Prenatal quality and child mortality outcomes in Zimbabwe

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Abstract: The effect of the quality of prenatal care on child mortality outcomes has received less attention in sub-Saharan Africa. This study sought to explore the consequence of the quality of prenatal care and its individual components on neonatal, infant and under-five mortality using the three most recent rounds of the nationally representative Demographic and Health Survey data for Zimbabwe conducted in 1999, 2005/06 and 2010/11. The model for the demand for the quality of prenatal care is estimated using an OLS regression while the child mortality models are estimated using standard probit regressions. Since infant mortality rates and access to quality prenatal care might differ by rural and urban residence, we estimate separate models for the overall sample, urban and rural samples. The results indicate that a one-unit increase in the quality of prenatal care lowers the risks of neonatal, infant and under-five mortality by nearly 36%, 29.31%, and 27.53% respectively for the overall sample. The probability of neonatal, infant and under-five mortality is lowered by about 41.67%, 35.18%, and 30.77% respectively for urban-born children following a one-unit increase in the quality of prenatal care. For the rural sample, we found that a one-unit increase in the quality of prenatal care lowers the risks of neonatal, infant and under-five mortality by nearly 34.61%, 27.12%, and 25.35% respectively. These findings are all statistically significant at the 1% significance level. Examining the effect of individual prenatal care components on child mortality revealed that blood pressure checks, information on pregnancy complications, iron supplementations, and tetanus vaccinations are all important in lowering child deaths. Overall, our results suggest the need for public health policy makers in Zimbabwe to focus on ensuring high-quality prenatal care especially in low-income and rural segments of the population to save Zimbabwe's children.

Key words: Quality of prenatal care; neonatal, infant and under-five mortality; rural and urban communities; sub-Saharan Africa; Zimbabwe

Introduction

Previous research suggests that women who seek prenatal care during pregnancy are more likely to have healthier babies and less liable to experience child deaths than their counterparts who do not seek antenatal care (Gajate-Garrido 2013; Habibov & Fan 2011; Liu 1998; Maitra 2004; Mwabu 2009; Wehby et al. 2009b). However, the question of whether a causal relationship exists between prenatal care and child health is still an object of empirical research particularly in developing countries where only recently research has started to emerge (Awiti 2014; Gajate-Garrido 2013; Mwabu 2009). Prenatal care is the medical attention received by women from the time of conceiving up to but excluding labor and delivery (Harris 1982). A clear understanding of the underlying mechanisms and pathways through which prenatal care use affects child health is of particular importance to Zimbabwe, a country currently experiencing one of the worst infant and child health outcomes in sub-Saharan Africa (SSA) (WHO 2015). The designing of appropriate public health policies targeted at reducing infant and child mortality requires information on the importance and effectiveness of prenatal care on newborn and under-five mortality. Moreover, healthcare planners, policymakers, and other stakeholders will likely be interested in knowing whether it is the quality or the frequency of prenatal care that is relatively important in improving infant and child health outcomes. This information is particularly useful in aiding decision making both in the short and long-run periods to achieve cost-effective public health policies (Morris et al. 2007).

There are numerous channels through which prenatal care might positively influence infant and child health outcomes. First, through seeking prenatal care, women go through behavioral education to discourage unhealthy behaviors such as smoking and drinking alcohol during pregnancy. Second, women receive different nutritional intake advice targeted at improving their dietary habits and consequently the health of their unborn child. Third, prenatal care benefits women through parental advisory that prepares them for motherhood. Lastly, it lowers the risks of morbidity (Alexander & Korenbrot 1995) and decreases the chances of terminating a pregnancy (Lincetto et al. 2006).

