In this study, multilevel analysis was conducted with the expectation that there would be a difference in infant mortality across enumeration area. Therefore, before going to multilevel analysis, first testing the presence of heterogeneity in the data set or test the null hypothesis of no significant difference between enumeration area on infant mortality is very important.

3.4.3 Empty model

We were use an empty two-level model for dichotomous outcome variable in which there are no explanatory variables at all and it contains only random groups and random variation within enumeration area. It is given by:

$$logit(\pi_{ij}) = \beta_0 + U_{0j} \tag{1}$$

3.4.4 Random Intercept Model

Random intercept models are models where only the intercept of the level-one dependent variable is modelled as an effect of the level-two grouping variable and possibly other level-one or level-two (or higher). Random intercepts are used to model unobserved heterogeneity in the overall response and in this model the intercept is the only random effect.

Let Y_{ij} be the binary outcome variable for infant i in j enumeration area is coded '0' or '1', associated with level-one unit i nested within level two unit j and X_{ij} an explanatory variable at the infant level. Also let π_{ij} be the probability that the response variable for infant i in j eenumeration area equals 1. Like as an ordinary logistic regression, in the multilevel logistic regression Y_{ij} follows a Bernoulli distribution, then two level logistic regression model is:

$$logit(\pi_{ij}) = \beta_0 + \sum_{i=1}^{k} \beta_i X_{ij} + U_{0j} = log[\frac{\pi_{ij}}{1-\pi_{ij}}] = \beta_{0j} + \sum_{i=1}^{k} \beta_i X_{ij} \tag{2}$$

, since β_{0j}=β_0+U_{0j}
where: U_{0j} is the random effect at level two and it follows $(0,\sigma_u^2)$.
i=$1, 2, \ldots, k$, j=$1, 2, \ldots, N$
β_{0j} is intercept term, is assumed to vary randomly.
$\beta_0 + \sum_{i=1}^{k} \beta_i X_{ij}$ is fixed part of the model and U_{0j} is a random part of the model and it is assumed that they are mutually independent and normally distributed with mean zero and variance σ_0^2.

3.4.5 Random Slope Model

A random-effects model provides a mechanism for estimating the degree of correlation in the outcome that exists at enumeration area , while also controlling a range of all indicators may potentially influence the outcome. The intercepts β_{0j} as well as the regression coefficients, or slopes, β_{1j} are depend on enumeration area . These enumeration area dependent coefficient can be split into an average coefficient and enumeration area dependent deviation:

$$\beta_{0j}=\beta_0+U_{0j}$$
$$\beta_{1j}=\beta_1+U_{1j}$$

Therefore,

$$\text{logit}(\pi_{ij})=(\beta_0+U_{0j})+(\beta_1+U_{1j})X_{1ij}$$
$$\text{logit}(\pi_{ij})=\beta_0+\beta_1 X_{1ij}+U_{0j}+U_{1j}X_{1ij}$$

Now, we are going to extend the above single explanatory model by including a more explanatory variables that has random effects on outcome variable. Suppose that there are k level-one explanatory variables $X_1, X_2, \ldots, X_k$ and consider the model where all predictors have varying slopes and random intercept.

$$\text{logit}(\pi_{ij})=(\beta_0+U_{0j})+(\beta_1+U_{1j})X_{1ij}+\ldots+(\beta_h + U_{hj})X_{hij}$$

$$log[\frac{\pi_{ij}}{1-\pi_{ij}}] = \beta_0 + \sum_{h=1}^{k} \beta_h X_{hij} + U_{0j} + \sum_{h=1}^{k} U_{hj} X_{hij} \tag{3}$$

where:
β_0 is the average intercept of the response variable.
β_1 is fixed regression coefficient given explanatory variable X_1.
β_0+$\sum_{h=1}^{k} \beta_h X_{hij}$ is the fixed part of the model.
U_{0j}+$\sum_{h=1}^{k} U_{hj} X_{hij}$ is the random part of the model.

U_{0j},U_{1j},..., U_{hj} are assumed to be independent between enumeration area, but may be correlated within enumeration area.

Intra-Class Correlation

Typically, in the multilevel analysis there exist more similarities between individuals in the same enumeration area compared to those of different enumeration area. ICC is the degree of resemblance between level one units belonging to the same enumeration area. It is an indication of the proportion of variance at the second level enumeration area. When the logistic model is applied, the level-one residuals are assumed to follow the standard logistic distribution, with mean 0 and variance (σ_u^2)=($\frac{\pi^2}{3} \approx 3.29$) (Snijders and Bosker, 1999). This variance represents the within enumeration area variance for intraclass correlation (ICC) for dichotomous data. The ICC is then calculated as follows:

$$ICC = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_u^2} \tag{4}$$

where,σ_u^2 is variance of individual (lower) level units.

3.4.6 Model Building

Before going to multilevel analysis, we were use uni-variable analysis to detect the factors individually affect infant mortality at 25% level of significance.

3.4.7 Parameter Estimation

Parameter estimation in the multilevel logistic regression model is not straightforward like as single level logistic regression model. Thus, we were use Marginal Quasi Likelihood (MQL) (Goldstein, 1991; Goldstein and Rasbash, 1996) and Penalized Quasi Likelihood (PQL) (Laird, 1978); Breslow and Clayton, 1993) to estimate Multi-level logistic model.

3.4.8 Model Selection

Generally, we have many options available when modelling a data structure, and once we have successfully fit a model, it is important to check its fit to data that is called model selection.

$$D = -2log\big[\frac{\hat{L_c}}{\hat{L_f}}\big] = -2\big[log\hat{L_c} - log\hat{L_f}\big] \tag{5}$$

where:

$\hat{L_c}$ is the maximized likelihood of null model and $\hat{L_f}$ is maximized likelihood of full or saturated model. We were also use AIC and BIC to compare multilevel models and the model which is smallest value of AIC and BIC was selected as good fit for the data.

3.4.9 Model Diagnostics

In the multilevel study, we were use a similar diagnosis technique as a standard logistic regression model. Leverage and an influential value greater than one be considered as an influential observation for both level one and level two. Here we were use Cook's distance and dfbetas to check influential observation in the data (Snijders and Bosker, 1999).

CHAPTER FOUR

4 Results

In this chapter the data introduced earlier are analyzed, and results of the analysis based on multilevel logistic regression model will be presented. Recall that the aim of the study is to see trend and identify determinants of infant mortality in East African countries.

4.1 Descriptive Results

Figure 1 shows that trend over survey-year of infant mortality by country and horizontal line shows survey-year and vertical line shows prevalence in percetage of infant death. The results shows that infant mortality is decreasing in East African countries: Burndi, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe, but in Mozambique at the end it shows that increasing. Therefore, overall results of prevalence in percentage of infant mortality shows decreasing trend over time in East Africa.

