Determinants of Regional Differences in Infant and Child Mortality:

Micro-evidence from Uganda

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Abstract:

We use negative binomial analysis to examine the factors that explain the regional diversity in infant and child mortality in Uganda using data drawn from the Uganda Demographic and Health Survey 2006. Our results show that individual, household and community socio-economic differences in the four regions explain the differences in regional mortality rates. This suggests that efforts to reduce child mortality need to target measures that promote female education, delayed marriages, provision of clean water and sanitation facilities, and access to maternal health services in the most deprived regions need to be embraced by all stakeholders to promote child health.

Key words: Infant and child mortality, regions, Uganda, binomial model

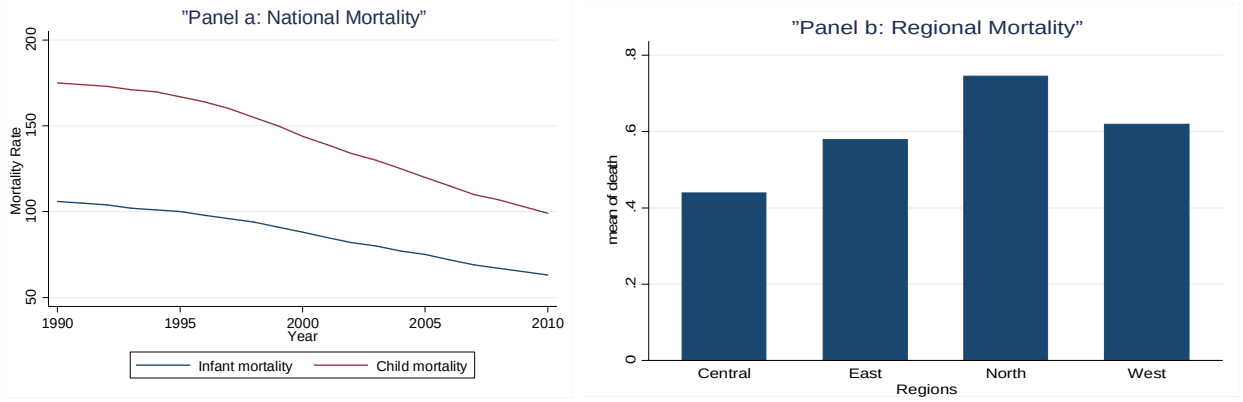
1. Background and study concerns

In Uganda, like other developing countries, child health is a central issue on the public policy agenda because the rate of infant and child mortality is an important indicator of any country's socioeconomic welfare. In principle, a decline in mortality should be a natural consequence of development, provided that the income effect is not offset by changes in the relative price of reducing mortality. On the other hand, if economic growth is to be sustainable an economy's human resources must be continually renewed with more healthy and skilled individuals. Thus a healthy new generation is a necessary condition for the continuance of growth-generating forces, and child health and infant mortality therefore play a crucial role in development. In comparisons of groups within a society, as well as comparisons among societies, a high mortality rate is considered an indicator of deprivation (Cramer, 1987). Even as infant and child mortality in general has shown substantial declines over time, differences in mortality across different groups and regions persist in many developing countries and are still a concern in less developed countries like Uganda. The reduction of infant and child death rates is one of the eight

Millennium Development Goals (MDGs)[1]. Infant mortality is defined as death during the first year of life and child mortality[2] as that between the first and fifth birth day (WHO, 1980).

Several policies geared to improving child health have been implemented over the years in most developing countries, with varying degrees of success (UNDP, 2002; Marmot, 2005; Fayissa, 2001; Hanmer et al., 2003; Ssewanyana et al., 2004). Despite this drastic decline in mortality rates, Uganda's infant and child mortality rates are still quite high in comparison to other countries, and within Uganda there is a significant disparity of mortality rates across regions in the country (Figure 1). Huge challenges still remain given the poor health indicators, for example 55 years of life expectancy are among the lowest in the world. Panel a below presents the trend in Uganda's infant and child mortality over the last three decades, while panel b highlight the existing mortality difference in the four regions. From Figure 1 little can be appreciated from the country's efforts to build a healthy labour force for future business and social development given the diverging regional mortality rates (UDHS, 2006).

Figure 1: National and Regional infant and child mortality in Uganda (1980-2011)



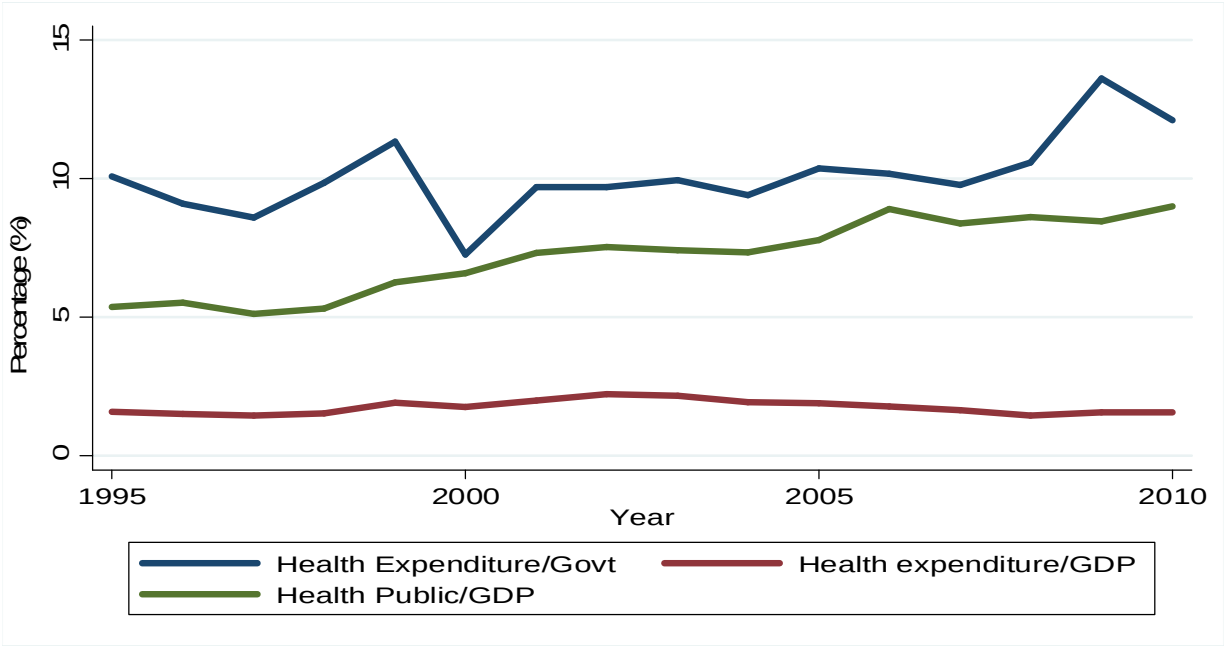
Basically, efforts to reduce infant mortality requires a range of investments that include increased health sector spending, improving health systems functioning, and "through socio-economic progress to improve nutrition, housing, hygiene, education, gender equality, and human rights" (UNICEF, 2008). However, which investment to make, given resource constraints is not clear as the health budget allocations in the country are more lacking with limited expenditure on health (Figure 2). Not only is it not clear which interventions to prioritise, but also whom or where to target the interventions. Government financial statistics obtained from the International Monetary Fund (IMF, 2010) show that the Ugandan health sector has been marginalized in terms of government budgetary allocation despite its importance in the economy (IMF, 2010). Government budget share and even as a share of GDP has not shown any remarkable increase over the last two decades, which casts doubt on government commitment to realise the MDGs by

[1] MDGs are drawn from the actions and targets contained in the Millennium Declaration which was adopted by 189 nations and signed by 147 heads of state and governments during the UN Millennium Summit (2000).

