Determinants of Neonatal and Under-five Mortality in Kenya: Do Antenatal and Skilled Delivery Care Services Matter?

By

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Abstract

Declines in neonatal and under-five mortality in Kenya were much slower than what was required to meet the Millennium Development Goal (MDG) on childhood mortality. Therefore, while Tanzania and Uganda met and surpassed their MDG targets, Kenya did not. Effort is now directed at ending all preventable deaths among neonates and under-fives, as envisaged in the Sustainable Development Goals (SDGs). Most childhood mortality can be prevented by ensuring that women have access to quality care during conception, pregnancy, intra-partum and in the post-natal period. This study investigated the effects of antenatal and skilled delivery care services on neonatal and under-five mortality in Kenya using pooled Kenya demographic and health survey data for 1998, 2003, 2008/2009 and 2014. Two-stage residual inclusion estimation procedure and the control function approach were used to test and control for potential endogeneity of antenatal and skilled delivery care and for potential unobserved heterogeneity. The study unveiled presence of both endogeneity and unobserved heterogeneity and found that failure to control these would have biased downwards the effects of antenatal and skilled delivery care services on childhood mortality. Findings indicated that adequate use of antenatal care services reduced risk of neonatal and under-five mortality by 2.4 and 4.2 percentage points respectively. Similarly, use of skilled delivery care services was associated with reduced risk of neonatal and under-five mortality by 0.3 and 1.8 percentage points respectively. Increasing coverage of women using adequate antenatal care services and skilled delivery care services can reduce the risk of neonatal and under-five mortality in Kenya. Policies that promote use of these services such as promoting women education and reducing average distances to health facilities should be promoted.

1. Introduction

Child mortality is an important indicator of children's well-being and health. Thus, it is unsurprising that it is the fourth United Nations Millennium Development Goal (MDG) on measuring progress towards poverty reduction with an aim of reducing under-five mortality rate by two-thirds between 1990 and 2015 (UN Millennium Project, 2005). The child mortality agenda is also embedded in the recently launched Sustainable Development Goals (SDGs), where it is targeted that by 2030 countries should end preventable neonatal deaths and deaths of children under five years of age.

Childhood mortality in Kenya

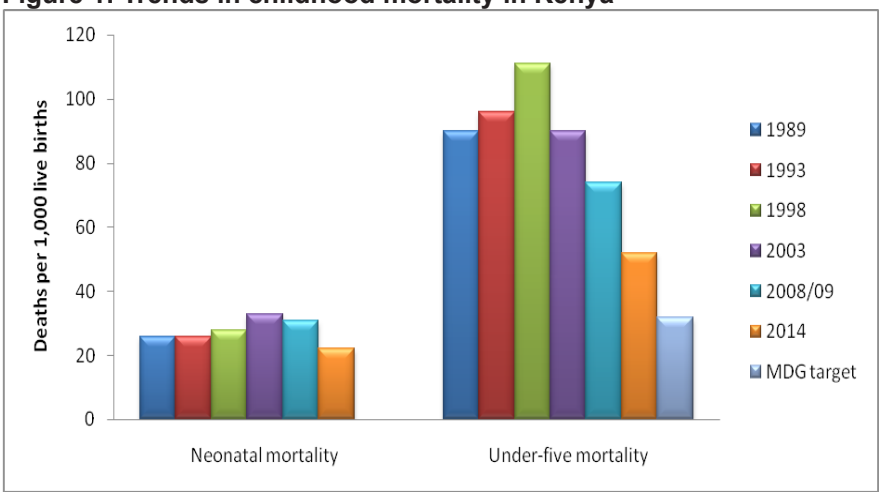
Remarkable progress has been made in reducing childhood mortality. Globally, a 53% decline in under-five mortality rate was recorded between 1990 and 2015 (UNICEF et al, 2015). Sub-Saharan Africa managed to reduce its under-five mortality by 54% (UNICEF et al, 2015). Kenya had a 52% decline in its under-five mortality compared with 70% and 71% for Tanzania and Uganda respectively. This meant that while Tanzania and Uganda met and surpassed their MDG targets, Kenya did not meet its target.

Neonatal mortality is becoming increasingly important both because of the rising share of neonatal deaths in under-five deaths and an appreciation that health interventions to deal with neonatal mortality differ from those needed to address other under-five deaths (UNICEF et al, 2014). Projections indicate that between 2016 and 2030 half of the 60 million child deaths will occur during the neonatal period with the share of neonatal deaths in under-five deaths increasing from 45% in 2015 to 52% in 2030 (UNICEF et al, 2015). This, therefore, means that effort and attention need to be devoted to neonatal mortality if the recent decrease in child mortality witnessed globally is to be sustained. Neonatal mortality rate refers to the number of deaths occurring during the first 28 days of life per 1,000 live births in a given year or any other period while post-neonatal mortality refers to the number of deaths from day 28 of life until the first birthday per 1,000 live births per year or other given period (WHO, 2011). Under-five mortality rate is the probability of a child born in a specific period or year dying before five years of age if the age-specific mortality rate for that period or year are subjected to them (WHO, 2011).

Although neonatal mortality has been declining, the declines have been much slower than for post-neonatal mortality. Globally, neonatal mortality has declined by

47% compared with 58% for post-neonatal mortality over the 1990 to 2015 period. Sub-Saharan Africa had a 38% decline in neonatal mortality rate over this period (UNICEF et al, 2015). Kenya's rate of decline in neonatal mortality was half that of sub-Saharan Africa at 19%. This rate was also much lower than those of Uganda and Tanzania who reduced their neonatal mortality rate by 51% and 53% respectively over the 1990–2015 period. Figure 1 shows trends in childhood mortality in Kenya. Both under-five mortality and neonatal mortality rates have fallen over the years although neonatal mortality rate fell more slowly almost remaining constant over the years (Figure 1).