Table 2 shows that summary of percentage change in infant mortality in East Africa. The results show that decreasing prevalence of infant mortality in all countries, except Mozambique(it shows significantlly increasing by 1%). In both base-survey and recent-survey the highest prevalence of infant mortality was observed in Rwanda and Mozambique(10.9% and 11.1%, respectively). And in both base-survey and recent-survey, the lowest prevalence of infant mortality was observed in Madagascar(5.1%) and 1.0%, respectively). The lowest percentage change of infant mortality was observed in Rwanda(-80.6%) and the highest percentage change of infant mortality was observed in Mozambique(9.9%). Overall percentage change shows that statistically significant decrease of infant mortality in east Africa. The average percentage change of infant mortality is significantly decrease by 49.3% in East Africa.

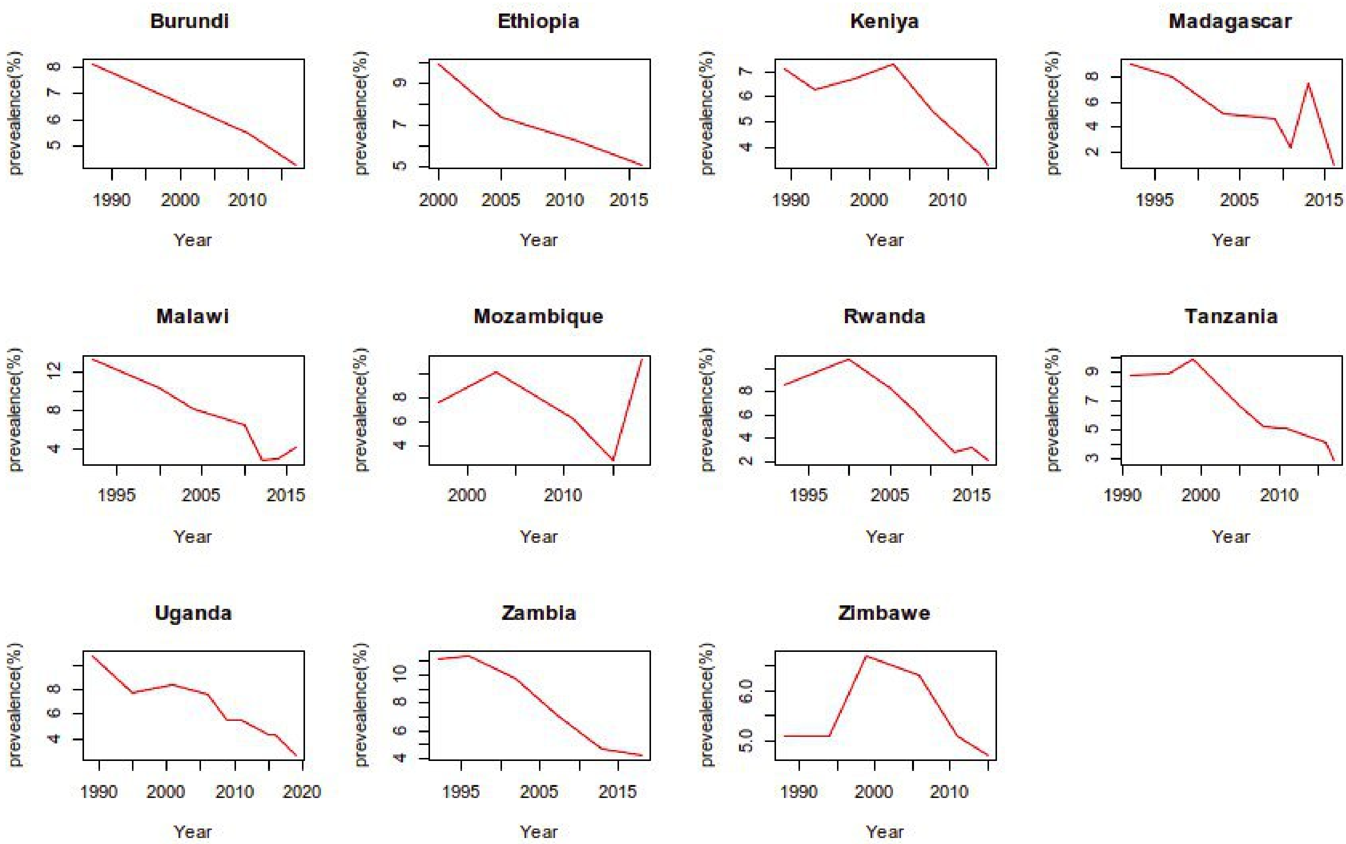

Figure 1: Trends of Infant Mortality by Country

Table 3: Summary of Percentage Change in infant Mortality Since 2000 to Recent Survey in East African countries

Country (base survey - recent survey)	Baseline survey		Recent survey		Percentage change	
	Prev	95%CI	Prev	95%CI	Prev	95%CI
Burundi (2010-2016/17)	5.5%	(5.0% , 6.0%)	.3%	(4.0% , 4.6%)	-21.8%	(-23.3%,-20.0%)
Ethiopia (2000-2016)	9.9%	(9.3% , 10.4%)	5.1%	(4.7% , 5.6%)	-48.5%	(-49.5% , -46.2%)
Kenya (2003-2015)	7.3%	(6.6% , 7.9%)	3.3%	(2.7% , 3.9%)	-54.8%	(-59.1% , -50.6%)
Madagascar (2003-2016)	5.1%	(4.5% ,5.7%)	1%	(.8% , 1.2%)	-80.4%	(-82.2% , -78.9%)
Malawi (2000-2015/16)	10.4%	(9.9% , .109)	4.2%	(3.9% , 4.5%)	-59.6%	(-60.6% , -58.7%)
Mozambique (2003-2018)	10.1%	(9.5% , 10.6%)	11.1%	(9.5% , 12.9%)	9.9%	(.0% , 21.7%)
Rwanda (2000-2017)	10.8%	(10.1% , 11.5%)	2.1%	(1.6% , 2.7%)	-80.6%	(-84.2% , -76.5%)
Tanzania (2004/05-2017)	6.7%	(6.2% , 7.3%)	3%	(2.6% , 3.4%)	-55.2%	(-58.1% , -53.4%)
Uganda (2000/01-2018/19)	8.4%	(7.8% , 9.1%)	2.6%	(2.2% , 2.9%)	-69.0%	(-71.8% , -68.1%)
Zambia (2001/02-2018)	9.8%	(9.1% , 10.5%)	4.2%	(3.8% , 4.6%)	-57.1%	(-58.2% , -56.2%)
Zimbabwe (2005/06-2015)	6.3%	(5.7% , 6.9%)	4.7%	(4.2% , 5.3%)	-25.4%	(-.26.3% , -23.2%)

4.2 Test of Hetrogeneity

Before going to multilevel analysis, first testing the presence of heterogeneity in the data set or test the null hypothesis of no significant difference between enumeration area on infant mortality is very important.

4.3 Model Building

Before going to multilevel analysis, we were use uni-variable analysis to detect the factors individually affect infant mortality at 25% level of significance. In Ethiopia, the factors such as: residence, religion, mother education, toilet, anemia level, birth size, birth type and family size were found to be statistically significant at 25% level of significance. The results of uni-variable by country are prented in the Appendix.

