Immunization Status and Child Survival in Uganda

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Abstract

Using the UDHS 2006 and 2011 and employing the Cox model, we tested the hypothesis that childhood immunization equalizes all children irrespective of parental background. Our findings reject this hypothesis. However, we find strong support to the view that childhood immunization decisively dampens child mortality. Immunised children reduce the risk of mortality by 17-38%. Immunised children with DPT/Polio reduce risk of mortality by 25-43%. Children immunised with measles and BCG shots reduce the risk of mortality by 38-44%. Efforts intended to improve child survival need to go beyond the childhood immunization campaigns and recognise other sources of mortality and morbidity.

Key words: Immunization status, child survival, cox model, Uganda

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1.0 Study Concern

Inspite of the great strides the government of Uganda has made towards reducing child mortality, huge challenges still remain. According to the Uganda Demographic and Health Survey Report (2011), for the period 2006-2011, the infant mortality rate was 54 per 1,000 live births. This implies that one in every 19 babies born in Uganda does not live to the first birthday. Those who survive to the first birthday, 38 out of 1,000 would die before reaching their fifth birthday. This shows that one in 11 children dies before their fifth birthday. The under-five mortality rate is 90 per 1,000 live births. The neonatal and postneonatal mortality rates were 27 deaths per 1,000 live births, each. Under-5 mortality rates in rural and urban areas are 111 and 77 deaths per 1,000 live births, respectively. Under-5 mortality in Kampala and Karamoja is 65 and 153 deaths per 1,000 live births, respectively (UBOS and ICF International, 2011). Compared to the neighbouring countries, Kenya and Tanzania, Uganda is still doing so badly in the area of child survival.

Several authors support the view that childhood Immunization against the eight vaccine-preventable diseases (tuberculosis, diphtheria, whooping cough (pertussis), tetanus, hepatitis B, *Haemophilus influenzae*, polio, and measles) is crucial for reducing child mortality (Bhandari et al. 2007; Kiros et al. 2004; Ndirangu et al. 2009; Nyarko et al. 2001; Roth et al., 2005; Victoria et al., 2003; Levine et al., 2005; Kristensen et al., 2000). It is said to offset the detrimental effects of parental poverty and low education attainment on child health (Bawah et al. 2006). It eliminates healthcare inequality by bridging the wealth gaps (Gwatkin et al. 2005). Hence, it’s an important conduit for the attainment of Millenium Development Goal 4 of reducing under-five mortality by two thirds by 2015 (Bawah et al. 2006). The government of Uganda embraced the UNICEF/WHO Expanded Program on Immunization (EPI) and undertakes outreach programs. As a result, immunization coverage rate has improved from 46% to 52% but still below the worldwide target of 90% (Uganda Bureau of Statistics (UBOS) and ICF International, 2011).

Contrary to the above evidence, several authors contend that despite the widespread immunization efforts poor child health conditions still persist (World Bank 2005; Ahmad et al., 2000; Black et al., 2003; United Nations 2005a and 2005b; Mosley and Chen 1984; and Hill, 1993). This kind of evidence deflates the proposition that childhood immunization is associted with favorable child health outcomes. The weight of this view rests the ground that there are other serious threats to child health that are outside the routine immunization net. Such threats may include diarrheal diseases, malaria, acute respiratory infections, and malnutrition. Consequently, it is clear that the debate concerning the role of childhood immunization in promoting child survival is still a very hot issue for health policy. We sought to contribute to the debate by examining the role of childhood immunization in promoting child survival. We test the hypothesis that childhood immunization offsets the detrimental child-survival effects of parental poverty and low educational attainment. To the best of my knowledge, this is the first paper to examine the relationship between childhood survival and routine vaccination in Uganda, hence it represents a real value added.

2.0 Methodology

2.1 Data and Variables

We pooled 2 cross-sectional data sets of Uganda Demographic and Health Surveys (UDHS); that of 2006 and 2011 conducted by UBOS and ICF International. The pooled data set contains information on vaccination coverage and child mortality for 16,247 children aged 0-59 months born in the five years preceding each survey. Information on vaccination coverage was collected from vaccination cards and from mothers’ verbal reports. WHO/UNICEF immunization schedule shows that for a child to be fully immunized he must attain 8 dozes of: BCG at birth, 3 dozes of polio and 3 dozes of DPT vaccines at 6th, 10th and 14th week after birth, and measles vaccine at nine months. In the data 4,029 (27%), 9,758 (66%) and 1,042 (7%) children were fully, partially and not immunized, respectively. For DPT/Polio vaccine (6 dozes) 4,749 (32%), 8,595 (58%) and 1,543 (10%) children were fully, partially and not immunized, respectively. For measles vaccine 9,854 (66%) and 5,030 (34%) were immunized and not immunized respectively. For BCG vaccine 13,531 (91%) and 1,396 (9%) were immunized and not immunized respectively. For child mortality, mothers were asked the number of sons and daughters that died in the 5 years preceding the survey; 9,636 (59%) survived and 6,611 (41%) died. This data set is also very rich in other child, parental, regional, location and other characteristics which we utilize during the analysis.