The relationship between prenatal care and infant and child health outcomes in developed countries has received lots of attention (Behrman & Rosenzweig 2004; Joyce & Grossman 1990; Rosenzweig & Schultz 1983). In the context of developing countries where poor pregnancy outcomes are mostly problematic, research is surprisingly scarce. Existing studies for developing countries mainly focus on the impact of prenatal care on child health measured at birth (birth weight) (Awiti 2014; Celik & Younis 2007; Habibov & Fan 2011; Maitra 2004; Mwabu 2009; Todd Jewell & Triunfo 2006). Except for the study by Maitra (2004) for India and Panis and Lillard (1994) for Malaysia, all the mentioned studies for developing countries focus on the impact of prenatal care on child's birth weight and none of these focus on prenatal care's impact on neonatal, infant and under-five mortality. Besides, we are not aware of any studies that assess the impact of the quality of prenatal care on infant outcomes. An understanding of the connection between the quality of fetal care and child health outcomes beyond those observed at birth is of significant interest to health practitioners and public health policy makers in developing countries.

Against this background, the focus of this study is on examining the impact of the quality of prenatal care on the likelihood of children dying within the first 28 days (neonatal mortality), first 12 months (infant mortality) and first five years of life (under-five mortality) in Zimbabwe. There are few reasons why we should be focusing on examining the effects of prenatal care on infant and child mortality in Zimbabwe.

First, Zimbabwe still has one of the highest mortality rates for children in SSA and the world (Unicef 2015; WHO 2015). Besides, high mortality rates for children have continued to co-exist with high formal prenatal care rates (ZIMSTAT 2012). Second, there exists a gap in research on the effect of the quality of prenatal care on child mortality outcomes in settings with high infant mortality rates particularly in SSA (WHO 2015). Surprisingly, there is a dearth of empirical studies focusing on the impact of the quality of prenatal care on child mortality. In Malaysia and India, the frequency of prenatal care has been found to significantly lower infant mortality (Maitra 2004; Panis & Lillard 1994). This study adds to the current discussions in developing countries on the effects of prenatal care on child health outcomes by evaluating the effectiveness of the quality of prenatal care and its components on neonatal, infant and under-five mortality in Zimbabwe. To the best of our knowledge, this is the first study that attempts to examine the critical role played by the quality of prenatal care in saving Africa's infants.

Background

Zimbabwe is a landlocked country established in central southern Africa sharing borders with Mozambique, Botswana, Namibia, South Africa, and Zambia. Following its independence in 1980, the Zimbabwe government headed by Robert Mugabe inherited an arguably fragmented health system which was principally urban-centric and biased towards therapeutic health services (Chinemana & Sanders 1993; Loewenson et al. 1991). Post-independence policies were targeted at correcting any pre-independence inequities in access to medical health services (Bassett et al. 1997). Thus, achieving the goal of equity meant an increase in health expenditures and expansion in primary health care centers through the implementation of the Primary Health Care (PHC) approach in 1980 (Bassett et al. 1997). One of the central goals of the PHC approach was to improve maternal and neonatal health. Achieving these goals meant (i) the implementation of a comprehensive and well supported antenatal and postnatal care program; (ii) the adoption of a national expanded program on immunization; and (iii) the use of village health workers to monitor the health of children at the community level. By 1989, the number of medical centers and clinics in rural areas had risen from 247 in 1980 to 1,062. The increase in health facilities improved access to sanitary facilities such that nearly 85% of the population was living within proximity of health centers (8-10 kilometers). The improved access to sanitary services coincided with significant reductions in infant mortality by nearly half from 100 to 50 deaths per 1,000 live births between 1980 and 1990. The combined impact of the PHC initiatives coupled with the setting-up of the Child Survival Foundation in 1983 contributed to the reductions in under-five mortality from 104 to 75 deaths per 1,000 live births in 1978/82 and 1983/88 periods, respectively (MoHCW 2010).

In 1991, Zimbabwe implemented the Economic and Structural Adjustment Programme (ESAP) which was a package of economic reforms that included the reduction of social expenditures, devaluation of the local currency, trade liberalization and the enforcement of health user fees (Bijlmakers et al. 1995). The ESAP period saw a reduction in economic growth which shifted the focus from equity to cost recovery and efficiency (Bassett et al. 1997). However, some of the gains in maternal and child health have been reversed by the ravaging effects of the acquired immuno-deficiency syndrome (AIDS), chronic droughts, the economic crisis over the past decade or so, outmigration of skilled health personnel, and a deterioration in the quality of health infrastructure (ZIMSTAT 2010). Building on the agreements and objectives of various regional and international conferences that seek to promote maternal and child well-being, Zimbabwe adopted the Maternal and Neonatal Health (MNH) roadmap 2007-2015 launched in 2009 to promote maternal and child health outcomes. To date, many other initiatives targeted at improving maternal and infant health have been implemented (MoHCW 2010).