4.4 Model Comparison

Table 4: shows that model comparison based on loglikelihood, AIC and BIC. Generally, we have many options available when modelling a data structure, and once we have successfully fit a model, it is important to check its fit to the data that is called model selection. when we compare models by AIC and BIC, the model which is small value is good fit for the data. In Ethiopia, the value of AIC(20091.37) and BIC(20255.62) for random intercept model indicates that smaller than AIC and BIC for random slope model therefore, the random intercept logistic model is good fit for the data. We were use the same comparison for all countries and the results shows that the random intercept model is good fit for the data in Mozambique and Zambia, but in Madagascar and Tanzania random slope model is good fit for the data.

Table 4: Results of Model Comparison

Model	ll(model)	df	AIC	BIC
Ethiopia				
Empty	-10879.05	2	21762.1	21779.41
Random intercept	-10026.69	19	20091.37	20255.62
Random slope	-10025.81	20	20091.63	20264.52
Madagascar				
Empty	-7990.768	2	15985.54	16002.97
Random intercept	-7144.792	19	14327.58	14492.83
Random slope	-7142.5	20	14325	14498.95
Mozambique				
Empty	-8301.291	2	16606.58	16623.31
Random intercept	-7563.742	16	15159.48	15292.92
Random slope	-7563.428	17	15160.86	15302.64
Tanzania				
Empty	-14850.65	2	29705.3	29723.37
Random intercept	-7260.068	15	14550.14	14674.33
Random slope	-7254.217	16	14540.43	14672.9
Zambia				
Empty	-12884.27	2	25772.53	25790.14
Random intercept	-11194.86	23	22435.72	22637.92
Random slope	-11194.78	24	22437.57	22648.56
	N for Ethiopia=41,965		N for Madagascar	= 44,237
	N for Mozambique = 30,946		N for Tanzania	= 29,127
	N for Zambia = 48,597			

4.5 Model Diagnostics

The model diagnostics for random coifficient model was done and here the value of Cook's distance and dfbetas were used to check influential observation in the data. The results reveal that there was no influential observation that impacts any part of the regression analysis, as the value of Cook's distance and dfbetas are below one. Farthermore, we were seen that multicolliearity among independent variables and the results show that there is no multicollinearity, as the value of variance iflation factor less than 10. The rsults of dfbetas and variance inflation factor is present in the appendix.

4.6 Interpretations of Multilevel Logistic Results

To identify the risk factors for infant mortality in each country, a multilevel logistic regression model were fitted. Here we present the results of multilevel models which are good fit for the data among other's. The multilevel results of countries are presented in the Appendix.

Table 6 shows that the results of random intercept model for Ethiopia, and the results reveal that residence, mother education, religion, contraceptive use, anemia level, birth type, sex of infant, birth order, family size and survey year were statistically significant predictors of infant mortality in Ethiopia. The odds of infant death for rural is 17.7% less likely than that for urban. The odds of infant death for secondary education is 53.4% more likely than that for mother's who has no education. The odds of infant death for mother's who has higher education are 2.937 times higher than that for no education. The odds of infant death for Chirstian and other religion follower's are 50.3% and 79.2% more likely than that for Catholic religion followers, respectively. The odds of infant death for non user's are 26.2% less likely than that for contraceptive user's. The odds of infant death for anemic is 14% less likely than that for no anemic infant. The odds of infant death for multiple birth are 85.6% less likely than that for single birth. The odds of infant death for females are 29.5% more likely than that for males. The odds of infant death for 5 and above birth order is 33% less likely than that for first birth order. The odds of infant death for family size 4-6, 7 and more are 2.932, 5.526 times higher than that for family size 1-3, respectively. The odds of infant death is increased by 1.287 times for every one unit increase in survey year. The estimated result of intra-class correlation for enumeration area(level two) in table 5 shows that about 1.7% of overall variation in the infant death is due to variation between enumeration area.

Table 5: Results of Empty Model for Ethiopia

	Odds	Std. Err.	Z	P.value	(95% CI)
Constant	13.426	.304	114.77	0.000	12.843, 14.034
EN's					
var(cons)	.055	.015			.032, .096
ICC	.017	.004			.009, .028

Table 6: Random Intercept Result for Ethiopia

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	2.592	.584	4.23	0.000	(1.666, 4.032)
Residence (ref: Urban)					
Rural	.823	.056	-2.80	0.005	(.719, .943)
Mother educ (ref: No educ)					
Primary	1.098	.059	1.72	0.086	(.986, 1.222)
Secondary	1.534	.172	3.80	0.000	(1.230 , 1.913)
Higher	2.937	.821	3.85	0.000	(1.697, 5.082)
Toilet (ref: Yes)					
No	1.066	.051	1.34	0.180	(.970, 1.171)
Religion (ref: Catholic)					
Muslim	1.412	.283	1.72	0.085	(.953, 2.093)
Christian	1.503	.300	2.04	0.041	(1.015, 2.226)
Other	1.792	.432	2.42	0.016	(1.117,2.875)
Contraceptive(ref:Yes)					
No	.738	.047	-4.74	0.000	(.651,.837)
Anemia (ref: Not anemic)					
Anemic	.860	.048	-2.68	0.007	(.771,.960)
Birth type (ref Single)					
Multiple	.144	.011	-25.22	0.000	(.124, .168)
Sex of infant(ref: Male)					
Female	1.295	.050	6.59	0.000	(1.199, 1.399)
Birth order (ref:1)					
2-4	1.045	.058	0.79	0.430	(.936, 1.167)
5 and more	.670	.043	-6.15	0.000	(.589, .761)
Family size (ref: 1-3)					
4-6	2.932	.164	19.13	0.000	(2.626, 3.274)
7 and more	5.526	.382	24.68	0.000	(4.824, 6.329)
Year	1.287	.026	12.37	0.000	(1.236, 1.340)
Random effects					
EN's					
Var(cons)	.0314073	.014499			(.012708 , .0776216)

Table 7: Results of Empty Model for Madagascar

	Odds	Std. Err.	Z	P.value	(95% CI)
Constant	24.048	.772	99.08	0.000	(22.582,25.609)
EN's					
var(cons)	.119	.025			(.078 , .181)
ICC	.035	.007			.023 ,.052

Table 8 shows that the results of random slope for Madagascar. The odds of infant death for rural is 16.7% less likely than that for urban. The odds of infant death for secondary education are 32.8% more likely than that for mother's who has no education. The odss of infant death for higher education are 2.075 times higher than that for mother's who has no education. The odds of infant death for Muslims are 2.572 times higher than that for Catholic religion follower's. The odds of infant death for Christian and other religion follower's are 5.4% and 10% more likely than that for Catholic religion follower's, respectively. The odss of infant death for multiple birth's are 83.6% less likely than that for single birth's. The remaining factors are interpreted as in the same way as we interpreted in the above. The estimated result of intra-class correlation for enumeration area(level two) in table 7 shows that about 3.5% of overall variation in the infant death is due to variation between enumeration area in Madagascar.