[2] Child mortality, also known as under-5 mortality rate is the number of children who die by the age of five, per thousand live births per year.

2015 (Figure 2). This might partly explain the poor health status in the different regions of the country relative to the growth of the economy.

Figure 2: Government Health expenditure share and Health expenditure GDP proportions



Source: IMF (2010)

This paper assesses the relative contributions of socio-economic and demographic factors to the explanations of infant and child mortality differentials between the four regions (central, western, northern and western) of Uganda. It addresses the following specific issues: to what extent is there variation in infant and child mortality between regions? And, if there are indeed differences, to what should these differences be attributed to? And together with these questions the study identifies the factors that are primary important determinants of regional infant and child mortality in Uganda. Investigating the distribution and determinants of adverse health outcomes, therefore, can usefully inform more focused and cost effective interventions. In particular, the targeting of high risk health regions can inform policy planning.

The question is whether regional variations in infant and child mortality reflect differences in socio-economic and demographic characteristics? The role of demographic and socio-economic characteristics in contributing to regional differences in infant mortality has been alluded to in the literature (Marmot, 2005; Hill et al., 2001). However, the relative effects of socio-economic and demographic factors on infant and child mortality at regional level in Uganda has not been thoroughly probed. This is an important question for policy makers. If regional differences in infant and child mortality can be attributed to demographic and socio-economic characteristics at regional level, rather than national level, then mortality reduction programs can be targeted to compensate for the differences between regions in traits such as education, health services, and clean water supply among others. The identification, targeting and quantification of factors contributing to regional level mortality can contribute to more focused public health

interventions in Uganda as the government runs a decentralized local government system (BOU, 2008), as many other developing countries confronted with similar problems.

The factors that influence the differences in regional mortality rates in Uganda are investigated by employing count data models, using microeconomic survey data drawn from the UDHS (2006). This paper makes a primary contribution in the health domain in Uganda by developing a more integrated argument for the determinants of infant and child mortality at regional level. The paper also makes a contribution by using count data modeling to determine mortality differences at the regional level thus extending the conclusions advanced by earlier studies in Uganda (UNDP, 2002; Ntozi & Nakanaabi, 1997; Ssewanyana et al., 2004; Bbaale & Buyinza, 2010; Rutaremwa, 1999) to interface with service delivery and other indicators. Finally, the paper contributes to the public sector domain by suggesting the delivery of basic services that influence child outcomes and deprivation. In this context, identification of possible socioeconomic factors behind the infant and child mortality might shed some light on the differences in the mortality rates[3] between the different regions in Uganda, and might help explain why infant and child mortality has fallen faster in some regions than others.

The paper begins with a review of earlier studies in Section 2 that have attempted to relate social-economic and demographic factors to infant and child mortality. Section 3 presents an appropriate modeling approach to study the factors that influence regional difference of child mortality in Uganda. Section 4 provides a description of the data and discussion of model estimation results. Finally, Section 5 presents a summary and the concluding remarks.

2. Reviewed literature

There are many factors that influence health outcomes in developing countries (Marmot, 2005; Fayissa, 2001; Hanmer et al., 2003). A series of studies have identified the availability and use of health care and medical attendance at birth, mother's education, proximal and overall availability of doctors, nurses, hospitals, and health centers as key determinants of children health outcomes (Kovsted et al., 2003; Caldwell, 1979; Sahn & Stifle, 2003; Muntago, 2004; Mturi & Curtis, 1995; Ezra & Gurum, 2002; Wang, 2003; Kumar & Gemechis, 2010; Hojman, 1996; Kombo & Ginneken, 2009, Bbaale and Buyinza, 2010). Social factors such as ethnicity, rural and urban distribution, poverty, and female fertility have also been found to be predictive of child survival in developing countries (Marmot, 2005). Hill et al. (2001) reveal that urban areas are associated with low mortality rates because of better social services than rural areas. The author concludes that the source of drinking water and sanitation facilities are highly correlated with the reduction of infant deaths. Baker (1999) indicates that educational variations between regions in Malawi contribute to regional variation of infant and child mortality. However, other studies have identified that urban areas are associated with higher risk of infant and child mortality than rural areas (Mustafa & Odimegwu, 2008). Also it is noted that birth related mortality is not distributed equitably and is much higher in rural and indigenous populations for the case of China (Xing et al., 2008).

[3] This is a key indicator of the differences in child health outcomes and future human resource quality for welfare of the country.

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Poverty has been widely studied as a factor that influence health care utilization and health outcomes and has been found to be influential on the ability to seek medical care which affects overall child survival (Howe et al., 2008; Xing et al., 2008). The importance of education cannot be underscored in promoting child survival because a number of authors have found a correlation between overall female educational attainment and maternal and infant mortality (Krishna, 2006; Sen, 2003; Xing et al., 2008). Female education is taken to be a measure of socio-economic status that influence better health seeking behavior, illness management and hence better health outcomes for the family. Female education shapes and modifies the traditional familial relationships regarding the awareness of how to care for children before and after birth (Caldwell, 1979; Sahn & Stifle, 2003; Muntago, 2004; Mturi & Curtis, 1995; Ezra & Gurum, 2002; Wang, 2003; Kumar & Gemechis, 2010; Kombo & Ginneken, 2009). The authors also reveal that education plays an important role to improve knowledge of medical and health care, particularly mother's education enhance more effective preventative and health care practices, which increase the mother's productivity and subsequently influence infant and child mortality. WHO (2007) notes that child mortality whose mothers have no schooling is 121% higher than those whose mothers have at least a secondary education. In addition, Muntago (2004) notes that maternal age, maternal education and gender of the child had no significant association with child mortality. Mondal et al. (2009) found that the most significant predictors of neonatal, postneonatal, and child mortality levels are mother's age at birth along with child immunization, breastfeeding, and birth interval.