Figure 1: Trends in childhood mortality in Kenya



Source: KNBS et al, 2015; KNBS, 2015

Most neonatal deaths can be prevented. Children who die in the neonatal period suffer from conditions and diseases that can be linked to the quality of care around the time of pregnancy and childbirth and can be prevented and treated (UNICEF et al, 2014). Most neonatal deaths and still births occur during labour and child birth. In 2012, Lawn et al (2014) estimated that 71% of all neonatal deaths happened within the first week of life with 36% of the deaths happening on the day of birth. Three major factors account for more than 85% of neonatal mortality: pre-term births, intra-partum (period from onset of labour until end of third stage of labour) related neonatal deaths and neonatal infections such as sepsis, meningitis, pneumonia, and diarrhoea. Bhutta et al (2014) found that increased coverage and quality of interventions before conception, during pregnancy and intra-partum, and during the post-natal period could prevent 71% of neonatal deaths and 33% of stillbirths per year in the 75 high burden countries by 2025.

Good pregnancy care is important for the mother's health as well as for the development of the unborn child. Antenatal care refers to the health care that a woman receives during pregnancy (Lincetto et al, 2006). It entails screening and identification of women who need specialized care; testing for complications related to pregnancy such as pre-eclampsia and managing them; testing for illnesses and conditions such as HIV/AIDS that are worsened by pregnancy; providing women with preventive care such as iron supplements, folic acid iron tablets; advising pregnant women on danger signs and preparing them for delivery; and advising women on healthy eating (Lincetto

et al, 2006). It is meant to prepare for birth and to remove, manage, detect, and prevent pregnancy complications, already existing conditions that make the pregnancy worse and effects of unhealthy lifestyles that affect mothers and babies (Lincetto et al, 2006). It is also a chance to promote the use of skilled attendance at birth. The World Health Organization (WHO) recommends that all pregnant women should attend at least four antenatal visits, and the first antenatal visit should occur before week 12 (Berg, 1995).

Maternal health care services in Kenya

In Kenya the beginning of maternal health care services can be traced back to the integrated maternal and child health (MCH) programme in 1972, although specific programmes to reduce maternal mortality and improve health of the mother were only established after the launch of the Safe Motherhood Initiative in 1987 in Nairobi. The programmes mainly concentrated on training traditional birth attendants (TBAs) to screen for complications in high risk pregnancies. Efforts are now directed towards ensuring that during pregnancy and child birth women have access to skilled care (that does not include TBA). Various strategies and policies have been formulated to this end such as the National Reproductive Health Strategy of 1997 and the National Reproductive Health Policy. More recently, in 2013, the Government of Kenya initiated free maternity services in all public facilities. This was to ensure that as many women as possible are able to access skilled delivery care. The First Lady of the Republic of Kenya added to the agenda of improving maternal health by launching the "Beyond Zero Campaign". The campaign seeks to ensure no new HIV infections in children and that women have access to prenatal and post-natal care.

Maternal health services are provided at every level of the Kenyan health care system by health facilities. The lowest levels of facilities in the public health sector are dispensaries and health centres that provide mainly prenatal care, diagnose and treat simple pregnancy complications such as anaemia, and sometimes perform normal deliveries. The next level is district hospitals which, besides providing the services provided by dispensaries and health centres, also perform caesarean sections. The higher level is provincial hospitals and then referral or national hospitals all of which provide maternal health services for both simple and complicated cases. Doctors, clinical officers, and registered and enrolled midwives and nurses comprise the skilled attendants.

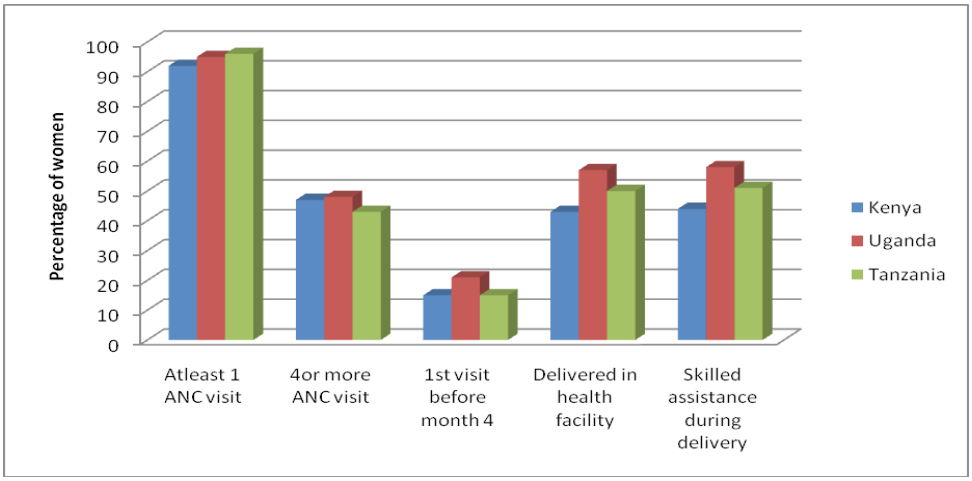
Utilization of maternal health services in Kenya has improved over time. Statistics show that in 2014 many women in Kenya (96%) made at least one antenatal visit, the proportion having increased from 92% in 2008/2009 (KNBS et al, 2015)). WHO recommends that women make at least four antenatal visits during pregnancy and that the first antenatal visit should occur within the first four months of pregnancy. In Kenya, in 2014, only 58% of women made at least four antenatal visits, an increase from 47% in 2008/2009 (KNBS et al, 2015). Further, only 20% of women made their first antenatal visit before the fourth month of pregnancy which is a five percentage points increase from the 2008/2009 figures (KNBS et al, 2015).

Skilled assistance during delivery (also referred to as skilled delivery care) is considered important in reducing childhood and maternal mortality. It refers to care given to a woman by a skilled attendant during labour, delivery and early post-partum

period; and involves ability to access necessary supplies, equipment and infrastructure, and ability to make appropriate referrals (Graham et al, 2001). A skilled attendant is a person with midwifery skills (such as a doctor, nurse or midwife) who has been trained in skills to manage normal deliveries and diagnose, manage and refer complicated deliveries (WHO, 1999). Although good progress has been made in increasing the proportion of women with access to skilled delivery care in Kenya, 38% still delivered without skilled assistance in 2014.

Figure 2 shows some disparities between Kenya, Uganda and Tanzania in utilization of maternal health services. Kenya lags behind in most of the maternal health services compared with Tanzania and Uganda.