Table 8: Random Slope Result for Madagascar

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	2.693	.314	8.49	0.000	(2.142, 3.385)
Residence (ref: Urban)					
Rural	.833	.055	-2.72	0.007	(.731, .950)
Mother educ(ref:No educ)					
Primary	1.074	.065	1.18	0.239	(.953,1.212)
Secondary	1.328	.109	3.46	0.001	(1.131, 1.560)
Higher	2.075	.557	2.72	0.007	(1.226, 3.513)
Toilet (ref: Yes)					
No	.795	.176	-1.03	0.303	(.515, 1.228)
Religion (ref: Catholic)					
Muslim	2.572	1.000	2.43	0.015	(1.200, 5.512)
Christian	1.054	.061	0.91	0.365	(.940, 1.181)
Other	1.100	.072	1.47	0.142	(.968,1.251)
Birth type (ref: Single)					
Multiple	.164	.016	-18.46	0.000	(.136, .199)
Sex of infant(ref:Male)					
Female	1.217	.059	4.06	0.000	(1.107, 1.339)
Birth order (ref:1)					
2-4	1.132	.070	2.01	0.044	(1.003, 1.278)
5 and more	.783	.056	-3.36	0.001	(.679, .903)
Water (ref: Protected)					
Otherwise	.898	.052	-1.82	0.069	(.801,1.008)
Sex of household head (ref: Male)					
Female	1.180	.079	2.46	0.014	(1.034, 1.347)
Family size (ref:1-3)					
4-6	2.197	.147	11.76	0.000	(1.927,2.505)
7 and more	3.176	.242	15.12	0.000	(2.734,3.689)
Year	1.459	.025	22.01	0.000	(1.411,1.510)
Random effects					
EN's					
Var(Year)	.0038862	.0019506			(.0014531, .0103937)
var(cons)	.0282088	.0250853			(.0049367, .1611884)

Table 9: Results of Empty Model for Mozambique

	Odds	Std. Err.	Z	P.value	(95% CI)
Constant	13.110	.339	99.24	0.000	(12.460, 13.793)
EN's					
var(cons)	.082	.021			(.049, .136)
ICC	.024	.006			.015, .039

Table 10 shows that the random intercept result for Mozambique and the results shows that mother education(secondary), sex of household head, water, birth type, sex of infant, birth order, family size and survey year were statistically significant predictors of infant mortality in Mozambique. The odds of infant death for secondary education are 42.7% more likely than that for mother's who has no education. The odds of infant death for female is 28.9% more likely than that for male household head. The odds of infant death for not protected water is 16.3% more likely than that for protected water. The estimated result of intra-class correlation for enumeration area(level two) in table 9 shows that about 2.4% of overall variation in the infant death is due to variation between enumeration area in Mozambique.

Table 10: Random Intercept Result for Mozambique

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	2.407	.249	8.48	0.000	(1.965,2.949)
Residence(ref:Urban)					
Rural	1.042	.061	0.70	0.483	(.928,1.169)
Mother educ(ref: No educ)					
Primary	.939	.048	-1.22	0.221	(.849, 1.038)
Secondary	1.427	.140	3.61	0.000	(1.176,1.731)
Higher	1.457	.521	1.05	0.292	(.723,2.938)
Toilet (ref:Yes)					
No	.906	.045	-1.94	0.052	(.821, 1.000)
Sex of household head(ref: Male)					
Female	1.289	.068	4.76	0.000	(1.161, 1.430)
Water(ref: Protected)					
Otherwise	1.163	.060	2.89	0.004	(1.050, 1.288)
Birth type(ref:Single)					
Multiple	.196	.015	-20.13	0.000	(.167,.230)
Sex of infant(ref:Male)					
Female	1.144	.051	2.99	0.003	(1.047, 1.250)
Birth order (ref:1)					
2-4	1.510	.085	7.30	0.000	(1.351,1.686)
5 and more	1.275	.086	3.61	0.000	(1.117, 1.455)
Family size(ref:1-3)					
4-6	2.639	.161	15.84	0.000	(2.340, 2.976)
7 and more	3.839	.264	19.53	0.000	(3.354, 4.395)
Year	1.187	.029	6.94	0.000	(1.131,1.246)
Random effects					
EN's					
Var(cons)	.0923444	.0242277			(.0552188,.1544307)

Table 11: Results of Empty model for Tanzania

	Odds	Std. Err.	Z	P.value	(95% CI)
Constant	15.276	.353	117.73	0.000	(14.598,15.985)
EN's					
var(cons)	.102	.016			(.075, .138)
ICC	.030	.004			(.022 , .040)

Table 12 shows that the results of random slope for Tanzania and the results reveal that mother education, birth type, sex of infant, birth order, family size and survey year were statistically significant predictors of infant mortality in Tanzania. The odds of infant death for multiple birth's are 79.7% less likely than that for single birth's. The odds of infant death for females are 27% more likely than that for males. The odds of infant death for family size 4-6 are 97.7% more likely than that for 1-3 family size. The odds of infant death for family size 7 and more are 2.73 times higher than that for 1-3 family size. The estimated result of intra-class correlation for enumeration area(level two) in table 11 shows that about 3% of overall variation in the infant death is due to variation between enumeration area in Tanzania.

Table 12: Results of Random Slope for Tanzania

Factors	Odds Ratio	Std. Err.	Z	P.value	(95% CI)
Constant	3.366	.344	11.85	0.000	(2.754, 4.115)
Water (ref: Protected)					
Otherwise	1.000	.054	0.00	0.997	(.899,1.112)
Residence (ref:Urban)					
Rural	.962	.064	-0.58	0.563	(.843, 1.097)
Mother educ(ref:no educ)					
Primary	1.153	.062	2.63	0.009	(1.037 , 1.284)
Secondary	1.625	.171	4.62	0.000	(1.322, 1.998)
Higher	1.397	.443	1.06	0.291	(.750, 2.603)
Birth type(ref:Single)					
Multiple	.203	.016	-19.36	0.000	(.173, .239)
Sex of infant(ref:Male)					
Female	1.270	.059	5.14	0.000	(1.159, 1.391)
Sex of household head					
(ref:Male) Female	1.010	.067	0.15	0.879	(.887, 1.150)
Birth order(ref:1)					
2-4	1.362	.082	5.13	0.000	(1.211, 1.534)
5 and more	1.186	.080	2.50	0.012	1.037 , 1.355
Family size (ref:1-3)					
4-6	1.977	.143	9.40	0.000	1.715 , 2.279
7 and more	2.730	.207	13.24	0.000	2.352, 3.167
Year	1.105	.013	8.47	0.000	1.080, 1.131
Random effects					
EN's					
var(Year)	.0043489	.0015035			(.0022086 , .0085636)
var(cons)	.0965845	.0245334			(.0587075 , .1588989)

Table 13: Results of Empty Model for Zambia

	Odds Ratio	Std. Err.	Z	P.value	(95% CI)
Constant	13.75978	.3501111	103.04	0.000	13.090,14.463
EN's					
var(cons)	.093	.017			.065, .134
ICC	.028	.005			.019, .039

Table 14 shows that the random intercept results for Zambia and the results reveal that all covariates are statistically significant predictors of infant mortality, except religion. The odds of infant death for 4-6, 7 and more family size are 2.154, 3.109 times higher than that for 1-3 family size, respectively. The odds of infant death for widowed is 20.4% less likely than that for married. The estimated result of intra-class correlation for enumeration area(level two) in table 13 shows that about 2.8% of overall variation in the infant death is due to variation between enumeration area in Zambia.