In the case of Uganda[4], previous authors (UNDP, 2002; Ntozi & Nakanaabi, 1997) linked the variations in infant mortality to the HIV/AIDS epidemic. Their analysis was at a national level. In Uganda the geographic distribution of health problems such as mortality is also not uniformly distributed and aggregate poverty and health statistics often do not describe the variations in mortality experienced within regions in the country (UBOS, 2010). The differential mortality rate is also reflected in unequal socio-economic status (SES) and access to services and facilities that vary widely across the four regions[5] (USD, 2009). Ssewanyana et al. (2004) investigate the determinants of infant mortality rates in Uganda using UDHS (2001); they find that household income, mothers' education and child vaccination have a significant effect in reducing infant mortality in Uganda. In a more recent study (Bbaale and Buyinza, 2010), the authors examine the causes of neonatal, post-neonatal and child mortality using the UDHS (2006). Their main conclusion was drawn on a national basis that mothers' education and child vaccination have a significant effect in reducing neonatal, postnatal child mortality in Uganda. The current study extends the analysis of the cause of mortality in Uganda by focusing on the determinants of regional differences in infant and child mortality in Uganda. Also, our study employs a more relevant econometric analysis of count data. However, no single study that has studied the factors

[4] UBOS (2005) notes that mortality rates vary significantly between geographic locations, as well as across within regions in Uganda. Also, according to the UDHS (2006), the incidence of infant mortality differs widely across race groups and regions.

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[5] For analytical purposes, the country was divided into four regions, Central, Eastern, Northern and Western region.

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behind regional variations in infant and child mortality in Uganda to provide policy guidance in line with decentralisation government programmes of service provision. Thus, this study is intended to fill this gap and contribute real value added in the field of health research.

3. Theoretical background, empirical model and data

This section explains in detail the modeling techniques used to investigate the factors that influence regional differences in infant and child mortality in the four regions of Uganda.

3.1 Theoretical Background

Differences in socio-economic and demographic characteristics are the main cause of observed differences in mortality between regions (Marmot, 2005; Hill et al., 2001). The hypothesis of this paper is that mortality differentials merely reflect socio-economic and demographic differences between the different regions in the country. The basic assumption is that irrespective of regional background, people who possess the same socio-economic and demographic characteristics should have similar mortality experiences. Regional differences in mortality are seen as resulting solely from socio-economic and demographic differences in levels of education attainment, employment earnings, and availability of social services like clean water, affordable medical care among others (Panis & Lillard, 1995; Xing, 2008). Therefore, once differences in the pertinent social, demographic, familial, and economic characteristics are eliminated through statistical controls, mortality variations among regions should disappear (Mott & Haurin, 1985; Mare, 1990; Rogers, 1992).

3.2 The model and estimation strategy

In analyzing geographical diversity of infant and child mortality in Uganda, we can model the death of children as a non-negative count event with a skewed distribution. Distribution of such data violates fundamental assumptions of many commonly used multivariate statistical technique (OLS regression), leading to biased results (Hammer & Landu, 1981). Statistical techniques in form of Poisson and Negative Binomial Models have been developed to deal with this type of data (Cameron & Trivedi, 1998). The Poisson distribution was first published by Simeon Denis Poisson in 1938.

We begin by defining the model employed in this study, where counts of the number of deaths of children in a region are obtained at a single point in time. Let Y_i, n_i, and $r_i = Y_i/n_i$ respectively represent the number of deaths, sample size, and observed mortality rate for the i^{th} woman $(i = 1, 2, 3, ..., \cdots n)$ in region j $(j = 1, .., 4)$. It is assumed that the number of children, who died, Y_i is independently distributed as Poisson variates, with the expected number of deaths in each region given by $E(Y_{i,j}) = \mu_{i,j}$. Suppressing subscript j, the probability density function of the Poisson random variable, Y_i representing the number of children who die in Uganda before their first birth day (infant mortality) and fifth birth day (child mortality) for the i^{th} woman in region j can be characterized by:

$$\Pr(Y = y_i; \mu_i) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!}, \quad for \quad y_i = 0, \quad 1, \quad 2, \quad \ldots j = 1, .., 4 \qquad (1)$$

From Equation 1, $\Pr(Y = y)$ is the probability of a child born alive who died for any given mother in region j, and μ_i is the expected number of deaths of children which can be modeled as:

$$\mu_i = n_i \lambda(X_i'\beta) \tag{2}$$

From Equation 2, X_i is the vector of predictor variables that describes each region such as household head gender, mother's and the partner's education attainment, desired children by mother and partner, marital status, forms of medical facilities, distance to medical centers, health decision making, access to maternal health care through antenatal and tetanus immunisation, and work activities outside the home, religion among others, β is a vector of estimable coefficients, and $\lambda(X_i\beta)$ is the underlying rate function which is estimated by r_i. This multiplicative model can be expressed as a generalised linear model (GLM), which relates the expected value of the outcome value to the predictor variables via a link function. For the Poisson distribution the log link function is specified as follows:

$$\ln \mu_i = \ln(n_i) + (X_i'\beta) \tag{3}$$

From Equation 3, X_i is a vector of explanatory variables; and β is a vector of estimable coefficients. The Poisson regression, as defined in (1) and (3), is estimable by standard maximum likelihood methods with the likelihood function defined as:

$$L(\beta \mid y_i, X_i) = \prod_{i=1}^{N} \Pr(y_i \mid \mu_i) = \prod_{i=1}^{N} \frac{\exp(-\mu_i)\mu_i^{y_i}}{y_i!} \tag{4}$$

From Equation 4, we express the mean as $\mu_i = E(y_i \mid X_i) = \exp(X_i'\beta_i)$. The Poisson regression is inappropriate if the mean and variance of the distribution is not approximately equal[6]. This problem leads to an overdispersion. Failure to take overdispersion into account leads to serious underestimation of standard errors and misleading inference for the regression results and the solution is to apply the negative binomial model. The negative binomial model is derived from the Poisson model by adding an independently distributed error term ε_i to Equation 3, which yields the following negative binomial model:

$$\ln \mu_i = \ln(n_i) + (X_i'\beta) + \varepsilon_i \tag{5}$$

From Equation 5, $\exp(\varepsilon_i)$ is a gamma-distributed error term with mean one and variance α[7]. Thus, the resulting binomial distribution function can be written as:

[6] This means that the standard errors, usually estimated by the maximum Likelihood method, will be biased and the test statistics derived from the model will be incorrect.