The immunisation status formed our key explanatory variable constructed as follows: We generated a variable with three outcome categories; children fully immunised, those partially immunized and those not immunized. We considered only children that were 10 months or older because this is the group that is supposed to have completed its immunization cycle by 9 months. In all our regression, the children that were not immunised served as our reference category. Second, DPT and Polio are administered at the same time; we combined their six dozes into one variable with three outcome categories. Children fully immunized, those partially immunised and those not immunized at all with DPT/Polio. We considered children that were 4 months or older because DPT/Polio immunization is completed by age 3.5 months. In all our regressions, those who were not immunised formed our reference group. Third, we used measles and BCG vaccines each independently during the regression analysis based on the fact they are clearly detached from others in terms of the immunization schedule as aforementioned.

Other explantory variables other than the vaccines include child's sex, mother received tetanus injections before birth, mother delivered from hospital/health center, mother's age at first birth, mother's education, residential status, household size, regions and relative poverty. Our dependent variable (survival status) is coded 1 if the child died and 0 if the child survived.

2.2 Analytical Framework

The theoretical pillars of the demand for child health (survival) can be analysed within the framework proposed by Rosenzweig and Schultz (1983). Intrinsic in the model is the need to maximize household welfare, by making a choice between child health and other consumption goods subject to the budget, health production, and time constraints. The utility of a typical household is a function of the child health (ch), consumption of market goods (g), leisure (l) and taste (t).

(1) $U = U[ch, g, l, t]$

The production function for child health relates health inputs to child health outcome (child survival). Health inputs include market purchased health inputs, n (immunization and other medical care and nutrition), time of the mother (m_t) and father (f_t) in producing child health, education of the mother (m_e) and father (f_e) and the innate child healthiness (ω).

(2) $ch = ch(n, m_t, f_t, m_e, f_e, \omega)$

A parent's (especially, mother's) time constraint appears as follows:

(3) $m_c = l_m + y_m + c_h$

m_c, l_m, y_m, and c_h is total time available to the parent, distributed to leisure, work, and producing child health.

We finally introduce a budget constraint that relates expenditures to income.

(4) $P_g g + P_n n + P_l l = y_m w_m + y_f w_f + I$

Where $P_g g, P_n n, P_l l, y_m w_m, y_f w_f$, and I refer to the cost of the composite good, cost of healthcare inputs, cost of the leisure good, labour income of the mother, labour income of the father, and the exogenous non-labour income.

From this structural model, we can solve for the reduced form of the demand for child healthcare inputs (immunization) and outputs (child survival) in terms of exogenous variables. The exogenous variables include time and money prices for healthcare inputs, mother's education and wealth (income). All these characteristics are assumed to be exogenous to the indvidual's decisions about behaviors and investments related to health, time allocation and resource allocation. In addition, they are all, by definition, observed. These are also factors which influence demand for each of the health inputs and outputs that are not observed, ε. These encompass not only tastes, t, but also innate healthiness, ω.

(5) $D_n = D_n(P_n, P_l, P_g, wi, m_e, m_a, \eta_{env}, \mu_{env}, \varepsilon)$

Where D_n, wi, m_a, η_{env}, and μ_{env} is the demand for child healthcare inputs, household income, mother's age, household environment, and community or social environment. The environmental factors include the disease environment, public health infrastructure, treatment practices or standards of care. The rest of the variables remain as defined earlier. The reduced form demand for child health (survival) can be written in a similar way:

(6) $c_h = c_h(P_n, n, P_l, P_g, wi, m_e, m_a, \eta_{env}, \mu_{env}, \varepsilon)$

Equation (6) is our model of interest which we estimated in this paper.

2.3 Empirical Strategy

Empirically, we employed the Cox proportional-hazards regression model introduced in a seminal work by Cox (1972). It entails the specification of a linear-like model for the log hazard.

(7) $\log h_i(t) = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik}$

Where, i is a subscript for the observation, and the x's are the covariates. The constant α in this model represents the of log-baseline hazard when all of the x's are zero. The greatest virtue of the hazard model is that it accounts for censored survival times and allows individual characteristics to change over time. A censored child is one who survives until the end of the observation or one who doesn't experience the event of death before being lost to follow-up as the case can be in case of migration. Uncensored children, on the other hand, are those who experience the event of death at the specified time (Nyarko et al., 2001). Kaplan-Meier survival functions were ploted for different age groups in order to examine differences in childhood mortality given the vaccination coverage.

3.0 Findings and Discussion
Table 1 shows the status of immunization for the eight vaccines by age of the child for the period 2006 to 2011. As expected, given the immunization schedule, there is a high percentage of children (82%) aged 0-11 months that are immunized with BCG compared to all other vaccines. The lowest percentage of children aged 0-11 months is immunized with the measles vaccine (13%). Our results show that for all vaccines, the percentage of children aged 12-59 months that are immunized far exceeds that of children aged 0-11 months probably because our sample included more children above one year of age. A striking observation is where there is a discrepancy between the percentage of children immunized with DPT and polio vaccines, yet, these two are administered together. A possible explanation might be due to stock outs of one of the vaccines such that when children are brought for immunization, one of the dozes might not be administered. Another possible explanation might due to the mismatch between the government immunisation schedule and a particular vaccine that a child is supposed to get. This might imply that a child may get a later vaccine without an earlier one either due to parental mistakes or government supply side constraints.