Figure 2: Utilization of maternal health services by country



Objectives

The main objective of this study was to examine the effect of antenatal care services and skilled delivery care services on under-five and neonatal mortality in Kenya. The specific objectives were to:

i. Examine the effect of antenatal care services on neonatal and under-five mortality.

ii. Examine the effect of skilled delivery care services on neonatal and under-five mortality.

iii. Suggest policy recommendations.

The rest of the paper is organized as follows. Section two provides a review of literature on maternal health services and childhood mortality. Section three discusses the methodology used in this study, the data and the descriptive statistics. The results and discussion are presented in Section four; and Section five concludes and suggests policy recommendations.

2. Literature review

According to the American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG), a woman with an uncomplicated pregnancy should make her first antenatal visit in the first trimester and then follow-up visits should occur after every four weeks for the first 28 weeks; then every two weeks up to week 36; and then weekly there after (AAP and ACOG, 2014). Based on these guidelines, various indexes of adequacy of antenatal care have been constructed and applied in literature. The Kessner Adequacy of Prenatal Care index and the Adequacy of Prenatal Care Utilization (APNCU) index are the two main indexes used to study the relationship between antenatal care and birth outcomes (see Gortmaker, 1979; Showstack et al, 1984; Murray and Bernfield, 1988; Theodore, 1994; Partridge 2012; Tayebi et al, 2013; Heaman et al, 2008). Other indicators are timing of initiation of antenatal care, whether antenatal care was ever initiated; and number of antenatal visits made among others (see Beauclair et al, 2014; Poma, 1999; Lambon-Quayefio and Owoo, 2010).

According to WHO, the antenatal guidelines set by AAP and ACOG may be unsuited for developing countries because antenatal care is costly and less accessible than in Western countries, and the marginal benefits of antenatal care may be higher due to limited access to preventive care (Gajate-Garrido, 2013). The WHO Technical Working Group recommended that for developing countries every woman needs a minimum of four antenatal visits: the first should occur by week 16; the second at weeks 24–28; the third at week 32; and the final one at 36–38 weeks (Berg, 1995). On the basis of these guidelines, adequacy is defined by starting antenatal visits by week 16 and making at least four visits. Several studies have used this measure of adequacy of antenatal care (see Gajate-Garrido, 2013; Awiti, 2014). This study will use these guidelines to define adequacy of antenatal care.

Several studies have estimated the effect of antenatal and skilled delivery care services on childhood mortality (Poma, 1999; Singh et al, 2014; Beauclair et al, 2014; Lambon-Quayefio and Owoo, 2010; Singh et al, 2014). Very few studies focus on sub-Saharan Africa (see, for example, Lambon-Quayefio and Owoo, 2010) who studied the effect of number of antenatal visits on neonatal mortality in Ghana). This study will augment studies on sub-Saharan Africa by considering the effect of adequate antenatal care services and skilled delivery care services on childhood mortality in Kenya. A study by Awiti (2014) considered adequacy of antenatal care, but studied its effect on birth weight. Other studies in Kenya on childhood mortality (Mutunga, 2007; Omariba, 2005; Mustafa and Odimegwu, 2008; Ettarh and Kimani, 2012; Kabubo-Mariara et al, 2012) do not consider effects of maternal health services on childhood mortality.

3. Methodology

Following several authors (Rosenzweig and Schultz, 1982; Rosenzweig and Schultz, 1983; Mwabu, 2009; Awiti, 2014), we assume a mother maximizes the following utility function

$$U = U(X, H) \tag{1}$$

Where a mother derives utility from consumption of goods and services that have no effect on the health of the child, X and from the unborn child's health status, H. Health of the child enters directly into the mother's utility function because health is viewed as a consumption good that brings utility (Grossman, 1972). It is assumed that an individual inherits a stock of health which depreciates with age and which can be increased through investments such as use of health care (Grossman, 1972). Health of the child is therefore assumed to be influenced by the mother's consumption of maternal health services such as antenatal care services and skilled delivery care services, M; other factors, Y; and unobserved biological endowments of the child, μ. Hence the health production function can be specified as follows:

$$H = F(Y, M, \mu) \tag{2}$$

The mother maximizes the utility function subject to the health production function and the budget constraint given as:

$$I = P_X X + P_Y Y + P_M M \tag{3}$$

Where P_X is the price of X, P_M is the price of M and P_Y is the price of Y, and I is mother's income. Setting up the langrangian function and solving the first order conditions yields the demand equations for the three goods as functions of prices and income:

$$\begin{aligned} X &= D_X(P_X, P_Y, P_M, I, \mu) \\ M &= D_M(P_X, P_Y, P_M, I, \mu) \\ Y &= D_Y(P_X, P_Y, P_M, I, \mu) \end{aligned} \tag{4}$$

From Equation 4, the prices of the three goods and services, X, M, Y, affect quantities of X, M, Y and, since M and Y are functions of the health production function, the prices of the three goods and services also indirectly enter the child health production.

In studying the effects of antenatal and skilled delivery care services on child health,

this study is guided by a conceptual framework developed by Schultz (1984) as shown in Figure 3. In the framework proximate determinants (such as antenatal and skilled delivery care services) and biological endowments are linked to child health. The child health production function in Equation 2 can therefore be re-specified as follows:

$$H = \alpha + \sum_j \beta_j M_j + \phi \mathbf{Y} + \varepsilon_1, j = 1,2 \quad (5)$$

Where H is neonatal or under-five mortality, M_j is a vector of adequacy of antenatal care services and skilled delivery care services, $\mathbf{Y}$ is a vector of other factors that also act as controls, and ε_1 is the stochastic error term. The unobserved biological endowments variable, μ in Equation 2 and in the conceptual framework, drops out of Equation 5 because this is a random variable whose value on average is zero.