[7] $\exp(\varepsilon_i) \sim (1, \alpha)$

$$\Pr(Y = y_i \mid \mu, \alpha) = \frac{\Gamma(y + \alpha^{-1})}{y_i!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}}\left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{y_i} \quad (6)$$

From Equation 6, the negative binomial has two parameters μ and α, where μ the expected value of the distribution and α is the overdispersion parameter[8]. Therefore, the emerging maximum likelihood function for the negative binomial model is given as:

$$L(\beta \mid y, X_i) = \prod_{i=1}^{N} \Pr(y_i \mid X_i) = \prod_{i=1}^{N} \frac{\Gamma(y + \alpha^{-1})}{y_i!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i}\right)^{\alpha^{-1}}\left(\frac{\mu_i}{\alpha^{-1} + \mu_i}\right)^{y_i} \quad (7)$$

The foregoing formulation results in a negative binomial that allows the mean to differ from the variance. From Equation 7, the expected value of Y is given as $E(y_i \mid X_i) = \exp(X_i\beta) = \mu_i$. Equation 7 indicates that the variance of the gamma-distributed error term (α) is a measure of dispersion and is estimable by standard maximum likelihood techniques. The appropriateness of the negative binomial relative to the Poisson model is determined by the statistical significance of the estimated coefficient α. If α is not significantly different from zero as measured by the test-statistics, the negative binomial model simply reduces to a Poisson regression with $\text{var}(y_i) = E(y_i)$. If α is significantly different from zero, the negative binomial is the correct choice and the Poisson model is inappropriate.

3.3 Data

In an attempt to find out the determinants of regional difference in infant and child mortality in Uganda, the study is based on the data drawn from the Uganda Demographic and Health Survey (UDHS, 2006). The UDHS considered 8531 Ugandan women of a reproductive age (15-49) and who at least had born one child by the time of the survey. The objectives of collecting this data are to analyze and monitor the population and health situation in Uganda and the UDHS contain information on fertility, mortality, health issues, socioeconomic and environmental situations. The UDHS contains information that is important in analyzing the regional diversity in infant and child morality in Uganda.

More importantly, UDHS (2006) data entail the background of the household, children ever born, child mortality and survival, region of residence, household head gender, mother's and the partner's education attainment, desired children by mother and partner, marital status, forms of medical facilities, distance to medical centers, health decision making, access to maternal health care through antenatal and tetanus immunisation, and work activities outside the home, religion among others. In addition, the survey collected extensive information regarding women' actual age, age at first birth, fertility preferences, and maternal and a detailed reproductive history which included a record of each conception, duration of breast feeding and amenorrhoea from nationally representative sample. Household-level data include type of toilet facility and source of water. The study draws on child death histories for the women in the reproductive ages from

[8] When $\alpha = 0$, the negative binomial distribution is the same as a Poisson distribution.

UDHS (2006) to analyse the factors that explain the regional diversity of infant and child mortality in Uganda.

4. Study findings

4.1. Descriptive evidence

Data on some of the background characteristics of the study sample[9] are presented in Tables 1 and 2. Results in Table 1 indicate that the central region has the highest urban population (42%), followed by the western (8%), eastern and northern region with 7% respectively. The regional variations in urban population implies that there is high contraceptive use in the central (62%), followed by the eastern (47%), western (43%) and northern lags with 22%. In addition, the central region has the highest proportion of women with secondary and postsecondary educations (33% and 9%), the eastern and western regions with highest proportion of primary education (64%). Overall, the worst educational indicators are observed in Northern region with only 1% postsecondary education level. We also observe a significant difference in child deaths among women with different education levels (Table 2), northern (51%) for women with no education, followed by western (21%), eastern (16%) and central (12%).

Furthermore, Table 1 shows that across the four regions, the eastern (70%) had the highest proportion of married women while the central (52%) had least proportion of currently married women. More child mortality by region is the northern (40%), followed by the eastern (23%), western (21%), and central (16%). The expectation is that women who are currently married have low support from their partner and are in a poor position to look after their children well in contrast to their unmarried counterparts who experience lower child mortality. More child survival by region is central (18.3%), followed by eastern (16.6%), northern (12.5%) and western (17.4%).

In addition, Table 1 indicates that 70% of women in the central region are employed all year followed by women in the western region (55%), eastern (39%) and northern (24). Seasonal employment is more pronounced in the north (64%) followed by the east (55%), whereas occasional employment is lowest in the central (8%). The analysis of first age birth indicates that a large proportion of women 64%, 70%, 60% and 67% in the central, east, north and west respectively had their first birth when they were 16-20 years of age. Overall, 18% of women in the central below the age of 16 year produced their first born when they were below 16 year. By religion, the Christian women dominated by 45%, 54% and 53% in the central, eastern and western respectively, while women of the Catholic faith dominated in the northern (65%).

Table 1: Background characteristics of Mothers aged 15-49 by regions in Uganda (2006)

Factors/Variables	Covariates	Central	East	North	West	National
Family welfare:	Poor	19	41	79	28	39
	None poor	12	20	9	33	18
	Rich	79	39	12	39	43
Mother's education:	No education	8	14	37	22	21
	Primary	50	64	56	64	58

[9] Women of a reproductive age (15-49).

	Secondary	33	19	6	12	18
	Postsecondary	9	3	1	2	4
Contractive Methods:	Used	62	47	22	43	43
	No	38	53	78	57	57
Employment status:	All year	70	39	24	55	46
	Seasonal	22	55	64	35	45
	Occasional	8	6	12	10	9
Source of water:	Piped water	35	5	7	16	16
	Boreholes	14	53	55	14	34
	Covered wells	19	23	13	25	20
	Uncovered wells	32	19	25	45	30
Age of first birth:	>26 years	3	2	4	2	39
	21-25 years	15	11	22	16	16
	16-20 years	64	70	60	67	65
	<15 years	17	18	15	16	17
Marital status:	Married	52	70	69	61	65
	never	32	21	19	25	24
	Widowed	16	9	12	14	13
Religion:	Muslim	18	16	6	4	11
	Christian	45	54	21	53	44
	Catholic	37	29	65	43	45
Infant size:	Small	4	7	6	7	6
	Medium	20	31	31	25	27
	Large	76	60	63	68	67
Place of birth:	Home	56	60	63	68	62
	Public	36	31	31	25	31
	Private	6	9	6	7	7
Toilet facilities:	Flash	17	3	2	2	6
	Covered	67	61	53	80	65
	Uncovered	15	21	12	14	15
	Bush/No Toilet	1	15	33	4	14
Breast feeding:	Current	24	37	41	32	33
	No	76	63	59	68	67
Antenatal care:	Given	50	36	36	42	41
	No	50	64	64	58	59
Residence:	Urban	42	7	7	8	17
	Rural	58	93	93	92	83

Source: Author's computations from the UDHS (2006)

Analysing the access to health facilities indicates that more women and children were delivered at home. It was also shown that women who delivered at home a bigger proportion was in the west (68%), followed by north (63%), east (60%) and central (56%). Overall, about 31% and 7% of women delivered in public and private hospitals respectively in the country. In terms of antenatal care services, a large proportion of women in the north and east (64%), followed by west (58%) and central (50%) did not get antenatal care. As results in Table 1 indicate, 50%, 63%, 59% and 58% of women in the central, east, north and west respectively, breast fed the children.