Table 2 shows the status of childhood immunization and key background characteristics. It reveals that only 2% of children whose mothers have postsecondary education are not immunized compared to 6% of children whose mothers have no education at all. Only 23% of children whose mothers have no education are fully immunized compared to 42% (almost double) of children whose mothers have postsecondary education. There is no discernible difference between the children that not immunised, partially immunised, and fully immunised by the relative wealth of the parents. Its only children whose parents are in the most prosperous quintile that have a slight advantage over others. 33% of children whose parents are in the richest quintile are fully immunized compared to 26% of children whose parents are in the poorest wealth quintile. 37% of children in the urban area are fully immunized compared to only 25% of children in the rural area.

Figure 1 shows the Kaplan Meier survivor functions for children 0-59 months by age in months. It is revealed that the probability of child survival is lowest amongst infants (0-11 months) and highest amongst older children (12-59 months). Figure 2 shows that children located in the urban area have a higher probability of survival compared to their counterparts in the rural areas. Table 3 shows that all the dozes of vaccines apart from polio 3 are individually important in reducing the relative risk of child mortality in Uganda. BCG vaccine reduces the relative risk of child mortality by 21%, DPT1 by 38%, DPT2 by 32%, DPT3 by 28%, polio 1 by 13%, polio 2 by 11% and Measles by 26%. These findings are in line with the previous literature (Bawah et al., 2006). However, these findings are from a univariate analysis and hence should be interpreted with caution.

At a multivariate level we first run simple regressions with only maternal characteristics; education of the mother, age of the mother at first birth, relative poverty, and mother received tetanus injection(s) during pregnancy/delivered from hospital. In the second model we include a variable of childhood immunization to test the hypothesis that immunization averts the adverse child-survival effects resulting from parental poverty and low education attainment. We later introduce controls for residence and region, household size, and child sex and interaction terms between immunization status and relative poverty. All our results (Tables 4, 5, 6 and 7) reveal that maternal education, especially at postsecondary level, is associated with a reduced relative risk of child mortality. A mother with primary, secondary and postsecondary education, compared to counterparts with no education, reduces the relative risk of child mortality by 8-15%, 41-49% and 58-66%, respectively. These associations are statistically highly significant at 1 percent level. These finding are in line with the previous literature (Nyarko et al., 2001; Bawah et al., 2006; Bbaale et al., 2012).

Our findings articulate that being in the richest quintile, compared to counterparts in the poorest, reduces the relative risk of child mortality by 6-12% (Tables 4, 5, 6 and 7). This association is statistically highly significant at 1% level. This is in line with the previous literature (Nyarko et al., 2001; Bawah et al., 2006; Wagstaff 2000; Kiros et al., 2001). The authors contend that the poor are unable to afford the basic curative and preventive healthcare and are highly susceptible to malnutrition. Mothers in the 25+ age cohort, compared to counterparts in the less than 15 years age cohort, reduce the relative risk of child mortality by 29-33% in all our specifications (Tables 4, 5, 6, and 7). This finding is in line with the previous literature (Nyarko et al., 2001; Bawah et al., 2006).

Our findings assert that mothers that obtained a tetanus injection during pregnancy and those delivered in the hospital reduce the relative risk of child mortality by 23-33% and 12-17%, respectively (Tables 4, 5, 6 and 7). These associations are statistically highly significant at one percent level. These results point to the importance of maternal healthcare seeking behavior in being associated with favorable child health outcomes and in line with the previous literature (Kristensen et al., 2000). Our findings show that being fully and partially immunised, compared to counterparts that are not immunised, reduces the relative risk of child mortality by 36-38% and 17-19%, respectively, and these association are statistically highly significant (Table 4). We limited our analysis to children aged 10-59 months because these children are supposed to have completed their immunization cycle by the age of 9 months. Kaplan Meier survivor functions in Figure 3 shows that children that are fully immunised have a higher probability of survival compared to their counterparts that are partially or not immunized at all. These findings find support from the previous literature (Bawah et al., 2006).

Our findings reveal that being fully and partially immunised with DPT/Polio, compared to counterparts that are not immunised, reduces the relative risk of child mortality by 33-43% and 25-27%, respectively (Table 5). Kaplan Meier survivor functions in Figure 4 shows that children that are fully immunised with DPT/Polio have a higher probability of survival compared to their counterparts that were partially or not immunized at all. This analysis was limited to children between 4-59 months because children complete their immunization with DPT/Polio at 3.5 months. These findings are in line with the previous literature (Nyarko et al., 2001) but at odds with Kristensen et al., (2000) who found that children who had received one DPT shot had nearly twice the mortality of those who had not received any in the case of Guinea-Bissau.

We show that being immunised with measles vaccine, compared to counterparts that are not immunised, reduces the relative risk of child mortality by 38-41% (Table 6). These associations are statistically highly significant at 1% level. Kaplan Meier survivor function in Figure 5 shows that children that are immunised with measles vaccine have a higher probability of survival compared to their counterparts that are not immunized. This analysis was limited to children aged between 10-59 months because children complete their immunization cycle with the measles shot at the age of 9 months. These findings are in line with the previous literature that looked at the strength of the measles vaccine in averting child mortality (Kristensen et al., 2000; Koenig et al., 1991; Nyarko et al., 2001). Our findings assert that receiving a BCG shot, compared to counterparts that have not, reduces the relative risk of child mortality by 4-42% (Table 7). These associations are statistically highly significant at 1% level. Kaplan Meire survivor function in Figure 6 shows that children that received a BCG shot have a higher probability of survival compared to their counterparts that had not. This analysis was open to all children under five years (0-59 months) because BCG shot is administered at birth. These findings are in line with the previous literature (Kristensen et al., 2000; Bawah et al., 2006).