Following the leadership of the World Health Organization, the Zimbabwe MNH program promotes a minimum of four prenatal care visits cataloged at 16 weeks, 24-28 weeks, 32 weeks, and 36 weeks for healthy women with no underlying medical problems (Lincetto et al. 2006). Also known as "focused antenatal care," each visit includes care that is appropriate to the woman's overall fitness and stage of pregnancy and facilitates preparation for birth and care for the newborn. The first visit confirms the pregnancy, estimates the date of delivery, screens, and tests the mother for potential sexually transmitted infections, offers treatments, preventive measures, develop a birth and emergency plan as well as offer education and counsel. At each corresponding visit, the woman gets a urine, blood, weight, and blood pressure check including other educational advice (Lincetto et al. 2006).

Methods

Data

The empirical analysis uses data from four three rounds of the nationally representative Zimbabwe Demographic and Health Survey (ZDHS) conducted in 1994, 1999, 2005/06 and 2010/11. The ZDHS collects detailed health information for women of reproductive ages 15-49 and their children. This survey employed a stratified two-stage cluster sample scheme based on the Zimbabwe population censuses of 1982, 1992 and 2002. The initial stage comprised a random sampling of the enumeration areas followed by a random sampling of households (excluding individuals living in institutional facilities such as army barracks, hospitals, police camps, and boarding schools) at the second stage. The analysis in this study uses the child data file of the ZDHS, which contains both parental and household characteristics as well as child health information for the most recent birth that occurred within the five years before each survey.

Our sample is a pooled cross-section of 11,288 women who gave birth to 14,452 children five years preceding each survey. We combine the multiple rounds of the ZDHS to have a broader understanding of the data, have a bigger sample size to improve the precision of the estimates as well as provide more robust estimates (Lockwood et al. 2011). Also, pooling across multiple surveys allows us to examine the trends in child mortality. To minimize the potential bias associated with pooling multiple cross-sectional surveys, we adjusted the survey weights such that the initial sampling probabilities were preserved in each survey. Then, we rescaled the sampling weights so that each survey received an equal weight and making the assumption that the overall population did not significantly change to the extent of altering our conclusions. The final sample weights consist of the original ZDHS weights adjusted to reflect pooling across multiple surveys.

Table 1 furnishes the breakdown of our sample including the characteristics of the women with missing information on prenatal care by survey year. From the original sample of 11,288 interviewed women in the three selected ZDHS, 3,434 (30.42%) women had missing information on prenatal care, 1,006 in 1999, 1,075 in 2005/06, and 1,349 in 2010/11. Many of these women have completed primary school or less, mostly unemployed, have limited access to information, reside in rural areas and have above average child mortality rates. For example, women with missing prenatal care information in 1999 had an average under-five mortality rate of about 9% while those with non-missing prenatal care information had an average under-five mortality rate of nearly 8.1% representing an 11.11% $((9/8.1 - 1) * 100)$ difference. Women with missing prenatal care information in 2010/11 had an average infant mortality rate of approximately 6% while those with non-missing prenatal care information had an infant mortality rate of nearly 5.5% representing a 9.09% $((6/5.5 - 1) * 100)$ difference.

[Insert Table 1 here]

Child mortality and prenatal care quality measures

The ZDHS collects detailed birth histories information for every respondent of reproductive ages 15-49 interviewed in the survey. This information includes the dates of birth and death of all the children the woman has ever had including the age at death measured in days, months and years for the deceased children. We construct three measures to indicate mortality of children in neonatal, infancy and childhood phases. First, we created a binary variable taking 1 if the child died before reaching the age of 28 days (neonatal period) and 0 otherwise. Second, we created a binary indicator equals 1 if the child died before reaching the age of one year and 0 otherwise. Lastly, we construct an indicator for under-five mortality, which equals 1 if the child died before reaching the age of five years and 0 otherwise. It is imperative to note that these mortality rates might deviate slightly from published estimates by the ZDHS because of the different sample sizes considered. The ZDHS calculates the mortality rates using information for all the children who died five years preceding each survey yet, the present analysis only considers the most recent birth of each woman that occurred within the five years before each survey.