Results in Table 1 also show that better sanitation was most lacking in the north (33%) of women had no toilet facilities. Poor source of water and type of toilet facility are correlated with high mortality rates (Table 2), with the north having the highest deaths (45%), east (34%), west (28%) and central (18%). This result accentuates the importance of these facilities for child survival. In addition, they show variations in the level of regional development, since we expect more developed regions to have higher levels of infrastructure use. Table 1 indicates that children born from households where piped water and flush toilet facility are available enjoy a higher standard of living, and child survival among children in these households is higher across all regions compared to their counterparts[10].

Descriptive results show that there are differentials in child mortality in the four regions of Uganda, namely between poor, near-poor and rich (Table 2). The proportion of infant and child deaths among women from families of poor background is high across all regions, namely central (15%), east (18%) north (54%) and west (13%) compared to mortality for women from high income groups with central (5%), east (29%), north (35%) and west (17%).

From Table 2, significant differentials in the numbers of child death were also observed among women with various potential risk factors, namely absence of contraception, short birth intervals, young maternal age at first birth, divorced women, religion, women who gave birth at home and absence of antenatal care. It was also shown that women with large infants had a bigger proportion of child death in the north (37%), followed by east (22%), west (21%) and central (20%). Meanwhile, the proportion of child deaths in urban and rural areas in the different regions was quite alarming almost with a bigger proportion of child death in the north (38%), followed by the east and west (22%) and central (13%).

Among the personal and biological characteristics, there are clear differences in mortality rates according to birth weight[11] and multiple deliveries. As expected, low birth weight is associated with highest child mortality in the northern region (39%), followed by the eastern (29%) and lastly the central (5%). Mortality rates also vary with multiple deliveries in line with other findings in the literature, infant mortality is highest for children with multiple deliveries, while it is lowest for children with single birth.

Table 2: Number of child death by determinant factors in Uganda by regions (2006)

Variables	Covariates	Central	East	North	West	National
Family welfare:	Poor	102	123	371	86	687
	None poor	122	124	49	143	432
	Rich	58	22	11	18	109
Mother's education:	No education	56	75	237	96	464

[10] Esrey and Habicht (1986), note that improvements in the quality of drinking water and provision of disposal of human waste greatly benefit child survival.

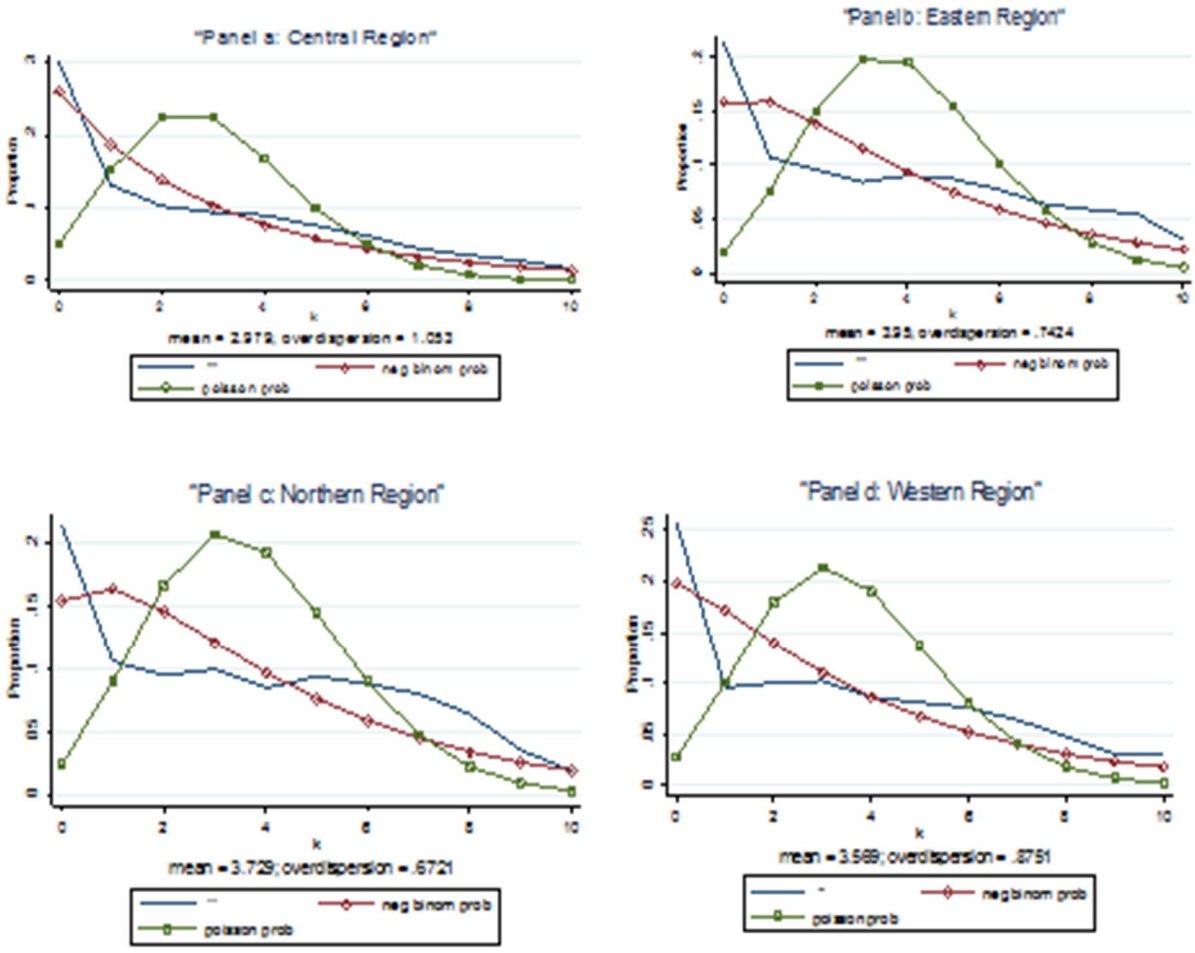
[11] The proxy for premature delivery.