In sum, even when immunization and other controls are introduced in the model, the impact of parental education and relative poverty on child mortality remains strong. This might imply that immunization, though important, doesn't offset the detrimental child-survival effects of parental poverty and low education attainment. However, we find that immunisation remains robust even when we control for region, location, household size and child sex. Its only when we introduce interaction terms between the wealth index and immunisation status that the significance of this association is dampened. This can probably be attributed to high correlation between the level variables and the interaction terms. Efforts intended to improve the health of children under five years need to go beyond comprehensive immunization campaigns and recognise other threats to child survival.

4.0 Conclusion and Policy Implications

Using the UDHS 2006 and 2011 and employing the Cox model, we tested the hypothesis that childhood immunization equalizes all children irrespective of parental background. Our findings reject this hypothesis. Hence, immunization doesn’t offset the detrimental child-survival effects of parental poverty and low educational attainment. However, we find strong support to the view that childhood immunization decisively dampens child mortality. Children that are fully and partially immunized with all vaccines reduce the relative risk of mortality by 17-38%. Children that are fully and partially immunized with DPT/Polio reduce the relative risk of mortality by 25-43%. Children immunised with measles and BCG shots reduce the relative risk of mortality by 38-44%. Efforts intended to improve child survival need to go beyond the childhood immunization campaigns and recognise other sources of mortality and morbidity.

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Appendix1

Table1: Immunization Status by Age of Children

Vaccine	0-11 Months	12-59 Months	All ages
BCG	81	93	91
DPTI	43	71	65
DPT2	32	64	57
DPT3	22	52	45
Polio1	69	92	88
Polio2	51	84	77
Polio3	33	59	54
Measles	13	80	66
Children (N)	**3,358**	**12,889**	**16,247**

Source: Author's own computations from UDHS 2006 & 2011

Table 2: Immunization Status and Key Background Characteristics

Characteristics	Not Immunized	Partially Immunized	Fully Immunized
Mother's education: No education	8	69	23
Primary	8	67	26
Secondary	6	60	34
Postsecondary	2	56	42
Poverty levels: Poorest	5	69	26
Poorer	8	67	26
Middle	9	65	26
Richer	8	65	27
Richest	6	61	33
Residence: Urban	4	59	37
Rural	8	67	25
Total (%)	**7**	**66**	**27**
Total (N)	**1,042**	**9,758**	**4,029**