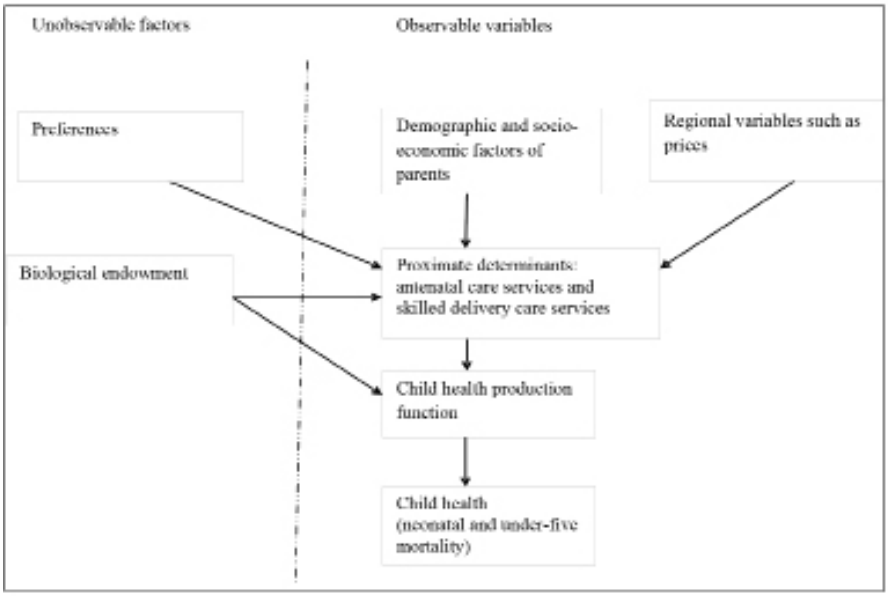
Proximate determinants are expressed also as dependent variables influenced by socio-economic and demographic factors, preferences and regional variables. Unobservable factors affect demand for antenatal and skilled delivery care services, but also enter the child health production function (i.e., they belong to Equation 5). For example, biologically weaker children may be at a higher risk of childhood mortality but also such weaknesses may increase use of antenatal and skilled delivery care services. This causes the error term in Equation 5 to be correlated with M_j, leading to the problem of endogeneity (Wooldridge, 2002).

Frick and Lantz (1996) identified four forms of selection that can cause antenatal care and skilled delivery care services to be endogenous in Equation 5. The first is favourable selection, which occurs when there are unobservable factors or behaviour that makes women more likely to use antenatal and skilled delivery care services, and more likely get positive birth outcomes. For example, knowledgeable women may be more likely to use antenatal care services because they understand the benefits of such services, but they may also be more likely to adopt a healthy lifestyle that may be associated with positive birth outcomes. This type of selection biases upwards the effect of antenatal and delivery care services on childhood mortality. The second selection is adverse selection, which occurs when women who are at a higher risk of poor birth outcome are also the ones who are more likely to use antenatal and skilled delivery care services. Women may know, for example through previous experience, family history, prevailing illness/disease, that they are at a higher risk of poor birth outcome and so may be more likely to seek maternal health care services. This selection biases downwards the effect of antenatal and delivery care services on childhood mortality.

The estrangement selection occurs when women who are at a higher risk of poor birth outcomes are also the ones less likely to use antenatal and skilled delivery care services. In this case, it is not low use of these services that cause poor birth outcome, but certain socio-economic conditions or behaviours that are associated both with low use of these services and poor birth outcomes. Women living in marginalized areas, for example, may be both less likely to use antenatal and skilled delivery care services and less likely to have favourable birth outcomes, hence likely to experience this kind of selection. This selection biases upwards the effect of antenatal care on birth outcomes. Finally, the confidence selection occurs when some women due to prior experience

and knowledge feel confident enough such that they are less likely to use antenatal and skilled delivery care services, but are also more likely to have positive birth outcomes. Women, for example, who have given birth previously and had favourable birth outcomes without complications may feel confident enough not to use these services but still have favourable outcomes. This biases downwards the effect of these services on birth outcomes.

Figure 3: Conceptual model for analysing the effect of antenatal and skilled delivery care on child health



Source: Adopted from Schultz (1984).

Similarly, from Figure 3, biological endowments vary from one child to another. Therefore, use of antenatal and skilled delivery care may be influenced by what mothers know about the endowments of their children, creating an interaction between unobserved biological endowments and use of maternal health care services. Thus there could be non-linear interaction between the unobservable factors and M_j causing differences in the effect of M_j on child health across the individuals leading to the problem of unobserved heterogeneity (Wooldridge, 2002).

To control for potential endogeneity of M_j, this study will use two-stage residual inclusion (2SRI) estimation procedure (Terza et al, 2008). Potential unobserved heterogeneity is controlled for using the control function approach estimation procedure (Card, 2001; Florens et al, 2008; Petrin and Train, 2009; Diagne and Diene, 2011). The 2SRI approach requires that we first estimate an equation for the potentially endogenous variables M_j as follows:

$$M_j = \varphi_0 + \varphi_1 Y + \varphi_2 \mathbf{Z} + \varepsilon_2 \quad (6)$$

Where $\mathbf{Z}$ is a vector of instrumental variables, M_j and $\mathbf{Y}$ are as defined before, and ε_2 is a stochastic error term. Some of the instrumental variables used in the literature are: population density, health care price index, insurance status, distance to nearest health facility, number of health facilities, population per hospital bed, unemployment rate, rate of uninsured females, husband's education and average number of antenatal visits of the neighbours (see Conway and Deb, 2005; Wehby et al, 2009; Lambon-Quayefio and Owoo, 2010; Awiti, 2014).

In this study we use proportion of women per cluster who used skilled delivery care, proportion of women per cluster who started antenatal visits before week 12 and average number of antenatal visits by cluster. Figure 3 suggests that regional variables can directly influence proximate determinants (use of antenatal and skilled delivery care services) but not directly enter the health production function. Proportion of women per cluster who used skilled delivery care services, proportion of women per cluster who started antenatal visits before week 12 and average number of antenatal visits by cluster act as proxies for regional variables such as distances to health facilities, prices of services, knowledge on antenatal and skilled delivery care services among others.