Table 14: Random Intercept Result for Zambia

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	5.736	.598	16.73	0.000	(4.675, 7.039)
Religion (ref:Catholic)					
Muslim	.794	.228	-0.80	0.423	(.451, 1.395)
Christian	1.035	.046	0.79	0.432	(.948, 1.131)
Other	.831	.157	-0.98	0.328	(.573, 1.204)
Mother educ (ref:No educ)					
Primary	1.005	.054	0.10	0.923	(.903, 1.117)
Secondary	1.162	.075	2.31	0.021	(1.022, 1.320)
Higher	1.407	.193	2.49	0.013	(1.075, 1.843)
Breast fed (ref:Yes)					
No	.336	.013	-27.95	0.000	(.311,.362)
Marital status (ref:Married)					
Widowed	.796	.085	-2.11	0.035	(.644, .984)
Divorced	.989	.072	-0.15	0.884	(.857, 1.141)
Single	1.002	.061	0.04	0.970	(.888, 1.131)
Sex of infant (ref:Male)					
Female	1.228	.045	5.59	0.000	(1.142, 1.319)
Contraceptive (ref:Yes)					
No	.694	.0301	-8.39	0.000	(.637, .756)
Family size (ref:1-3)					
4-6	2.154	.114	14.42	0.000	(1.940, 2.391)
7 and more	3.109	.180	19.51	0.000	(2.774, 3.484)
Birth type (ref:Single)					
Multiple	.227	.015	-21.85	0.000	(.199,.260)
Birth size (ref:Large)					
Average	.963	.043	-0.81	0.418	(.882, 1.053)
Small	.557	.032	-10.00	0.000	(.496, .624)
Don't know	.346	.051	-7.17	0.000	(.259, .463)
Birth order (ref:1)					
2-4	.888	.043	-2.44	0.015	(.808,.977)
5 and more	1.032	.0490	0.67	0.503	(.940, 1.132)
Year	1.293	.014	22.40	0.000	(1.265, 1.323)
Random effects					
EN's					
Var(cons)	.0297262	.0121643			(.01333, .0663)

CHAPTER FIVE

5 Discussion

This study was carried out to see trend and to identify determinants of infant mortality in east Africa based on available DHSs dataset. Consequently, multilevel logistic regression models were used to identify the most important significant variables that affect infant mortality in east Africa.

Our findings revealed that child related factors such as: birth type, birth order, sex of child, and anemia were found to be statistically significant predictors of infant mortality in Ethiopia. The factors related to mother such as: mother education, religion, and contraceptive use were statistically significant and from household related factors residence and family size were significanly affect the infant mortality in Ethiopia. This findings are inline with the findings by Suwal,j.V.(2001), Rahman and Sankar.(2009), Kembo and Van Ginneken.(2009) and Kibrie et al.(2018).

According to our results in Madagascar, factors related to child: birth type, birth order and sex of child were found to be an important significant factors and factors related to mother: mother education, religion and household related factors: residence, sex of household head and family size were important significant factors. Our finding here is confirmed with Muluye and Wencheko, (2012), Mekonen et al. (2013), Rahman and Sankar.(2009).

The results showed by Nisar and Dibley. (2014), Febriyuna,N.,(2015) is inline with our finding of child related factors: birth type, birth order and sex of child were significantly affect infant mortality in Mozambique. Factors related to mother: mother education(secondary) was important significant factors and household related factors: family size and sex of household head were also statistically significant factors.

In Tanzania, child related factors: birth type, birth oreder and sex of child were found to be significant predictors on infant mortality and we have mother related factors: mother education was significant on infant mortality. Household related factors: family size was found to be significant impact on infant mortality. This results are confirmed with the results by Rahman and Sankar.(2009), Muluye and Wencheko, (2012), Nisar and Dibley. (2014). Time effect year is statistically significant predictor on infant mortality in Tanzania.

In Zambia, child related factors: breastfed, birth type, birth order, birth size, sex of child and place of delivery were found to be statistically significant on infant mortality. Mother related factors: contraceptive use, marital status(widowed) and household related factors: family size was statistically significant on infant mortality. This results are confirmed with the results by Rahman and Sankar.(2009), Muluye and Wencheko, (2012), Nisar and Dibley. (2014).

CHAPTER SIX

6 Conclusion and Recommendation

To achieve the aim of this study, multilevel analysis has been used and based on our results, we have the following conclusion and recommendation.

Multilevel analyses shows that child related factors: birth type, birth size, birth order, sex of child, anemia level, breastfed and factors related to mother: mother education, age of mother at first birth, religion, contraceptive use, marital status and finally, factors related to household: family size, residence were found to be statistically significant predictors of infant mortality in East Africa. Survey year has also statistically significant effect on infant mortality in East African countries.

According to our multilevel analysis, infant mortality is highly occured in which household members are four and/or more, and for multiple birth's in all African countries . Also, birth type is statistically significant predictor of infant mortality in all East African countries.

In order to reduce infant mortality in East Africa, awareness creation efforts have to increase family planning, contraception, improve the education level of parents, encourage breastfeeding, providing availability of toilet and safe water. To this effect, the outcome of reducing infant mortality is achieved by considering those significant factors related to infant birth.

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Appendix

Table 15: Random Slope Result for Ethiopia

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	2.567	.579	4.18	0.000	(1.649, 3.995)
Residence (Ref: Urban)					
Rural	.825	.057	-2.76	0.006	(.720,.945)
Mother educ (Ref: No educ)					
Primary	1.096	.059	1.69	0.091	(.985, 1.220)
Secondary	1.533	.172	3.79	0.000	(1.229 , 1.912)
Higher	2.938	.823	3.85	0.000	(1.696, 5.087)
Toilet (Ref: Yes)					
No	1.064	.051	1.30	0.194	(.968, 1.169)
Religion (Ref: Catholic)					
Muslim	1.402	.281	1.68	0.092	(.945, 2.079)
Christian	1.490	.298	1.99	0.047	(1.006, 2.207)
Other	1.788	.431	2.41	0.016	(1.114, 2.870)
Contracep (Ref: Yes)					
No	.739	.047	-4.72	0.000	(.652, .838)
Anemia (Ref: Not anemic)					
Anemic	.858	.048	-2.72	0.007	(.768, .958)
Birth type (Ref: single)					
Multiple	.144	.011	-25.20	0.000	(.123, .167)
Sex of infant (Ref:Male)					
Female	1.294	.050	6.57	0.000	(1.198, 1.398)
Birth order (Ref: 1)					
2-4	1.045	.058	0.79	0.427	(.936, 1.167)
5 and more	.670	.043	-6.14	0.000	(.590, .761)
Family size(ref: 1-3)					
4-6	2.927	.164	19.09	0.000	(2.622, 3.269)
7 and more	5.516	.382	24.64	0.000	(4.815, 6.319)
Year	1.299	.028	11.99	0.000	(1.245, 1.356)
Random effects					
EN's					
Var(Year)	.004	.003			(.000 , .019)
Var(cons)	.010	.0208			(.000 , .485)