Figure 1: Kaplan Meier Survival Functions by Child Age

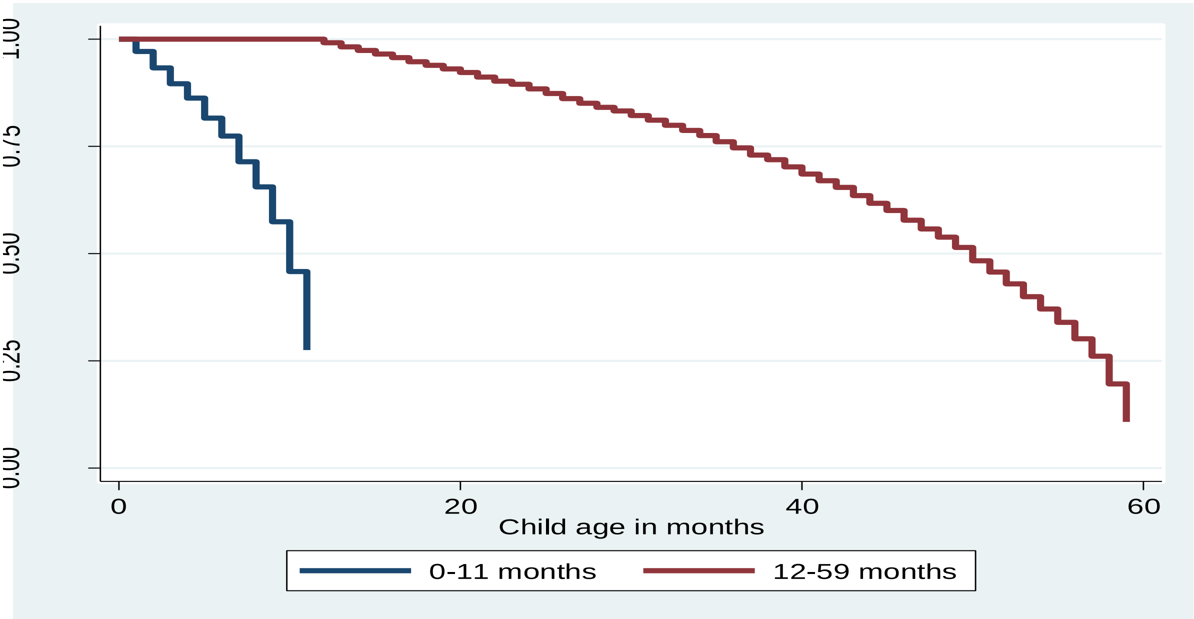


Figure 2: Kaplan Meier Survival Functions by Residence

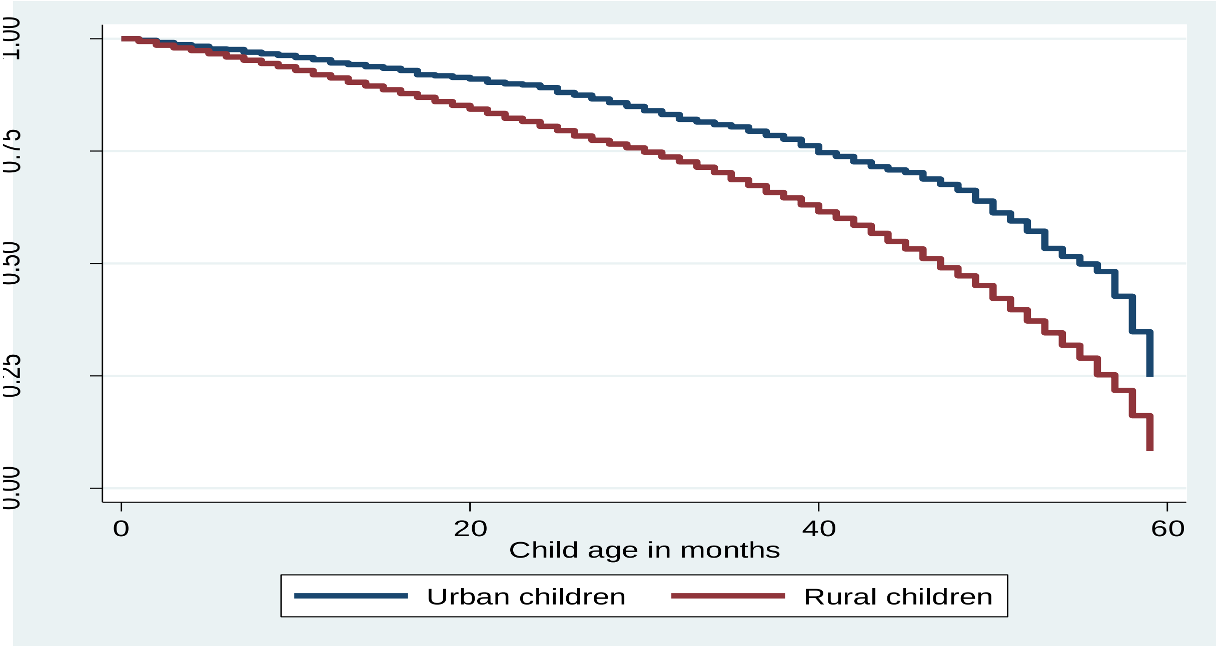


Table 3: Univariate Time-Conditional Hazard Ratios for the Impact of Individual Vaccines on Child Mortality

Vaccine	Hazard Ratio
BCG	0.79***
DPT1	0.62***
DPT2	0.68***
DPT3	0.72***
Polio1	0.87**
Polio2	0.89***
Polio3	1.01
Measles	0.74***

Level of significance: ** p<.05; *** p<.01

Table 4: Time Conditional Hazard Ratios for the Impact of Immunization on Child Mortality Amongst Children Aged 10-59 Months

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Mother's education: No education (r)					
Primary	0.95	0.92*	0.89**	0.89**	0.89**
Secondary	0.59***	0.53***	0.57***	0.57***	0.57***
Postsecondary	0.40***	0.35***	0.40***	0.40***	0.40***
Wealth index	0.90***	0.89***	0.92***	0.93***	1
Mother's age at first birth: <15 (r)					
15-19	0.92	0.94	0.91	0.93	0.93
20-24	0.86**	0.89	0.88	0.9	0.9
25+	0.71***	0.71***	0.68***	0.69***	0.69***
Mother obtained tetanus injection before birth	0.75***	0.76***	0.79***	0.78***	0.78***
Mother delivered in hospital/health center	0.84***	0.83***	0.87***	0.86***	0.86***
Immunization status: Not immunized (r)					
Partially immunized		0.82*	0.83*	0.81**	1.01
Fully immunized		0.62***	0.64***	0.62***	0.84
Child sex: Female (r)					
Male			1.05	1.05	1.05
Location: Urban (r)					
Rural			1.54***	1.46***	1.45***
Total number of children under five years			1.29***	1.29***	1.29***
Regions: Kampala (r)					
Regional controls				yes	Yes
Central 2				1.11	1.12
East Central				1.36***	1.36***
Eastern				1.16	1.16
North				1.26**	1.26**
Karamoja				1.07	1.07
West Nile				1.17	1.17
Western				1.11	1.12
Southwest				1.22	1.23
Interactions: Wealth index*Not Immunized (r)					
Wealth index*Partially immunized					0.92
Wealth index*Fully Immunized					0.9
Failures (N)	**2805**	**2403**	**2403**	**2403**	**2403**
Subjects (N)	**7090**	**6648**	**6648**	**6648**	**6648**
Log likelihood	**-21764.5**	**-18398.4**	**-18303.1**	**-18295.4**	**-18294.2**
chi2	**380.75**	**432.31**	**579.26**	**599.53**	**595.76**
Overall pvalue	**0.000**	**0.000**	**0.000**	**0.000**	**0.00**
Level of significance : * p<.1; ** p<.05; *** p<.01; (r)= reference category					