In the ZDHS, women of reproductive ages 15-49 years are asked a series of questions related to their use of prenatal care for the most recent pregnancy. These questions include whether they went for prenatal care (yes or no), whom they had seen (a doctor, nurse/midwife, auxiliary midwife, traditional birth attendant, community/village health worker and others), the place where prenatal care was received, and the number of times they sought prenatal care. For the subsample of women who had received at least one antenatal care visit, the ZDHS also collected information regarding the quality of the care as well as the specific components received. Each interviewed woman answered seven questions related to the specific elements she had received during her routine prenatal care visits. These components include; (1) blood pressure checks, (2) urine sample tests, (3) blood sample tests, (4) information regarding pregnancy complications including where to go in case of experiencing such things, (5) tetanus vaccinations, (6) iron and folic acid supplementations, and (7) malaria tablets. Each response was coded as 1 if a specific service was received and 0 otherwise. Following Deb and Sosa-Rubi (2005) we created an index to measure the quality of prenatal care found by adding up all the "yes" responses for each woman. Additionally, we checked whether the services received differed by the level of education or household wealth status of the woman. The results furnished in Table 2 suggest that the percentage of women receiving each of the available components of prenatal care (except for malaria tablets) increases with the level of education and household wealth. For example, 75% of the women with less than primary schooling received tetanus vaccinations compared to only 78%, and 83% with complete primary and more than primary school respectively. Similarly, nearly 78%, 80%, and 83% of the women in the low, average and high wealth categories received tetanus vaccinations during their most recent pregnancy, respectively.

[Insert Table 2 here]

Demand function for the quality of prenatal care

The decision to get a certain quality of prenatal care is thought to depend on a set number of individual characteristics, parental and household characteristics as well as other factors as identified in the previous literature. We controlled for many maternal-level features including the woman's age at the time of birth, marital status, religious beliefs, height (in centimeters) and previous birth experiences, pregnancy wantedness at the date of conception, and the number of live births in the last five years. Religious beliefs are believed to influence the attitudes towards modern health facilities (Chama-Chiliba & Koch 2015; Mekonnen & Mekonnen 2002; Muchabaiwa et al. 2012). The mother's previous birth experiences might influence the decision to seek prenatal care with negative experiences driving her to either seek more or timely care (Gajate-Garrido 2013). Height is a measure of her long-term health status which can also influence her decision to use care with healthy mothers more liable to seek fetal care (Gajate-Garrido 2013). Also included is the woman's education level and her employment status since these are considered enabling and efficiency factors (Wehby et al. 2009a). Variables indicating the woman's exposure to information have also been found to influence the demand for prenatal care in India (Maitra 2004). We, therefore, include binary indicator variables to measure information access (whether the woman watches television, read newspapers or magazines, and listens to the radio at least once a week) and health insurance coverage. The individual child level variables we included are indicators for the child's year of birth. We exclude the birth order of the child due to potential endogeneity conacerns. At the household level, we included indicators for household wealth quintiles. To control for the possibility of regional differences in access to prenatal care, we included provincial dummy variables including an indicator for urban residence. We also controlled for the potential effect of time due to pooling the data by including indicators for the year of survey. However, in some specifications, some of the survey indicators were dropped due to possible multicollinearity with the child's year of birth binary variables.

Neonatal, infant and under-five mortality functions

We model neonatal, infant and under-five mortality as functions of prenatal care use and other explanatory variables included in the antenatal care quality demand function. Additionally, we include indicators for the child's sex (=1 if female) and the number of births in the last five years. A complete description of all the variables used in the study is found in Table 3 including the summary statistics broken down by the year of survey.