	Primary	138	164	192	147	641
	Secondary	22	13	7	4	46
	Postsecondary	4	1	-	-	5
	All year	126	122	92	140	480
Employment status:	Seasonal	60	121	289	82	552
	Occasional	11	5	289	5	64
Contractive	Used	141	116	83	109	449
Method:	No	79	137	353	138	707
Age of first birth:	>26 years	2	3	18	2	25
	21-25 years	17	21	82	30	150
	16-20 years	133	165	240	152	690
	<15 years	68	64	96	93	291
Marital status:	Married	149	205	367	192	913
	never	2	-	1	3	6
	Widowed	69	48	68	52	237
Religion:	Muslim	32	36	30	13	111
	Christian	104	136	115	125	480
	Catholic	84	81	291	109	565
Infant size:	Small	23	31	39	32	125
	Medium	61	75	146	71	353
	Large	136	147	251	144	678
Place of birth:	Home	136	147	251	144	678
	Public	61	75	146	71	353
	Private	23	31	39	32	125
Birth weight	LBw	20	108	145	96	369
	Normal	4	15	27	18	64
Antenatal care:	Given	88	81	129	80	378
	No	132	172	307	167	778
Multiple birth:	Twins	45	34	38	29	146
	Single	21	25	33	18	97
Residence:	Urban	-	-	2	1	3
	Rural	193	244	413	239	1089

Source: Author's computations from the UDHS (2006)

Figure 2 graphs observed proportions of child mortality for a given woman along with the Poisson and negative binomial probabilities in the four regions. The Poisson probabilities are computed using an estimate of the Poisson mean. On the other hand, the negative binomial probabilities use the same mean and an estimate of the over dispersion parameter indicates that about 22% of children dies in the central region, 18% in the east, 21% in the north and 23% in the western region. However, the observed proportion plot indicates that about 10%, 6% and 3% of children die in the east, north and west respectively. The negative binomial plot in Figure 3 reveals that child mortality is about 5%.

Figure 2: Observed proportion, Poisson and Negative binomial probabilities



4.2 Empirical evidence

Tables 4 and 5 present the estimations of the negative binomial models in the four regions. The estimates are broadly in line with the expectations, as an extremely large goodness of fit statistic (χ^2=124) indicates that the Poisson mode is not appropriate and that it is advisable to estimate the negative binomial model. The empirical estimations report the Incidence Rate Ratios (IRR) along with the associated p-values.

4.2.1 Determinants of infant mortality

Results for all the models show that estimated effects of female education levels (primary, secondary and postsecondary) compared to no education were significant at conventional levels. Holding all the other variables constant, infant mortality is expected to be lower by 0.29, 0.52 and 0.64 units for women with postsecondary in the central, secondary in the east and postsecondary in the west respectively. The results reveal that women who gave their first birth at the age of 21-26 years, compared to women who first gave birth when they are less than 16 years, decreases the relative risk of infant mortality by 0.67, 0.55, 0.72 and 0.65 units in the central, east, north and western region respectively, other factors held constant. This implies that

there is need for government and other stakeholders to advocate for late child birth. In addition, holding other factors constant, the estimated effects of women's wealth status (near-poor and poor) compared to rich women increases the expected infant mortality by 1.04, 01 and 1.29 in the eastern region, 1.35 and 1.45 units in the north and west respectively among poor women.

Table 4: Negative Binomial estimates for the determinants of infant mortality rates in Uganda by regions (IRR)

Variable	**Central IRR**	**Eastern IRR**	**Northern IRR**	**Western IRR**
Mother's education:				
No education (RC)	-	-	-	-
Primary	0.903 (0.552)	0.873(0.341)	0.859(0.138)	0 .716***(0.004)
Secondary	0.716 (0.113)	0.524*** (0.007)	0.843(0.507)	0.638*(0.071)
Post-secondary	0.292*** (0.004)	0.658 (0.363)	0.499 (0.335)	0.221** (0.038)
Wealth index: Rich (RC)	-	-	-	-
Near- Poor	0.934 (0.749)	0.309* (0.069)	0.840 (0.343)	1.206 (0.148)
Poor	1.043** (0.024)	1.286* (0.091)	0.813* (0.056)	1.160** (0.015)
Contraceptive methods **(No-RC)**		-	-	-
Modern	0.895* (0.086)	0.873 (0.262)	0.036 (0.755)	0.890* (0.091)
Traditional	0.895 (0.386)	0.895 (0.386)	0.895 (0.386)	0.895 (0.386)
Age at first birth: (Below 16-RC)	-	-	-	-
16-20 year	0.850 (0.248)	0.799* (0.095)	0.834(0.183)	0.807(0.118)
21-26 years	0.669*(0.051)	0.546** (0.020)	0.718**(0.031)	0.654**(0.024)
27 and above	0.681(0.349)	0.525 (0.282)	0.821(0.438)	0.440(0.111)
Water sources: Unsafe water (RC)	-	-	-	-
Other safe water	1.123 (0.526)	1.257 (0.665)	0.847 (0.354)	1.099(0.589)
Piped water	0.259** (0.049)	0.528** (0.032)	0.770* (0.081)	0.188*(0.062)
Toilet facilities: (No toilet-RC)	-	-	-	-
Covered toilet	0.909 (0.566)	1.133 (0.819)	1.015 (0.967)	1.034(0.956)
Flash toilet	1.567 (0.381)	1.154 (0.802)	1.152 (0.701)	1.316 (0.676)
Marital status: (Married-RC)	-	-	-	-
Single	2.518*** (0.008)	3.348* (0.093)	7.653**(0.043)	1.543 (0.184)
Divorced	2.972*** (0.002)	2.444 (0.230)	8.183**(0.038)	1.341(0.394)
Employment status: All year (RC)	-	-	-	-
Seasonal	1.108(0.439)	1.006 (0.962)	0.938 (0.554)	1.203* (0.089)
Occasional	1.038(0.886)	0.413 (0.219)	0.779 (0.177)	1.014 (0.959)
Residence (**Rural –RC)**	-	-	-	-
Urban	1.074* (0.072)	1.291 (0.589)	1.092 (0.682)	1.133*(0.056)
Religion: Catholic (RC)	-	-	-	-
Protestant	1.115 (0.377)	1.101(0.495)	0.971 (0.784)	1.019 (0.858)
Muslim	1.090 (0.584)	1.169 (0.355)	0.989 (0.956)	0.893(0.708)
Birth weight: Low birth weight (RC)	-	-	-	-
Normal weight	0.345**(0.012)	0.861***(0.001)	0.674**(0.014)	0.974***(0.000)
Antenatal care: Not given (RC)	-	-	-	-
Given antenatal	0.728***(0.002)	0.875 (0.466)	0.699**(0.012)	0.955(0.758)
Breast feeding: Not breast feeding (RC)	-	-	-	-
Do breast feeding	0.603*** (0.000)	0.725**(0.015)	0.568***(0.000)	0.618***(0.000)
Child size at birth: Small (RC)	-	-	-	-
Medium	1.184 (0.266)	1.212(0.190)	1.823*** (0.000)	1.204(0.166)
Large	2.278***(0.000)	1.739***(0.006)	2.833***(0.000)	1.637**(0.014)
No. observations	1131	1053	1337	1053
LL	-710.11	-690.26	-954.26	-740.98
LR χ^2	79.47	61.38	94.13	62.77

The P-values are given in parenthesis (* p < 0:1, ** p < 0:05, *** p < 0:01)

In addition, the marital status of women has a significant effect of infant mortality across the four regions in Uganda. The findings reveal that holding other factors constant, a child born to a divorced and never married women compared to married women increases infant risk to die by 2.52 and 2.97 times greater than a married woman in the central region. Also infant risk to die is 3.35, 7.65 and 1.54 times greater for divorced women in east, north and west respectively compared to the reference category (married), while infant risk to die is 2.44, 8.18 and 1.34 times greater for divorced women in east, north and west respectively, compared to children born by a married woman. Other selected factors, traditional contraceptive methods and religion have the expected signs but they don't have a significant effect on infant mortality in any of our estimations. Considering contraceptive use, children born to mothers who use modern contraceptive reduces the relative risk of infant death by 0.90 units in the central region, while in other regions both traditional and modern contraceptives methods have no significant effect on infant mortality.