Figure 3: Kaplan Meier Survival Functions by Immunization Status

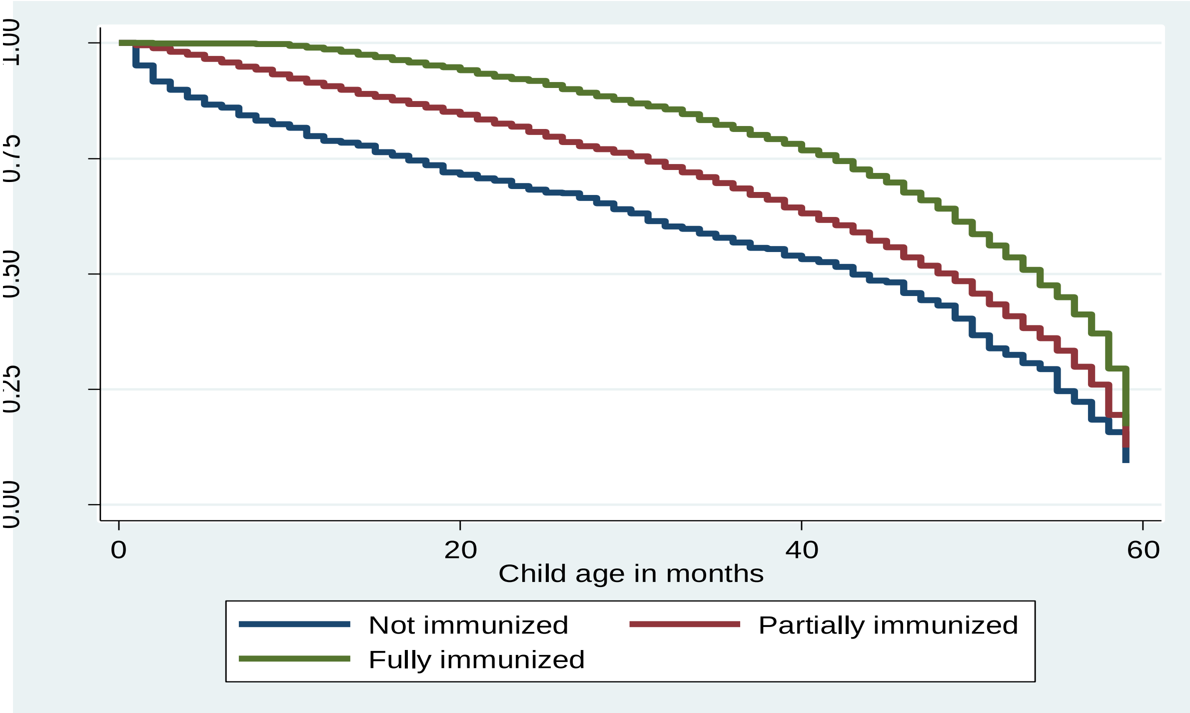


Table 5: Time Conditional Hazard Ratios for the Impact of DPT and Polio Vaccines on Child Mortality Amongst Children Aged 4-59 Months

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Mother's education: No education (r)					
Primary	0.89***	0.87***	0.85***	0.84***	0.84***
Secondary	0.56***	0.52***	0.56***	0.56***	0.56***
Postsecondary	0.42***	0.36***	0.41***	0.41***	0.42***
Wealth index	0.90***	0.89***	0.92***	0.93***	0.97
Mother's age at first birth: <15 (r)					
15-19	0.90*	0.92	0.89*	0.91	0.91
20-24	0.81***	0.83***	0.82***	0.83**	0.83**
25+	0.70***	0.69***	0.67***	0.67***	0.67***
Mother obtained tetanus injection before birth	0.72***	0.74***	0.77***	0.76***	0.76***
Mother delivered in hospital/health center	0.85***	0.84***	0.88***	0.87***	0.87***
Immunization status: No DPT/polio (r)					
Partially immunized with DPT/Polio		0.73***	0.75***	0.74***	0.81
Fully immunized DPT/Polio		0.56***	0.59***	0.57***	0.67**
Child sex: Female (r)					
Male			1.04	1.03	1.04
Location: Urban (r)					
Rural			1.51***	1.44***	1.43***
Total number of children under five years			1.31***	1.31***	1.31***
Regions: Kampala (r)					
Central 1				1.29**	1.29**
Central 2				1.07	1.08
East Central				1.33***	1.33***
Eastern				1.14	1.14
North				1.33***	1.33***
Karamoja				1.07	1.08
West Nile				1.20*	1.21*
Western				1.14	1.15
Southwest				1.27**	1.28**
Interactions: Wealth index*No DPT/Polio (r)					
Wealth index*Partially immunized with DPT/Polio					0.97
Wealth index*Fully Immunized with DPT/polio					0.94
Failures (N)	**3366**	**2886**	**2886**	**2886**	**2886**
Subjects (N)	**8748**	**8247**	**8247**	**8247**	**8247**
Log likelihood	**-26762.9**	**-22648.7**	**-22524.9**	**-22513.4**	**-22512.7**
chi2	**458.71**	**532.78**	**719.46**	**739.98**	**734.52**
Overall pvalue	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Level of significance : * p<.1; ** p<.05; *** p<.01; (r)= reference category					