Econometric model

For us to understand the relationship between the quality of prenatal care and child survival, we estimate the following equation:

$$H_i = \beta_0 + \beta_1 \times Prenat_i + \beta_2 X_i + \varepsilon_i \qquad (1)$$

where H_i is a measure of child health; $Prenat_i$ is a measure of the quality of prenatal care use which is either a continuous variable (quality index) or a binary indicator (individual components of prenatal care), β_1 is the primary coefficient of interest measuring the impact of the quality of prenatal care on infant and child mortality if all other factors remain unchanged; X_i is a vector of maternal and child-level characteristics, and ε_i is an idiosyncratic error term.

Equation (1) is estimated via a probit regression model with cluster-robust standard errors at the primary sampling unit to correct for potential heteroskedasticity in the error terms (Breusch & Pagan 1979). The primary sampling units in the ZDHS correspond to smaller geographic units also known as enumeration areas (EAs) which resemble smaller communities within wards (ZIMSTAT 2012). For ease of interpretation, we reported the marginal probability effects along with their 95% confidence intervals. The demand for the quality of prenatal care as measured by the quality index is estimated via an ordinary least squares regression (OLS) model of the following form:

$$Prenat_i = \alpha_0 + \alpha_1 X_i + \epsilon_i \qquad (2)$$

As in equation (1), we estimate equation (2) with cluster-robust standard errors at the primary sampling unit and report the coefficient estimates together with White's robust standard errors (Breusch & Pagan 1979). Numerous studies estimate equation (1) or a variant of it using instrumental variable methods to account for potential selection bias arising from the voluntary nature of the prenatal care decision (Habibov & Fan 2011; Maitra 2004; Wehby et al. 2009a). In this study, we argue that mothers seek prenatal care have no control over the services they receive during each antenatal care visit. In other words, these women receive the specific components of prenatal care as chosen by the service providers or caregivers, making these services exogenous in empirical estimation of equation (1). Thus, the antenatal care quality index created from the individual prenatal care components is also assumed to be exogenous in the empirical estimation of equation (1).

Results

Descriptive statistics

Table 3 provides the descriptions and survey-weighted percentages of all the variables used in the analysis for each survey year. Recall that the analysis in this study focuses on the most recent birth of each interviewed woman that occurred five years before each survey. The average neonatal mortality rate ranges from 2.9% in 1999 to about 3% in 2010/11. This shift represents a 3.44% $((3.0/2.9 - 1) * 100)$ increase in the neonatal mortality rate over the 1999-2010/11 period. Likewise, the infant mortality rate declined by an approximate 19.12% $((1 - 5.5/6.8) * 100)$ over the same period. Regarding under-five mortality, the average death rate in 2010/11 was 6.9% representing an approximate 14.81% $((1 - 6.9/8.1) * 100)$ decline from the 1999 under-five mortality rate. On the average, the number of women completing four or more prenatal care visits during pregnancy declined from 74.5% in 1999 to 73.1% in 2010/11, representing an approximate 1.88% $((1 - 73.1/74.5) * 100)$ overall reduction. The average number of services received by women during prenatal care changed from 3.3 services in 1999 to about 3.2 services in 2010/11. This change represents an overall 3.03% decline in the number of antenatal care services received over the 1999-2010/11 period. The drop in prenatal care utilization observed between 1999-2010/11 is possibly a result of the deterioration in the quality of health services, outmigration of key health personnel, continued dilapidation of existing health infrastructure and the ravaging effects of the economic recession that started in early 2000 (WHO 2010). The breakdown by each received service indicates that pregnant women are more liable to get a blood pressure check (84.8%), tetanus vaccinations (80.2%) and a blood sample test (71.4%) at each prenatal care visit completed. Also, a principal components analysis (PCA) of the seven services received during antenatal care visits reveal that blood pressure checks, blood tests, and urine sample tests are the three top drivers of the quality of prenatal care (the results not shown here are made available upon request). The percentage of women (observed at survey date) with more than completed primary school has increased over time from 47.8% in 1999 to 65.9% in 2010/11.