Table 16: Random Intercept Result for Madagascar

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	2.801	.325	8.88	0.000	(2.231, 3.517)
Residence (ref: Urban)					
Rural	.826	.055	-2.84	0.004	(.725,.942)
Mother educ (ref:No educ)					
Primary	1.072	.065	1.14	0.256	(.950, 1.208)
Secondary	1.327	.108	3.46	0.001	(1.130, 1.559)
Higher	2.072	.556	2.71	0.007	(1.223, 3.507)
Toilet (ref: yes)					
No	.803	.177	-0.99	0.322	(.521, 1.238)
Religion (ref: Catholic)					
Muslim	2.563	.997	2.42	0.016	(1.196, 5.495)
Christian	1.052	.061	0.88	0.380	(.938, 1.179)
Other	1.103	.072	1.51	0.132	(.970,1.254)
Birth type (ref: Single)					
Multiple	.165	.016	-18.43	0.000	(.136, .200)
Sex of infant (ref: Male)					
Female	1.218	.059	4.08	0.000	(1.108, 1.340)
Birth order (ref:1)					
2-4	1.131	.069	2.00	0.045	(1.002, 1.277)
5 and more	.784	.057	-3.34	0.001	(.680, .904)
Water (ref: Protected)					
Otherwise	.899	.052	-1.81	0.070	(.801, 1.008)
Sex of household head (ref: Male)					
Female	1.180	.079	2.45	0.014	(1.033, 1.347)
Family size (ref: 1-3)					
4-6	2.197	.147	11.76	0.000	(1.927, 2.505)
7 and more	3.165	.241	15.08	0.000	(2.725 , 3.676)
Year	1.440	.022	23.21	0.000	(1.397, 1.485)
Random effects					
EN's					
Var(cons)	0636817	.021429			(.0329294 ,.1231532)

Table 17: Random Slope Result for Mozambique

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	2.365	.250	8.13	0.000	(1.921, 2.910)
Residence (ref:Urban)					
Rural	1.043	.061	0.71	0.475	)(.929, 1.170)
Mother educ (ref:No educ)					
Primary	.939	.048	-1.21	0.226	(.850, 1.039)
Secondary	1.431	.141	3.63	0.000	(1.179, 1.737)
Higher	1.465	.525	1.07	0.286	(.725, 2.960)
Toilet (ref:yes) No	.907	.045	-1.94	0.052	(.821, 1.001)
Sex of household head(ref:Male)					
Female	1.288	.068	4.76	0.000	(1.161, 1.430)
Water (ref:Protacted)					
Otherwise	1.157	.061	2.78	0.005	(1.044, 1.283)
Birth type (ref:Single)					
Multiple	.196	.015	-20.09	0.000	(.167, .230)
Sex of infant(ref:Male)					
Female	1.144	.051	2.98	0.003	(1.047, 1.250)
Birth order (ref:1)					
2-4	1.509	.085	7.29	0.000	(1.351,1.685)
5 and more	1.271	.085	3.55	0.000	(1.113,1.451)
Family size (ref:1-3)					
4-6	2.641	.162	15.84	0.000	(2.342, 2.979)
7 and more	3.849	.265	19.54	0.000	(3.362, 4.407)
Year	1.196	.032	6.69	0.000	(1.135, 1.261)
Random effects					
EN's					
Var(Year)	.0037407	.0048177			(.0002997, .046690)
Var(cons)	.0716885	.0353207			(.0272939, .188293)

Table 18: Results of Random Intercept for Tanzania

Factors	Odds Ratio	Std. Err.	Z	P.value	(95% CI)
Constant	3.438	.350	12.13	0.000	(2.816, 4.198)
Water (ref: Protected)					
Otherwise	.999	.054	-0.01	0.994	(.898, 1.111)
Residence (ref:Urban)					
Rural	.976	.065	-0.36	0.719	(.857, 1.112)
Mother educ(ref:no educ)					
Primary	1.157	.063	2.69	0.007	(1.040, 1.287)
Secondary	1.621	.169	4.63	0.000	(1.321, 1.988)
Higher	1.389	.433	1.05	0.292	(.753, 2.561)
Birth type(ref:Single)					
Multiple	.202	.016	-19.54	0.000	(.173, .238)
Sex of infant(ref:Male)					
Female	1.272	.059	5.19	0.000	(1.161, 1.393)
Sex of household head					
(ref:Male) Female	1.010	.066	0.15	0.877	(.887, 1.149)
Birth order(ref:1)					
2-4	1.359	.082	5.10	0.000	(1.208, 1.530)
5 and more	1.186	.080	2.50	0.012	1.037 , 1.355
Family size (ref:1-3)					
4-6	1.970	.142	9.39	0.000	(1.710, 2.269)
7 and more	2.719	.205	13.25	0.000	(2.345,3.152)
Year	1.087	.011	8.35	0.000	(1.066,1.109)
		Random effects			
EN's					
var(cons)	.1190644	.0238725			(.080374 , .1763795)

Table 19: Random Slope Result for Zambia

Factors	OR	Std.Err	Z	P.value	(95%CI)
Constant	5.709	.599	16.59	0.000	(4.647, 7.014)
Religion (ref:Catholic)					
Muslim	.794	.228	-0.80	0.424	(.451, 1.396)
Christian	1.036	.046	0.79	0.427	(.948, 1.132)
Other	.832	.157	-0.97	0.331	(.574, 1.205)
Mother educ (ref:No educ)					
Primary	1.005	.054	0.10	0.919	(.904, 1.118)
Secondary	1.162	.075	2.31	0.021	(1.023, 1.321)
Higher	1.406	.193	2.48	0.013	(1.074, 1.842)
Breastfed (ref:yes)					
No	.336	.013	-27.95	0.000	(.311,.362)
Marital status (ref:Married)					
Widowed	.796	.085	-2.10	0.035	(.644, .984)
Divorced	.989	.072	-0.15	0.884	(.857, 1.141)
Single	1.002	.061	0.04	0.971	(.887, 1.131)
Sex of infant (ref:Male)					
Female	1.228	.045	5.59	0.000	(1.142, 1.320)
Contraceptive (ref:Yes)					
No	.694	.0301	-8.38	0.000	(.638, .756)
Family size (ref:1-3)					
4-6	2.154	.114	14.42	0.000	(1.941, 2.391)
7 and more	3.110	.180	19.51	0.000	(2.775, 3.486)
Birth type (ref:Single)					
Multiple	.227	.015	-21.84	0.000	(.199,.260)
Birth size (ref:Large)					
Average	.964	.043	-0.80	0.421	(.882, 1.053)
Small	.557	.032	-9.99	0.000	(.496, .624)
Don't know	.346	.051	-7.16	0.000	(.259, .463)
Birth order (ref:1)					
2-4	.888	.043	-2.44	0.015	(.807,.977)
5 and more	1.032	.0490	0.67	0.501	(.940, 1.133)
Year	1.295	.015	21.26	0.000	(1.265, 1.327)
Random effects					
EN's					
Var(Year)	.0004876	.001254			(3.15e-06 , .07539)
Var(cons)	.0257018	.0157206			(.00775, .08523)