Figure 4: Kaplan Meier Survival Functions by DPT/Polio Vaccines

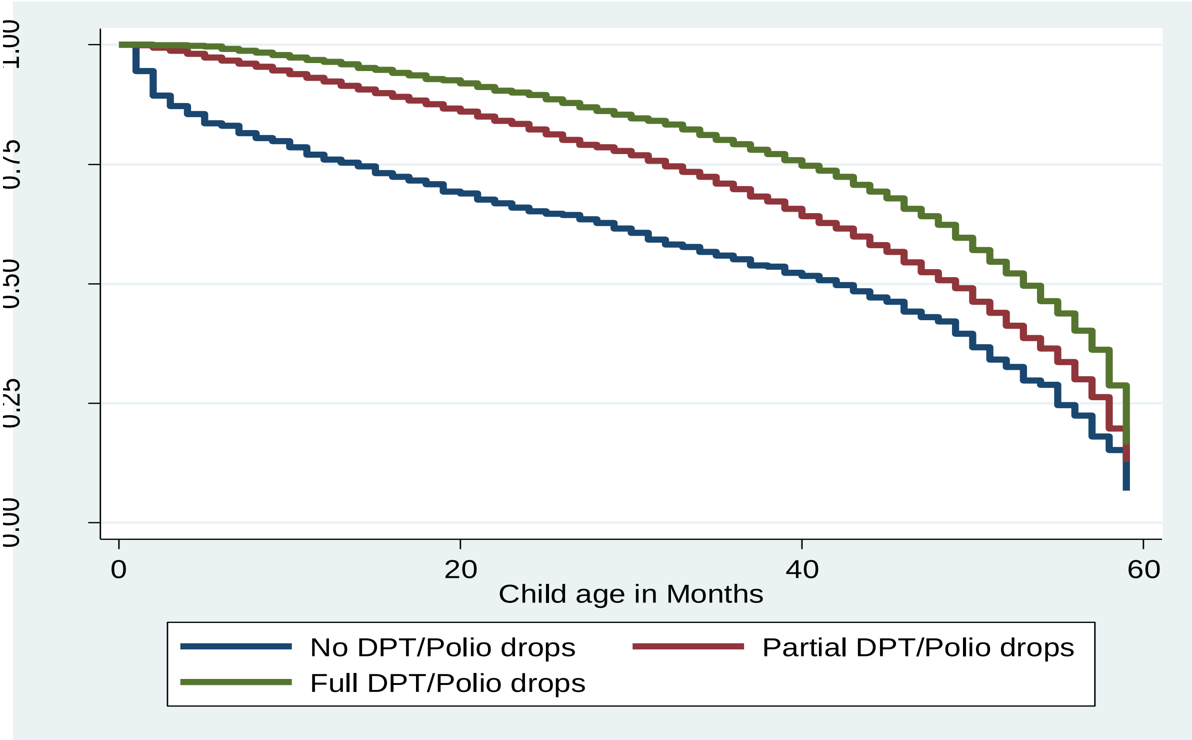


Table 6: Time Conditional Hazard Ratios for the Impact of Measles Vaccine on Child Mortality Amongst Children aged 10-59 Months

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Mother's education: No education (r)					
Primary	0.95	0.91*	0.89**	0.89**	0.89**
Secondary	0.59***	0.54***	0.58***	0.58***	0.59***
Postsecondary	0.40***	0.37***	0.42***	0.42***	0.43***
Wealth index	0.90***	0.88***	0.92***	0.93***	0.96
Mother's age at first birth: <15 (r)					
15-19	0.92	0.95	0.92	0.93	0.93
20-24	0.86**	0.91	0.9	0.91	0.91
25+	0.71***	0.73**	0.69***	0.69***	0.70***
Mother obtained tetanus injection before birth	0.75***	0.79***	0.82***	0.81***	0.81***
Mother delivered in hospital/health center	0.84***	0.84***	0.87***	0.87***	0.87***
Immunization status: No measles shot (r)					
Measles shot		0.59***	0.61***	0.61***	0.68***
Child sex: Female (r)					
Male			1.07		1.06
Location: Urban (r)					
Rural			1.56***	1.50***	1.49***
Total number of children under five years			1.28***	1.28***	1.28***
Regional controls				yes	Yes
Interactions: Wealth index*No Measles shot (r)					
Wealth index*Measles short					0.96
Failures	**2805**	**2409**	**2409**	**2409**	**2409**
Subjects (N)	**7090**	**6673**	**6673**	**6673**	**6673**
Log Likelihood	**-21764.5**	**-18421.9**	**-18329.4**	**-18321.7**	**-18320.9**
chi2	**380.75**	**490.78**	**633.55**	**643.76**	**638.7**
Overall pvalue	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