To implement 2SRI, Equation 6 is estimated and generalized residuals obtained which are then included as an additional variable in Equation 5 to substitute for the unobserved confounders (Terza, et al, 2008). The equation to be estimated becomes:

$$H = \alpha + \sum\nolimits_j \beta_j M_j + \sum\nolimits_j \lambda_j V_j + \phi\mathbf{Y} + \varepsilon_1, j = 1,2 \quad (7)$$

Testing whether the coefficient λ is statistically different from zero is the same thing as testing for endogeneity of antenatal and skilled delivery care services. If we reject the null hypothesis that the coefficient is not statistically different from zero, this is the same thing as saying antenatal and skilled delivery care services are endogenous (Bollen et al, 1995).

Control function approach estimation procedure is one step away from the 2SRI where, in addition to including generalized residuals from reduced form Equation 5, we also include interaction of generalized residuals and the potentially endogenous variable (M_j) to control for unobserved heterogeneity. The control function equation therefore becomes:

$$H = \alpha + \sum\nolimits_j \beta_j M_j + \sum\nolimits_j \lambda_j V_j + \sum\nolimits_j \lambda_j (V_j * M_j) + \phi\mathbf{Y} + \varepsilon_1, j = 1,2 \quad (8)$$

The models are then estimated using stata software.

Data and definition of variables

This study used data from the 1998, 2003, 2008/2009 and 2014 Kenya Demographic and Health Surveys (KDHS). These are nationally representative sample surveys of women aged 15 to 49 years. They contain comprehensive information on reproductive health and demography. The surveys are usually carried out after every five years. The data sets for the four years were appended to form one data set. The variables of interest

to this study were those on maternal health services, demographic characteristics of the woman, and mortality of the children. The sample was limited to children born upto five years before each survey. The sample sizes of such children were 3,531, 5,949, 6,079 and 20,964 for the 1998, 2003, 2008/2009 and 2014 years respectively. The variables used are defined in Table 1.

Table 1: Variable definitions

Variable	Definition
Dependent variables	
Neonatal mortality	1 if a child died within the first 28 of life; 0 if a child is alive
Under-five mortality	1 if a child died within the first five years of life; 0 if the child is still alive
Independent variables	
Adequacy antenatal care	1 if a women started antenatal visits in the first trimester and attended at least four antenatal visits; 0 otherwise
Skilled delivery care	1 if a woman had skilled assistance during delivery; 0 otherwise
Age of the mother	Age of the mother in years
Education level of the mother	
No education	1 if a mother has no formal education; 0 otherwise
Primary education	1 if a mother's highest education level is primary; 0 otherwise
Secondary education	1 if a mother's highest education level is secondary; 0 otherwise
Tertiary education	1 if a mother's highest education level is tertiary; 0 otherwise
Gender of child	
Male child	1 if child is male; 0 otherwise
Area of residence	
Rural residence	1 if area of residence is rural; 0 otherwise
Marital status	
Married	1 if married; 0 otherwise
Instrumental variables	
Percentage women who had skilled delivery care	Percentage of women in a cluster that had skilled delivery care
Percentage of women with adequate antenatal care	Percentage of women in a cluster who had adequate antenatal care
Average antenatal visits	Average number of antenatal visits by cluster

4. Findings

Table 2 presents the descriptive statistics. The statistics indicate that 5.5% of the children in the sample died between birth and exactly five years of age. Of these just slightly less than half (2.6%) died in the neonatal period. These statistics are not so different from those reported in the KDHS reports. Over the period covered by the data (1998–2014), neonatal mortality rate changed from 28 in 1998 to 33 in 2003 to 31 in 2008 and finally 22 in 2014 (KNBS et al, 2015). The average neonatal mortality rate was 28.5 over this period. When we convert the 2.6 percentage of neonatal deaths in the descriptive statistics to neonatal mortality rate, we get 26 deaths per 1,000 live births which is comparable to 28.5 deaths per 1,000 live births. When it comes to under-five mortality, the rate changed from 111 in 1998 to 90 in 2003 to 74 in 2008/2009 and to 52 in 2014 (KNBS et al, 2015), the average being 82 deaths per 1,000 live births over this period. The percentage of under-five deaths in the descriptive statistics gives us under-five mortality rate of 55 deaths per 1,000 live births which is lower than the Kenya national average of 82 deaths per 1,000 live births. This difference could have been brought about by the aggregation of the samples from the various years which we did in this study.

On the utilization of maternal health services, the results indicate that only 21% of the women in the sample used adequate antenatal care services. That is only 21% of women had at least four antenatal visits and started the visits within the first four months of pregnancy. This shows that while many women (92%) make at least one antenatal visit, very few meet the WHO recommendations of what is considered adequate antenatal care for developing countries. Also in the sample, 51% of the women reported that they used skilled delivery care services during their last birth. This statistic also compares well with the skilled delivery care statistic reported in the KDHS reports. Over the time covered by this study, use of skilled delivery care services at birth increased from 42% in 2003 to 44% in 2008/2009 to 62% in 2014. The average is 50% which compares well with the percentage reported in the descriptive statistics.

Slightly more than half of the women in this sample had primary education (55%) with only very few reporting to have tertiary education (5%). An equally high percentage of women reported to have no formal education (21%). The average age of women in this sample was 28 years and most of them were married (85%) and were residing in rural areas (72%). A total of 51% of the children were male. On the instrumental variables, each cluster had an average of 51% of women having utilized skilled delivery care and 21% received adequate antenatal care for their latest pregnancy. The average number of antenatal visits for each cluster was four.