Table 20: Uni-variable Results

Burundi

Factors	OR(95%CI)	Std.Err	Z	P.value
Residence	.873(.753,1.012)	.065	-1.80	0.072
Mother educ.	1.022(.949,1.101)	.038	0.59	0.555
Toilet	.735(.589,.916)	.082	-2.73	0.006
Sex infant	1.108(.999,1.231)	.058	1.94	0.052
Birth order	1.046(.962, 1.136)	.044	1.06	0.287
Birth type	.165(.137,.199)	.015	-19.14	0.000
Family size	1.913(1.766,2.072)	.077	15.92	0.000
Mother Age at first birth	1.064(.966,1.172)	.052	1.27	0.205

Ethiopia

Factors	OR(95%CI)	Std.Err	Z	P.value
Residence	.733(.656,.819)	.041	-5.49	0.000
Mother educ.	1.249(1.171,1.333)	.041	6.75	0.000
Toilet	.876(.806,.952)	.037	-3.11	0.002
Religion	1.117(1.044,1.196)	.038	3.23	0.001
Contracep. use	.682(.609,.764)	.039	-6.60	0.000
Anemia level	.817(.736,.908)	.043	-3.74	0.000
Birth size	-1.782(.180,.329)	.025	6.67	0.000
Birth order	.068(.018,.118)	.072	2.67	0.008
Sex infant	.254(-1.924,-1.639)	.038	-24.54	0.000
Family size	.601(.545, .657)	.028	21.07	0.000
Birth type	1.007(.961,1.055)	.024	0.32	0.752
Mother Age at first birth	1.085(1.008,1.167)	.040	2.18	0.029

Kenya

Factors	Odds Ratio	Std. Err.	Z	P.value	95% CI
Mother educ	1.170319	.0319688	5.76	0.000	(1.109309, 1.234684)
Contracep use	.5618811	.0292407	-11.08	0.000	(.5073964 , .6222165)
Breastfed	.3275728	.0150482	-24.29	0.000	(.2993676,.3584353)
Birth type	.2422178	.0172588	-19.90	0.000	(.210647,.2785204)
Sex infant	1.180431	.0465655	4.21	0.000	(1.092603,1.275318)
Drink Water	1.259128	.1188032	2.44	0.015	(1.04654,1.514899)
Family size	1.624305	.0473721	16.63	0.000	(1.534061, 1.719857)
Moth CurrentAge	.9251285	.0253062	-2.84	0.004	(.8768354, .9760814)

		Madagascar			
Residence	.7526139	.045007	-4.75	0.000	.6693752 , .8462034
Mother educ	1.177593	.0383995	5.01	0.000	1.104686 , 1.255311
Toilet	.8470134	.1690363	-0.83	0.405	.57282, 1.252456
Religion	1.008408	.0196618	0.43	0.668	.9705981 , 1.04769
Birth type	.1930254	.0179776	-17.66	0.000	.1608189 , .2316818
Sex infant	1.205032	.056637	3.97	0.000	1.098985 , 1.321312
Birth order	1.030772	.0341307	0.92	0.360	.9660011 , 1.099885
Water	.8572604	.0478346	-2.76	0.006	.7684512 , .9563332
Sex HHhead	1.006381	.0645539	0.10	0.921	.8874876 , 1.141201
Family size	1.520892	.0522003	12.22	0.000	1.421947 , 1.626723
		Malawi			
Place Residence	.7844458	.0363608	-5.24	0.000	.7163213 , .8590492
Avail toilet	.8638201	.0348541	-3.63	0.000	.7981386 , .9349068
Mother educ	1.087975	.0284766	3.22	0.001	1.03357 , 1.145245
Contracep use	.6567534	.0234862	-11.76	0.000	.6122974 , .7044372
Birth type	.2129549	.0104994	-31.37	0.000	.1933395 , .2345604
Sex infant	1.191391	.0362642	5.75	0.000	1.122393 , 1.264631
Birth order	1.152357	.0245701	6.65	0.000	1.105193 , 1.201534
Birth size	.674305	.0136896	-19.41	0.000	.6480007 , .7016771
Family size	1.918905	.0440847	28.37	0.000	1.834417 , 2.007284
		Mozambique			
Place Residence	.9097087	.0424106	-2.03	0.042	.83027 , .996748
Mother educ	1.040882	.0358015	1.16	0.244	.9730255 , 1.113471
Sex HHhead	1.068068	.053585	1.31	0.189	.9680413 , 1.178429
Drink Water	.9853554	.0455424	-0.32	0.750	.9000176 , 1.078785
Birth type	.2515088	.0189325	-18.34	0.000	.2170094 , .2914929
Sex infant	1.151231	.0498151	3.25	0.001	1.057621 , 1.253126
Birth order	1.20792	.0369652	6.17	0.000	1.137599 , 1.282587
Family size	1.85182	.0589122	19.37	0.000	1.739881 , 1.970962
Avail toilet	.8609268	.0376797	-3.42	0.001	.7901548 , .9380377
		Rwanda			
Drink Water	.8799713	.0342579	-3.28	0.001	.8153248 , .9497436
Place Residence	.7280543	.0373398	-6.19	0.000	.6584278 , .8050437
Mother educ	1.343192	.0418429	9.47	0.000	1.263635 , 1.427758
Avail toilet	.7200565	.0570786	-4.14	0.000	.616442 , .8410871
Birth type	.2240308	.0160954	-20.82	0.000	.1946048 , .2579062
Sex infant	1.188	.0439461	4.66	0.000	1.104916 , 1.277332
Sex HHhead	.938634	.0440361	-1.35	0.177	.8561742 , 1.029036
Birth order	1.032515	.0265651	1.24	0.214	.9817398 , 1.085917
Family size	2.098463	.0608426	25.56	0.000	1.982539 , 2.221166