Furthermore, we find that women who received antenatal care compared to counterparts who did not receive antenatal care are expected to reduce infant mortality risk by 0.78, 0.74, 0.68 and 0.79 times lower in the central, east, north and western region respectively, holding other factors constant. On the other hand, women who breast feed children decreases the infant mortality risk by 0.60, 0.75, 0.57 and 0.62 times lower than mothers who don't breast feed children in the central, east, north and west respectively, holding other factors constant. Concerning infant size, we find that a larger infants size increases the risk of infant mortality by 1.42, 1.23, 1.22 and 1.63 units in the central, east, north and west respectively, holding other factors constant. Finally, medium infant sizes decreases the infant mortality risk by 0.57, 0.64, 0.92 and 0.47 units in the central, east, north and west respectively, holding other factors constant.

4.2.2 Determinants of child mortality

Table 5 presents the estimated Incidence Rate Ratios (IRR) of the negative binomial model for the factors that influence regional differences in child mortality in Uganda. The estimated effects of female education levels (primary, secondary and postsecondary) on children's death after their first birth day compared to children born to mothers with no education were significant at 1%. Holding other factors constant, primary education of the mother reduces the chances of child death relative to no education by 0.66, 0.77, 0.74 and 0.80 units in the central, east, north and the west respectively. Children born to mothers with secondary education have lower chances of death relative to counterparts born by mother with no education by 0.51 units in the central, 0.38 in the east, 0.57 in the north and 0.47 in the west. In addition, children after their first birth day, born to mothers with secondary education have lower chances of death relative to counterparts born to mother with no education by 0.34 units in both the central and east, 0.21 in the north and 0.12 in the west.

Furthermore, holding other factors constant, the estimated relative risk of child death for children born to near-poor and poor mothers compared to children born to rich mothers increases the chances of child death by 1.04, 1.29, 1.81 and 1.16 units in the central, east, north and west for

poor women, while children born to near-poor mother in the east reduces the infant mortality risk by 0.31 units, other factor remaining constant. The results also reveal that women who gave their first birth at the age of 21-26 years, compared to women who first gave birth when they are less than 16 years, decreases expected child mortality rates by 0.48, 0.70, 0.61 and 0.60 units in the central, east, north and west respectively, other factor held constant. This implies that there is a need for government and other stakeholders to advocate for late child birth. In addition, access to other safe water sources reduces the relative risk of child mortality by 0.75, 0.58 and 0.42 relative to children in households that have no access to safe water in the central, eastern and western regions respectively. Access to piped water reduces the relative risk of child mortality across the four regions. This can be the case for instance if water services are used as conduits for preventing water borne diseases, other things being equal, would reduce water borne related infections and associated death in the country. Also access to good toilet services reduces the relative risk of child mortality as opposed to using bushes by 0.41, 0.84, 0.83 and 0.50 units in the central, eastern and western regions respectively. This can be the case for instance if toilet services are used as conduits for disposing off children faeces which, other things being equal, would minimise contagious disease. The policy implication of this finding is that government efforts in providing full coverage with access to safe drinking water and good toilet facilities could contribute to the reduction of infant and under-five mortality rates[12].

The effects of marital status of women have a significant impact on child mortality across the four regions in Uganda. The findings reveal that holding other factor constant, a child born to a divorced and never married women compared to married women increases the relative risk of child death by 2.95 and 3.53 units in the central region, other factors held constant. Also relative child risk to die is 7.07 and 8.19 units for children born to married and divorced women in the eastern region. In addition, the relative risk of a child risk to die increases by 3.18 and 3.39 units for children born to married and divorced women in the northern region, while the relative risk for child death for children born to singe and divorced mothers increases by 1.97 and 1.82 units in the western region, compared to children born by a married woman. In addition, aavailability of off farm employment opportunities in form of seasonal and occasional jobs reduces the relative risk of child mortality relative to all year employment by 0.87 units in the east.

Place of mother and child birth is another important determinant of regional difference in child mortality. Delivery at public or private health centres is used to proxy for availability of health facilities to the community. A woman giving birth at a public health centre reduces the relative risk of child mortality as opposed to producing at home by 0.33, 0.92, 0.41 and 0.08 units in the central, eastern and western regions respectively, holding other factors constant. Also, a child born by a woman at a private health centre reduces the relative risk of child mortality as opposed to being born at home by 0.11, 0.41, 0.10 and 0.77 units in the central, eastern and western

[12] While MDG 7 only calls for a reduction by half of the proportion of people without sustainable access to safe drinking water, a more ambitious goal of full coverage seems achievable for Uganda, with the combined benefit of synergies in terms of reduced infant mortality.

regions respectively, holding other factors constant. This might be attributed to the fact that child delivery at health centres reduces various health hazards to the child like tetanus infections, and HIV/AIDs, among others. It might, however, also be possible to argue that health facilities are fewer in other regions, specifically in rural areas. The relative risk of child death for women giving birth at a private health centre is significant in the north, where child mortality increases by 1.41 units relative to children born at public health centres.