Table 2: Descriptive statistics

Variable	Number of Observations	Mean	Standard deviation	Minimum	Maximum
Dependent variables					
Neonatal mortality	35,433	0.026	0.16	0	1
Under-five mortality	36,523	0.055	0.23	0	1
Independent variables					
Adequate antenatal care	36,523	0.21	0.41	0	1
Skilled delivery care	36,373	0.51	0.50	0	1
Age	36,523	28.41	6.61	15	49
No education	36,523	0.21	0.40	0	1
Primary education	36,523	0.55	0.50	0	1
Secondary education	36,523	0.19	0.39	0	1
Tertiary education	36,523	0.05	0.22	0	1
Male child	36,523	0.51	0.50	0	1
Rural residence	36,523	0.72	0.45	0	1
Marital status	36,523	0.85	0.36	0	1
Instrumental variables					
Percentage of women by cluster who received skilled delivery care	36,523	51.17	24.28	0	100
Percentage of women by cluster who had adequate antenatal care	36,523	20.83	11.82	0	100
Average antenatal visits	36,523	3.79	0.82	0	7.41

Determinants of adequate antenatal care and skilled delivery care

Table 3 presents the determinants of adequate antenatal care services and skilled delivery care services (average marginal effects). The coefficients are presented in Appendix Table 1. Age, education, rural residence and marital status were some of the factors associated with adequate use of antenatal care services and skilled delivery care services. The likelihood of using adequate antenatal care services and skilled delivery care services reduced with mother's age but the quadratic term suggested that more elderly mothers were more likely to use both services, holding other factors constant. This could be because older women are more prone to health problems such as high blood pressure and diabetes (Hansen, 1986). These are worsened by pregnancy. Similarly older women have been found to be more likely to suffer from pregnancy complications than their younger counterparts (Jolly et al, 2000). Awiti (2014) also found older women in Kenya to be more likely to seek adequate antenatal care services. Tsegay et al (2013) and Dhakal et al (2011) on the contrary found lower utilization of maternal health care services among older women. Overbosch et al, 2004) found no association between age of the woman and choice of sufficient antenatal care in Ghana.

The likelihood of utilizing skilled delivery care services and adequate antenatal care services increased with mother's education level, holding other factors constant. Mothers with primary, secondary and tertiary education were 3.3, 7.8 and 17.4 percentage points respectively more likely to use adequate antenatal care services compared with those with no formal education, holding other factors constant. Similarly, mothers with primary, secondary and tertiary education were 7, 20.7 and 37.4 percentage points more likely to use skilled delivery care than their counterparts with no formal education, holding other factors constant. This may be because education enables women to understand the benefits of maternal health service and also enables them to access employment opportunities. They are therefore able to afford these services. There appears to be consensus in literature on the positive effect of education on use of maternal health services. Other authors report similar findings (Overbosch et al (2004); Mengesha et al, 2013; Tsegay et al, 2013; Awiti, 2014; Gatimu et al, 2015).

Rural residents were less likely than their urban counterparts to utilize both skilled delivery care services and adequate antenatal care services, holding other factors constant. Rural residents were 1.1 and 2.8 percentage points less likely to use adequate antenatal care services and skilled delivery care services respectively compared with urban residents. This may be because access to health facilities is likely to be lower in rural areas than in urban areas. This could also be because urban residents have more access to media and hence have more access to information on these services than their rural counterparts. Mengesha et al (2013) found similar findings in Ethiopia that urban women were more likely to use skilled delivery care services than rural women.

Table 3: Reduced-form parameter estimates (average marginal effects), *Z* statistic in bracket

Variables	Adequate antenatal care (= 1 if had adequate antenatal care)	Skilled delivery care (= 1 if had skilled delivery care)
Age	-0.008 [-3.256]	-0.013 [-4.943]
Age squared	0.0001 [3.396]	0.0001 [3.498]
Education level (Base—No education)		
Primary education	0.039 [6.575]	0.108 [17.947]
Secondary education	0.098 [14.178]	0.284 [39.632]
Tertiary education	0.207 [21.811]	0.492 [33.037]
Male child	-0.003 [-0.660]	0.02 [4.604]
Marital status (Base—Not married)		
Married	0.006 [1.082]	0.021 [3.498]
Rural residence	-0.025 [-5.254]	-0.096 [-18.251]
Year of survey (Base—1998)		
1 if year 2003	-0.103 [-12.939]	-0.067 [-7.978]
1 if year 2008/9	-0.082 [-10.449]	-0.033 [-3.948]
1 if year 2014	-0.044 [-6.507]	0.023 [3.152]
Instrumental variables		

Proportion of women by cluster who sought skilled delivery care	-0.09 [-8.429]	0.719 [67.506]
Average number of antenatal visits by cluster	0.03 [8.243]	0.006 [1.510]
Proportion of women by cluster who started antenatal clinics before week 12	0.66 [31.558]	-0.123 [-4.988]
Pseudo R^2	0.0959	0.2578
Partial R^2 on excluded instruments	0.0732	0.1913
Joint X^2	1,777.64	3,970.61
Observations	36,523	36,373

Married women were more likely to use skilled delivery care services than their unmarried counterparts, holding other factors constant. This could be because married women can also benefit from husband's information set, ability to transport them to hospital when labour begins and support with financing the services. The probability of adequate antenatal care services use was lower in 2003, 2008 and 2014 than in 1998. Unobservable factors in these years reduced the likelihood of using adequate antenatal care services compared with 1998. Similarly for skilled delivery care services, unlike for 2014 which was associated with increased probability of using skilled delivery care services, 2003 and 2008 were associated with reduced probability of using skilled delivery care services compared with 1998.

On the instrumental variables, we find that the higher the percentage of women per cluster who started antenatal clinics before week 12 and the higher the average number of antenatal visits per cluster, the higher the probability of women using adequate antenatal care services. Similarly the higher the proportion of women using skilled delivery care services per cluster and the higher the average number of antenatal visits per cluster, the higher the probability of a woman using skilled delivery care services.

In this study, adequacy of antenatal care and skilled delivery care were treated as potentially endogenous. To test and control for potential endogeneity of these variables, we needed valid instrumental variables. Test on validity of the instrumental variables are presented in Table 3. The joint χ^2 statistic was high indicating that the instrumental variables strongly identify antenatal and skilled delivery care equations. The instrumental variables were also relevant because their joint effect on the potentially endogenous variables was significant. In this case, the number of instrumental variables was higher (three) than the number of endogenous variables (two). There was a need, therefore, to check that the extra instrument was not correlated with the error term in the structural model. The Sargan (score) and the Basmann test show that we do not reject the null hypothesis of exogeneity of the instrumental variables. Details of the test are presented in Table 4.