Tanzania					
Drink Water	.9261655	.0414961	-1.71	0.087	.8483034 , 1.011174
Place Residence	1.063859	.0436561	1.51	0.131	.9816455 , 1.152959
Mother educ	1.128873	.0313667	4.36	0.000	1.06904 , 1.192055
Sex infant	1.225685	.0402642	6.19	0.000	1.149255 , 1.307197
Birth type	.2195956	.0119495	-27.86	0.000	.1973808 , .2443108
Sex HHhead	.9226703	.0405388	-1.83	0.067	.8465405 , 1.005646
Birth order	1.100944	.0245525	4.31	0.000	1.053859 , 1.150134
Family size	1.557431	.0370958	18.60	0.000	1.486395 , 1.631861
Uganda					
Drink Water	.9349102	.0374224	-1.68	0.093	.864367 , 1.011211
Place Residence	.9415141	.0400907	-1.42	0.157	.8661272 , 1.023462
Mother educ	1.172556	.0284384	6.56	0.000	1.118121 , 1.22964
Sex infant	1.228571	.0400745	6.31	0.000	1.152485 , 1.309681
Birth type	.2424362	.0142349	-24.13	0.000	.2160818 , .2720049
Birth order	1.049138	.0233569	2.15	0.031	1.004344 , 1.09593
Family size	1.569782	.03704	19.11	0.000	1.498838 , 1.644084
Moth CurrentAge	1.005143	.0228055	0.23	0.821	.9614241 , 1.050849
MotherAge atfi h	1.039256	.0396979	1.01	0.313	.9642909 , 1.120049
Zambia					
Religion	1.021407	.0214442	1.01	0.313	.9802306 , 1.064314
Mother educ	1.066811	.0283636	2.43	0.015	1.012643 , 1.123877
Place delivery	.8969904	.0327712	-2.98	0.003	.8350057 , .9635763
Breast fed	.3155452	.0117099	-31.08	0.000	.293409 , .3393514
Maritalstatuss	.9446727	.0158066	-3.40	0.001	.9141948 , .9761668
Sexinfant	1.189857	.0415099	4.98	0.000	1.111219 , 1.274061
Contracep use	.6175076	.0249173	-11.95	0.000	.5705518 , .6683277
Birth type	.2296125	.0138829	-24.34	0.000	.2039529 , .2585004
Birth size	.6790042	.0182845	-14.38	0.000	.6440965 , .7158037
Birth order	1.19641	.0283472	7.57	0.000	1.142121 , 1.25328
Family size	1.773642	.045518	22.33	0.000	1.686635 , 1.865138
Zimbabwe					
Place Residence	.8396901	.0527684	-2.78	0.005	.7423815 , .9497534
Mother educ	1.297414	.0562487	6.01	0.000	1.191723 , 1.412479
Breast fed	.348767	.021679	-16.95	0.000	.3087631 , .3939537
Sex infant	1.226368	.0670947	3.73	0.000	1.10167 , 1.36518
Contracep use	.514717	.0283671	-12.05	0.000	.4620159 , .5734295
Birth type	.2082047	.0190883	-17.12	0.000	.1739611 , .2491891
Birth order	.8962981	.0356964	-2.75	0.006	.8289954 , .9690648
Family size	1.424684	.0552912	9.12	0.000	1.320334 , 1.537281

Table 21: Result of dfbeta

Tanzania			Ethiopia		
Factors	Obs	Max	Factors	Obs	Max
dfbeta water	29,127	.0429072	dfbeta1	41,954	.0652037
dfbeta for residence	29,127	.0599984	dfbeta2	41,954	.0322749
dfbeta for mother educ(1)	29,127	.0466881	dfbeta3	41,954	.0386117
dfbeta for mother educ(2)	29,127	.040974	dfbeta4	41,954	.0367803
dfbeta for mother educ(3)	29,127	.0634677	dfbeta5	41,954	.0419997
dfbeta for birth type	29,127	.0414602	dfbeta6	41,954	.2198303
dfbeta for sex of infant	29,127	.0229575	dfbeta7	41,954	.2211838
dfbeta for sex of HH head	29,127	.0178198	dfbeta11	41,954	.0640926
dfbeta for birth order(1)	29,127	.0464129	dfbeta12	41,954	.0226606
dfbetafor birth order(2)	29,127	.0534284	dfbeta8	41,954	.1911526
dfbeta for family size(1)	29,127	.0718446	dfbeta9	41,954	.0581139
dfbeta for family size(2)	29,127	.074837	dfbeta10	41,954	.0240649
dfbeta for Year(1)	29,127	.0330034	dfbeta13	41,954	.0296119
dfbeta for Year(2)	29,127	.0259663	dfbeta14	41,954	.0292387
dfbeta for Year(3)	29,127	.0392007	dfbeta15	41,954	.1328895
dfbeta for Year(4)	29,127	.027993	dfbeta16	41,954	.0466317
dfbeta for Year(5)	29,127	.029470	dfbeta17	41,954	.0570181
dfbeta for Year(6)	29,127	.0294705	dfbeta18	41,954	.0580813
dfbeta for Year(7)	29,127	.0392936	dfbeta19	41,954	.0635852
dfbeta for Year(8)	29,127	.0317225	dfbeta20	41,954	.0336719
			dfbeta21	41,954	.0387308
			dfbeta22	41,954	.0450111

Table 22: Results of dfbeta and VIF for Madagascar

Factors	Obs	Max	Factors	VIF
dfbeta1	44,237	.0711852	1.Place residence	1.42
dfbeta for residence	44,237	.0514498	Mothereduc	
dfbeta for mother educatin(1)	44,237	.0609724	1	1.63
dfbeta for mother educatin(2)	44,237	.0345697	2	1.89
dfbeta for mother educatin(3)	44,237	.0472137	3	1.13
dfbeta for toilrt	44,237	.0371395	1.Avail toilet	1.02
dfbeta for religion(1)	44,237	.0318597	Religion	
dfbeta for religion(2)	44,237	.047309	1	1.03
dfbeta for religion(3)	44,237	.0447425	2	1.34
dfbeta for birth type	44,237	.0252723	3	1.56
dfbeta for sex of infant	44,237	.0461872	1.Birth type	1.01
dfbeta for birth order(1)	44,237	.0536573	Sex infant	1.00
dfbeta for birth order(2)	44,237	.0396079	Birth order	
dfbeta for water	44,237	.0251591	1	1.53
dfbeta for sex of HH head	44,237	.0714129	2	1.89
dfbeta for family size(1)	44,237	.0742715	1.Drink Water	1.34
dfbetafor family size(2)	44,237	.0452491	Sex HHhead	1.03
dfbeta for year(2)	44,237	.0560582	Family size	
dfbeta for year(3)	44,237	.0683783	1	2.57
dfbeta for year(4)	44,237	.0728456	2	2.77
dfbeta for year(5)	44,237	.0697055	Yearr	
dfbeta for year(6)	44,237	.0664157	2	1.58
			3	1.90
			4	2.66
			5	2.29
			6	2.11
			7	2.19
			Mean VIF	1.68

Table 23: Results of VIF

Burundi		Ethiopia		Kenya	
Factors	VIF	Factors	VIF	Factors	VIF
Rsidence	1.06	Rsidence	1.50	Mother educ 1	1.72
Mother educ 1	1.67	Mother educ 1	1.16	Mother educ 2	1.79
Mother educ2	1.84	Mother educ 2	1.34	Contraceptive use	1.08
Mother educ3	2.09	Mother educ 3	3.80	Breastfed	1.06
Toilet	1.12	Toilet	1.24	Birth type	1.01
Sex infant	1.00	Religion 1	33.36	Sex infant	1.00
Birth order 1	1.83	Religion 2	33.53	Water	1.01
Birth order2	2.21	Religion 3	3.80	Family size 1	2.64
Birth type	1.00	Contraceptive use	1.20	Family size 2	2.88
Family size 1	3.14	Breastfed	.04	Mother Current age1	4.75
Family size2	3.50	Sex infant	1.01	Mother Current age 2	4.58
MotherAge at first birth 1	1.24	Anemialevel	1.03	Mother Current age 3	2.19
MotherAge at first birth2	1.04	Birth type	1.01	Mean VIF	2.14
MotherAge at first birth3	1.52	Birth size 1	1.41		
		Birth 2	1.43		
		Birth size 3	1.01		
		Birth order 1	2.12		
		Birth order 2	2.70		
		Family size 1	3.17		
		Family size2	3.69		
		MotherAge at first birth 1	1.06		
		MotherAge at first birth 2	1.03		
		Mean VIF	4.55		