Table 5: Negative Binomial estimates for the determinants of infant mortality rates in Uganda by regions (IRR)

Variable	**Central IRR**	**Eastern IRR**	**Northern IRR**	**Western IRR**
Mother's education: No education (RC)	-	-	-	-
Primary	0.662*** (0.000)	0.773***(0.000)	0.744***(0.000)	0 .801***(0.000)
Secondary	0.513*** (0.000)	0.376*** (0.000)	0.570***(0.004)	0.472***(0.000)
Post-secondary	0.339*** (0.000)	0.340*** (0.000)	0.214** (0.034)	0.120*** (0.004)
Wealth index: Rich (RC)	-	-	-	-
Near-Poor	1.040 (0.772)	1.216* (0.057)	0.884 (0.279)	1.087 (0.350)
Poor	1.057** (0.028)	1.172** (0.016)	1.731** (0.018)	1.945* (0.071)
Contraceptive methods **(No-RC)**		-	-	-
Use contraceptives	0.889 (0.000)	0.856* (0.054)	0.930 (0.328)	0.927 (0.333)
Age at first birth: (Below 16-RC)	-	-	-	-
16-20 year	0.716***(0.000)	0.823** (0.035)	0.745***(0.000)	0.715***(0.000)
21-26 years	0.479***(0.000)	0.699** (0.024)	0.607***(0.000)	0.602***(0.000)
27 and above	0.391***(0.005)	0.615 (0.213)	0.727**(0.037)	0.489**(0.035)
Water sources: Unsafe water (RC)	-	-	-	-
Other safe water	0.752* (0.063)	0.582* (0.091)	1.013 (0.920)	0.422***(0.010)
Piped water	0.849* (0.066)	0.883* (0.091)	0.902** (0.042)	0.381**(0.019)
Toilet facilities: (No toilet-RC)	-	-	-	-
Covered toilet	1.377** (0.036)	0.836 (0.623)	0.715* (0.096)	0.438***(0.006)
Flash toilet	0.407* (0.035)	0.836** (0.038)	0.838* (0.099)	0.496** (0.043)
Marital status: (Married)	-	-	-	-
Single	2.950*** (0.000)	7.069*** (0.007)	3.181***(0.006)	1.971*** (0.010)
Divorced	3.525*** (0.000)	8.187*** (0.006)	3.392***(0.004)	1.822**(0.028)
Employment status: All year (RC)	-	-	-	-
Seasonal	1.101(0.296)	0.886** (0.022)	1.000 (0.995)	1.005 (0.946)
Occasional	1.041(0.826)	0.714 (0.315)	0.911 (0.421)	0.778 (0.266)
Residence (**Rural –RC)**	-	-	-	-
Urban	1.437 (0.007)	1.372 (0.195)	0.984 (0.908)	(0.000)
Religion: Catholic (RC)	-	-	-	-
Protestant	1.098 (0.276)	0.964(0.672)	1.016 (0.818)	1.397 (0.132)
Muslim	0.982 (0.880)	0.948 (0.659)	1.167 (0.216)	(0.000)
Place of birth: Home (RC)	-	-	-	-
Public hospital	0.325** (0.012)	0.917* (0.062)	0.409***(0.000)	0.082* (0.023)
Private hospital	0.110***(0.000)	0.406** (0.016)	0.102***(0.000)	0.768***(0.000)
Antenatal care: Not given (RC)	-	-	-	-
Given antenatal	0.728***(0.002)	0.738*** (0.007)	0.677***(0.000)	0.788**(0.020)
Breast feeding: Not breast feeding (RC)	-	-	-	-
Do breast feeding	0.603*** (0.000)	0.761***(0.005)	0.570***(0.000)	0.682***(0.000)
Child size at birth: Small (RC)	-	-	-	-
Medium	0.567* (0.063)	0.640***(0.000)	0.920** (0.043)	0.467*(0.065)
Large	1.424**(0.045)	1.234**(0.035)	1.224**(0.018)	1.625**(0.014)
No. observations	1315	1292	1750	1277
LL	-129.95	-145.38	-218.49	-458.59
LR χ^2	69.24	61.58	59.20	54.55

The P-values are given in parenthesis (* p < 0:1, ** p < 0:05, *** p < 0:01)

Holding other factors constant, children that were born above average size, increases the relative risk of child death relative to children that were born below average by 0.71, 0.67, 0.34, and 0.88 in the central, east, north and west respectively. Considering children of normal size, the relative risk of child death reduces by 0.57, 0.64, 0.92 and 0.47 in the central, east, north and west respectively, keeping other factors constant. In addition, children born to mothers who use antenatal care during pregnancy understandably reduce the odds of child mortality as opposed to children born to mothers who are not given antenatal care by 0.78, 0.74, 0.68 and 0.79 in the central, east, north and west respectively, keeping other factors constant. Finally, considering children of breast feeding mothers, the relative risk of child death reduces by 0.60, 0.76, 0.57 and 0.68 units in the central, east, north and west respectively, keeping other factors constant.

5. Summary and policy implications

Our results reveal that there is a significant difference in the social-economic factors and individual characteristics of women in the four regions of in regard to children's ever increasing health risks and threatening sources of livelihood especially in the poorer parts of the country. This calls for responses both to current occurrences and to more long term infant and child mortality. This study employed data from the 2006 Uganda Demographic and Health Survey (UDHS) to shed light on some of the main factors that have a bearing of the regional differences in infant and child mortality in Uganda. The most commonly observed determinants of regional difference in mortality include, mothers' education level, use of antenatal services, place of birth, size of the child at birth, marital status, wealth index, use of contraceptives and age at first birth.

Understanding the factors that influence regional difference in mortality can be beneficial to mortality reduction in two ways. First, this knowledge can be applied during the design of health projects developments through the Ministry of Health for priority regions. Identifying and removing the factors that increase mortality in regions can be most easily accomplished in the plan reviews. Second, this knowledge can be used during periodic comprehensive mortality location reviews. As field reviews of individual high mortality are conducted, the reviewer can be looking for the presence of these factors known to increase infant and child mortality at the regional level. Once these factors are identified, the feasibility of revising the approach can be determined and a project to correct the concerns can be programmed and implemented.

These findings have important policy implications. Concerning education, our results suggest that additional efforts in increasing females' education levels, while contributing to the achievement of MDG 3 (promotion of gender equality) would also create synergies with MDG 4, since a mother's education has a negative and statistically significant impact on infant and child mortality across the four regions. To increase child survival, especially in underprivileged regions, strategies are needed for improving their socio-economic conditions. Social programs to increase education and employment opportunities could diminish the hazards related with infant and child mortality. It also implies that infant mortality could be reduced by reducing poverty, inadequate sanitation, and unhygienic conditions. People could be taught about proper use of toilets and this would help transform the unhealthy environment into a healthy one. Hence, measures should be taken to eradicate poverty and improve the socioeconomic conditions of the people. While it may take a long time to eradicate poverty, for immediate health benefits, efforts

directed towards improving household cleanliness by imparting information about personal hygiene practices, sanitary disposal of faeces could increase the overall welfare of the poor.

Another implication of our findings has to do with the high infant and child mortality at regional level, which clearly justifies the adoption of regional based mortality reduction programs. Such programs, however, need some empirical basis to guide the application of funds to the most needy projects. This paper has tried to provide some explanatory work in this regard. A related policy implication of this paper has to do with an important first step towards developing a systematic, statistically defensible approach to identifying the impacts of possible mortality improvements. In terms of future work, an analysis similar to the one performed in this paper should be conducted at district level in line with the government program of decentralization on a large random sample of health outcomes. Such analysis would allow further exploration of the determinants of infant and child mortality frequencies. Information from such work would provide a significant contribution to the government funding quotas to the districts.

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