Table 4: Test of over identifying restrictions

Dependent variables	Neonatal mortality	Under-five mortality
Sargan (score) χ^2	2.20678 (p = 0.1374)	1.80733 (p = 0.1788)
Basmann χ^2	2.20598 (p = 0.1375)	1.80667 (p = 0.1789)

Childhood mortality models

Table 5 presents the results on the determinants of neonatal and under-five mortality (average marginal effects). The coefficients are presented in Appendix Table 2. Different columns show results for different versions of the model. The models labelled (a) present results for neonatal mortality while those labelled (b) present results for under-five mortality. Model 1 in both cases is the basic model, a probit model. In Model 2 we controlled for endogeneity of both skilled delivery care and adequate antenatal care. This is the 2SRI model. Model 3 presents the control function approach model where both endogeneity and unobserved heterogeneity were control for. Model 2 helps us test and control for endogeneity of adequacy of antenatal care services and skilled delivery care services. As discussed in the methodology, the reduced form models for adequacy of antenatal care services and skilled delivery care services are estimated as in Table 3 and generalized residuals obtained. The residuals are then included in the childhood mortality equation as in Table 4 Model 2. If the generalized residuals of antenatal and skilled delivery are significant then the two are endogenous and if not they are exogenous. In Model 2 we see that both skilled delivery care and adequate antenatal care residuals were not significant suggesting that both could be treated as exogenous.

Model 3 tests and controls for both endogeneity and unobserved heterogeneity simultaneously. In this model, besides generalized residuals of antenatal and skilled delivery care services, we include interaction terms (interaction of skilled delivery care and adequate antenatal care and their respective residuals) to control for unobserved heterogeneity. In Models 3(a) and 3(b) the skilled delivery care residual and the interaction term were significant. This suggests presence of both endogeneity and unobserved heterogeneity of skilled delivery care services. By including the residuals and the interaction terms, we were able to control both for endogeneity and unobserved heterogeneity and so the coefficients are free from bias. Model 3 is therefore the chosen model and interpretations are based on this model.

Results in Model 3 indicate that adequate use of antenatal care services was associated with reduced risk of neonatal and under-five mortality. Adequate use of antenatal care services reduced the likelihood of neonatal and under-five mortality by 2.4 and 4.2 percentage points respectively, holding other factors constant. During antenatal visits women are screened and monitored for any pregnancy complication or health conditions made worse by pregnancy. They are also educated on proper nutrition and are provided with appropriate supplements and injections such as the tetanus toxoid injections. All these are geared to ensuring that the child grows well and

is protected from infections once born. These findings confirm findings of other studies that associate number of antenatal visits and reduced neonatal mortality (Lambon-Quayefio and Owoo, 2010), use of antenatal care and reduced risk of infant mortality rate (Poma, 1999). The findings, however, contradict those of Beauclair et al (2014), who found that no significant effect of timing of antenatal care on still births.

Use of skilled delivery care was also associated with reduced risk of neonatal and under-five mortality. Once endogeneity and heterogeneity are controlled for, the coefficient of skilled delivery care which was initially not significant becomes significant. Skilled delivery care reduced risk of neonatal and under-five mortality by 1 and 1.8 percentage points respectively, holding other factors constant. When we compare the probit estimates and the control function approach estimates we see that the probit estimates are much lower than the control function approach estimates. Thus, failure to control for endogeneity of skilled delivery care and unobserved heterogeneity would have biased down the effect of skilled delivery care services on childhood mortality. The study, therefore, unveils presence of adverse and confidence selection in demand for skilled delivery care services. Skilled assistance during child birth helps ensure labour progresses well and that appropriate tests are performed to identify abnormalities and other issues that may place the mother and baby at risk (Graham et al, 2001). They detect complications such as foetal distress and, therefore, make appropriate interventions and referrals. Also skilled birth attendants ensure the delivery takes place in a hygienic environment that prevents infection of both the mother and the baby. Findings in this study contradict those of Lambon-Quayefio and Owoo (2010) and Nathan and Mwanyangala (2012) who found no association between skilled delivery care/delivery in a health facility and risk of neonatal mortality in Ghana and southern Tanzania respectively. Singh et al (2014) found that in Africa, use of skilled birth attendants was associated with higher risk of neonatal mortality. These differences in findings could be because these studies do not control for endogeneity of skilled delivery care and for unobserved heterogeneity.

The results further showed that tertiary education was not significantly associated with reduced risk of neonatal mortality although it was associated with reduced risk of under-five mortality. Tertiary education was associated with 2.5 percentage point reduction in risk of under-five mortality compared to no formal education, holding other factors constant. Education allows women to access employment which empowers and enables them to afford prompt health care when needed, a hygienic and safe environment to raise the children, access to information and knowledge. All these contribute to healthier babies and hence lower mortality. These findings are in line with those of Kabubo-Mariara et al, 2012) who found that in Kenya, children born of mothers with some level of education have a higher chance of surviving than those whose mothers have no education. Also in line with this study Lambon-Quayefio and Owoo (2010) found higher education to have no significant effect on neonatal deaths in Ghana compared to having no education. The results also show that the risk of under-five mortality is lower among children from married women than unmarried women, holding all other factors constant.

The risk of neonatal and under-five mortality reduced with age. However, the quadratic term suggests that the risk is higher for much older women, holding other

factors constant. This may be because older women have been found to have a higher chance of suffering from complications related to pregnancy than younger women (Jolly et al, 2000). Similarly, Kabubo-Mariara et al, 2012) reported that mother's age reduced the risk of child mortality although there is a higher risk for children born of elderly women in Kenya.

Being a male child increased risk of neonatal and under-five mortality, holding other factors constant. Being a male child increased the likelihood of dying in the neonatal period and before age five by 0.6 and one percentage points respectively compared to being a female child, holding other factors constant. Literature suggests that there are biological and genetic differences between boys and girls and that boys are biologically weaker and so more likely to die prematurely (Naeye et al, 1971). Similarly, several pre-conception environment related factors affect the chances of a baby being male of female and these factors could also explain why boys are more likely to die than girls (Pongou et al, 2006). The risk of under-five mortality was higher in 2003, but was lower in 2008 and 2014 than in 1998. The risk of neonatal mortality was also lower in 2014 than in 1998.