Level of significance : * p<.1; ** p<.05; *** p<.01; (r)= reference category

Figure 5: Kaplan Meier Survival Functions by Measles Vaccine

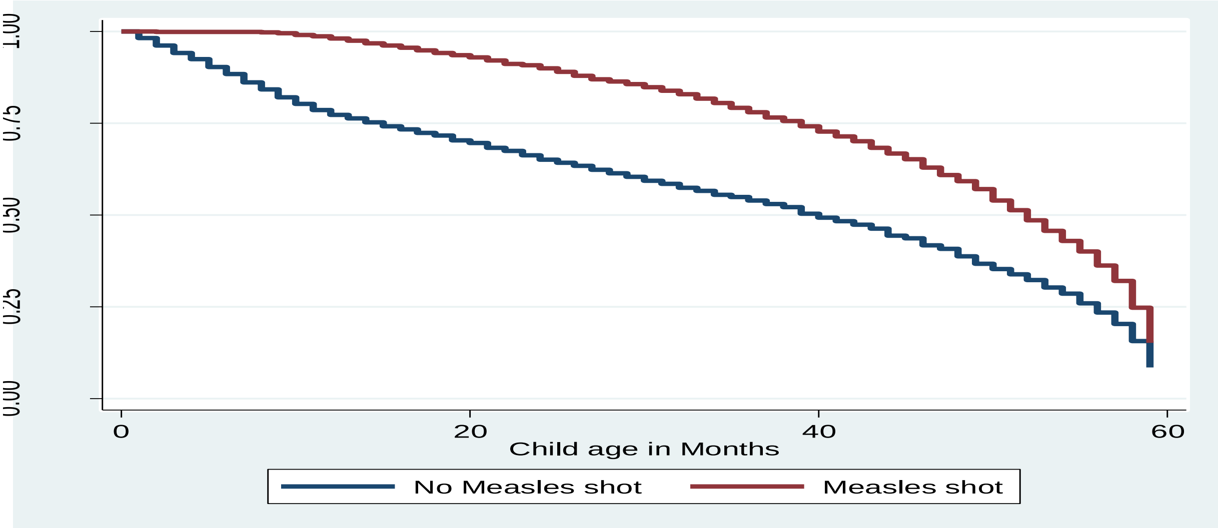
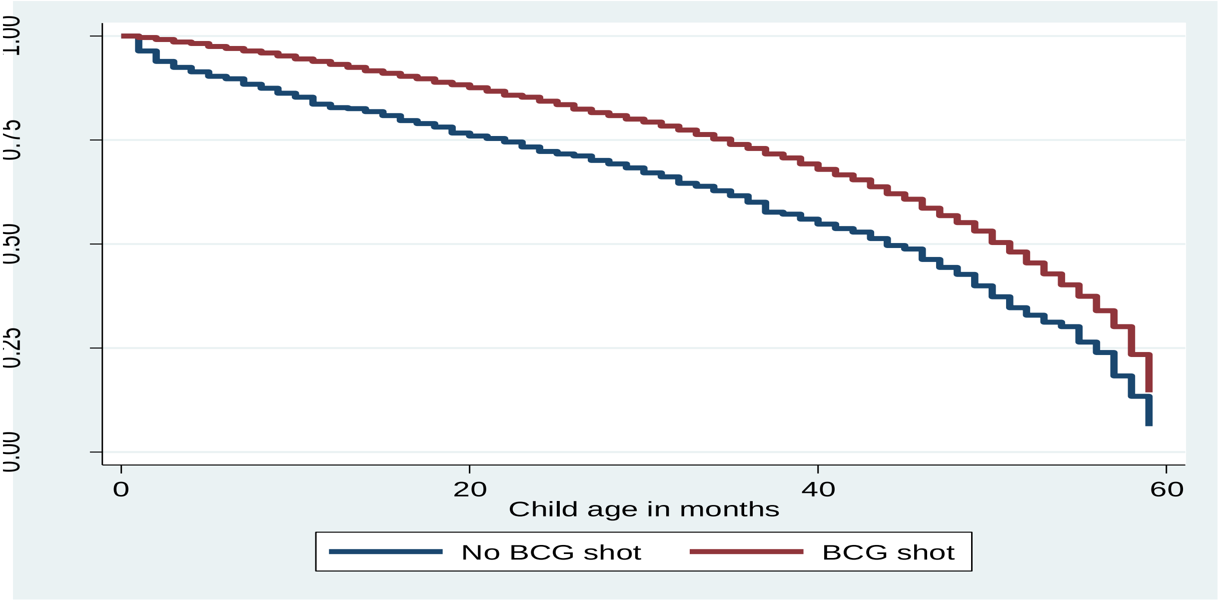


Table 7: Time Conditional Hazard Ratios for the Impact of BCG Vaccine on Child Mortality Amongst Children Aged 0-59 Months

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Mother's education: No education (r)					
Primary	0.90***	0.87***	0.85***	0.85***	0.85***
Secondary	0.56***	0.51***	0.55***	0.56***	0.56***
Postsecondary	0.40***	0.34***	0.40***	0.40***	0.40***
Wealth index	0.91***	0.89***	0.92***	0.94***	0.94
Mother's age at first birth: <15 (r)					
15-19	0.89**	0.91	0.88*	0.89*	0.89*
20-24	0.80***	0.81***	0.81***	0.82***	0.82***
25+	0.71***	0.70***	0.68***	0.68***	0.68***
Mother obtained tetanus injection before birth	0.72***	0.75***	0.78***	0.77***	0.77***
Mother delivered in hospital/health center	0.85***	0.83***	0.87***	0.86***	0.86***
Immunization status: No BCG shot (r)					
BCG shot		0.58***	0.59***	0.58***	0.58***
Child sex: Female (r)					
Male			1.04	1.04	1.04
Location: Urban (r)					
Rural			1.50***	1.45***	1.45***
Total number of children under five years			1.33***	1.33***	1.33***
Regional controls				Yes	Yes
Interactions: Wealth index*No BCG shot (r)					
Wealth index*BCG shot					1
Failures (N)					
Subjects (N)	**9636**	**9121**	**9121**	**9121**	**9121**
Log Likelihood	**-29412.8**	**-25027.6**	**-24874.5**	**-24862.3**	**-24862.3**
chi2	**490.64**	**557.04**	**807.86**	**836.71**	**837.38**
Overall pvalue	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Level of significance : * p<.1; ** p<.05; *** p<.01; (r)= reference category					

Figure 6: Kaplan Meier Survival Functions by BCG Vaccine


0.00
0.25
0.50
0.75
1.00
0
20
40
60
Child age in months
No BCG shot
BCG shot