Table 5: Parameter estimates of childhood mortality (average marginal effect), Z in bracket

Variables	Neonatal mortality			Under-five mortality		
	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)
Adequate antenatal care	-0.012	-0.012	-0.024	-0.019	-0.02	-0.042
	[-5.051]	[-4.934]	[-2.545]	[-5.802]	[-5.976]	[-3.144]
Skilled delivery care	0.003	0.003	-0.01	-0.001	-0.002	-0.018
	[1.635]	[1.383]	[-2.615]	[-0.492]	[-0.902]	[-3.247]
Age	-0.003	-0.003	-0.003	-0.004	-0.004	-0.004
	[-3.578]	[-3.540]	[-3.518]	[-2.900]	[-2.675]	[-2.668]
Age squared	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	[4.094]	[4.062]	[4.036]	[3.480]	[3.273]	[3.262]
Education level (Base—No education)						
Primary education	-0.002	-0.003	-0.004	0.006	0.002	0
	[-0.939]	[-1.021]	[-1.666]	[2.042]	[0.625]	[0.026]
Secondary education	-0.007	-0.008	-0.008	-0.007	-0.014	-0.014
	[-2.485]	[-2.131]	[-2.055]	[-1.577]	[-2.510]	[-2.461]
Tertiary education	-0.003	-0.004	0.0001	-0.016	-0.027	-0.022
	[-0.640]	[-0.722]	[0.002]	[-2.375]	[-3.179]	[-2.516]
Male child	0.006	0.006	0.006	0.01	0.01	0.01
	[3.641]	[3.599]	[3.656]	[4.178]	[4.118]	[4.141]
Marital status (Base—Not married)						
Married	-0.0001	-0.0001	0.0001	-0.008	-0.008	-0.007
	[0.014]	[0.009]	[0.110]	[-2.373]	[-2.390]	[-2.292]
Rural residence	-0.002	-0.002	-0.003	-0.005	-0.002	-0.003
	[-1.204]	[-0.807]	[-1.223]	[-1.838]	[-0.584]	[-0.974]
Year of survey (Base—1998)						
1 if year 2003	0.004	0.004	0.004	0.007	0.011	0.011
	[1.125]	[1.117]	[1.240]	[1.627]	[2.298]	[2.412]
1 if year 2008/2009	-0.0001	-0.0001	-0.0001	-0.011	-0.008	-0.008
	[-0.143]	[-0.091]	[-0.039]	[-2.502]	[-1.746]	[-1.703]
1 if year 2014	-0.008	-0.008	-0.007	-0.03	-0.029	-0.027
	[-2.928]	[-2.847]	[-2.433]	[-7.727]	[-7.148]	[-6.738]
Adequate antenatal care residual		0	-0.001		-0.008	-0.011
		[0.003]	[-0.388]		[-1.565]	[-2.023]
Adequate skilled delivery care residuals		-0.001	-0.007		-0.005	-0.012
		[-0.461]	[-2.122]		[-1.310]	[-2.587]
Interaction of adequate antenatal care and residual			0.009			0.017

			[1.362]			[1.744]
Interaction of skilled delivery care and residual			0.015			0.019
			[3.766]			[3.199]
Observations	35,312	35,312	35,312	36,373	36,373	36,373

5. Conclusion and policy recommendation

This study sought to estimate the effect of antenatal care services and skilled delivery care services on the risk of neonatal and under-five mortality in Kenya using data drawn from the 1998, 2003, 2008/2009 and 2014 KDHS. The study findings indicate that adequate use of antenatal care services and skilled delivery care services were associated with reduced risk of neonatal and under-five mortality. The study demonstrated the importance of controlling for endogeneity of antenatal care and skilled delivery care and also for controlling for unobserved heterogeneity.

These findings imply that one way to accelerate reduction in neonatal and under-five mortality is to ensure as many women as possible seek adequate antenatal care services and have access to skilled delivery care services. Adequate antenatal care services as measured here involve women making at least four antenatal visits and the first visit occurring before the fourth month of pregnancy. Emphasis should be put on adequate antenatal care services and not just use of antenatal care services. Statistics show that while many women use antenatal care services, few use adequate antenatal care services. Education increases the likelihood of women using these services. The government should therefore promote women's education, especially at higher levels. This could be through provision of bursaries for girls, promotion of sanitary facilities in schools, provision of low-cost boarding facilities for girls among others. Rural women were less likely to use adequate antenatal care services and skilled delivery care services. Mechanisms to promote use of these services in rural areas should be promoted. Awiti (2014) found that longer distances to health care facilities are a constraint to using adequate antenatal care services in Kenya. One way, therefore, is to reduce distances to health facilities in rural areas by, for example, constructing more health facilities and improving transport infrastructure. The Beyond Zero campaign that seeks to bring healthcare services as close to women as possible is a good initiative towards reducing average distances to health facilities and thus increasing use of maternal health services.

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Appendixes

Appendix Table 1: Reduced-form parameter estimates (coefficients), Z statistic in bracket

Variables	Adequate antenatal care (= 1 if had adequate antenatal care)	Skilled delivery care (= 1 if had skilled delivery care)
Age	-0.03[-3.255]	-0.043[-4.938]
Age squared	0.001[3.395]	0.001[3.497]
Education level (Base—No education)		
Primary education	0.15[6.570]	0.372[17.736]
Secondary education	0.382[14.103]	0.98[37.482]
Tertiary education	0.803[21.483]	1.695[31.880]
Male child	-0.01[-0.660]	0.069[4.600]
Marital status (Base—Not married)		
Married	0.024[1.082]	0.074[3.496]
Rural residence	-0.098[-5.250]	-0.331[-18.025]
Year of survey (Base—1998)		
1 if year 2003	-0.401[-12.881]	-0.231[-7.958]
1 if year 2008/2009	-0.32[-10.415]	-0.114[-3.946]
1 if year 2014	-0.169[-6.499]	0.08[3.151]
Instrumental variables		
Proportion of women by cluster who sought skilled delivery care	-0.351[-8.413]	2.479[57.903]
Average number of antenatal visits by cluster	0.116[8.230]	0.021[1.510]
Proportion of women by cluster who started antenatal clinics before 4 months	2.561[30.527]	-0.424[-4.983]
Constant	-1.263[-8.836]	-0.709[-5.186]
Observations	36,523	36,373