[Insert Table 3 here]

The average age at birth of the women in our entire sample is about 25.8 years with a mean height of 159.7 centimeters. The percentage of women in gainful employment is about 41.1% and has declined over time from 51.8% in 1999 to nearly 34.8% in 2010/11. Approximately 49.4 % of the children are females and the average parity for the women in our sample is nearly 1.5 births for the five years preceding each survey. Figure 1 shows the time trends in overall mortality rates in our data by child's year of birth. The trends indicate a decline in infant mortality between 1990 and 1994 possibly due to the impact of the ESAP reforms implemented by the Zimbabwe government in 1990. From 1995 to about 2001, we observe a flat evolution in neonatal and infant mortality. From 2001 onwards, child mortality has been on an upward trend partly due to the economic crisis that started in 2000 together with the devastating effects of the HIV/AIDS epidemic. Despite the observed overall declines in mortality, the average child mortality rates are still unacceptably high in Zimbabwe. A comparison of the frequency and quality of prenatal care reveals that women who complete more antenatal care visits also receive a high-quality prenatal care (Spearman's rho = 0.4356 and p = 0.0000).

[Insert Figure 1 here]

The demand for the quality of prenatal care

Table 4 presents the OLS model results for the demand for the quality of prenatal care together with the heteroskedasticity-robust standard errors shown in parentheses. Since the demand for antenatal care might differ by rural and urban residence (Chama-Chiliba & Koch 2015), we perform the analysis of the overall sample, an urban sample, and a rural sample. The results indicate that a one-centimeter increase in the height of the woman increases the quality of prenatal care by about 0.006 (0.007 for the rural sample) units (statistically significant at the 10% level). Also, we find that the quality of prenatal care increases with the mother's level of education. The quality of prenatal care received is likely to increase by approximately 0.434 and 0.248 units for women living in urban and rural communities respectively.

We also find that women who frequently watch and read newspapers or magazines at least once every week are more liable to receive a higher quality of prenatal care. For instance, women living in Zimbabwe's rural and urban areas who report reading newspapers or magazines at least once every week are likely to increase the number of services received during prenatal care by nearly 0.301 and 0.252 respectively. This finding is statistically significant at the 1% and 5% levels for rural and urban samples respectively. As expected, living in an urban area is positively associated with a higher quality of prenatal care. Moreso, women from low (high) wealth households, are less (more) likely to receive high-quality prenatal care, respectively. Particularly, we find that women from low-wealth families and living in rural areas are likely to get a quality of prenatal care that is lower by about 0.202 services.

[Insert Table 4 here]

The results also indicate that rural women with Christian values are more liable to increase the number of services received during prenatal care by approximately 0.165 services. This result is statistically significant at the 5% significance level. Overall, the results also suggest that women from high wealth backgrounds are likely to increase the number of received prenatal care services by approximately 0.189 while those from large families are likely to reduce the quality of prenatal care received by nearly 0.058 services. All the models included controls for provinces, child's year of birth and year of survey.

Impact of the quality of prenatal care on child mortality

Table 5 presents the marginal probability effects (including the 95% confidence intervals) of prenatal care quality on neonatal, infant, and under-five mortality in Zimbabwe. Since previous studies suggest that child death rates might differ by rural and urban residence (Van De Poel et al. 2009), we provide infant mortality estimates for the overall sample, urban, and rural samples separately (Van De Poel et al. 2009). Panel A of Table 5 shows the results from the overall sample of children with non-missing prenatal care information. The results indicate that increasing the quality of antenatal care by one unit or service (possibly tetanus vaccinations, blood pressure checks, or blood sample test) reduces the risk of neonatal mortality by about 0.9 percentage points. This outcome is statistically significant at the 1% significance level. Given that on the average 2.5% infants in our sample died before reaching 28 days, the decrease in neonatal mortality following a one-unit increase in the quality of received prenatal care represents an approximate 36% $(0.009 * 100/0.025)$ decrease in neonatal mortality rate.

Our results also indicate that a one-unit increase in the quality of received prenatal care lowers the probability of infant and under-five mortality by approximately 1.7 and 1.9 percentage points respectively and statistically significant at the 1% significance level. The decreases represent an approximate 29.31% $(0.017 * 100/0.058)$ and 27.53% $(0.019 * 100/0.069)$ declines in child mortality given that nearly 5.8% and 6.9% of the children in our sample died before reaching the ages of one year and five years respectively. The results also indicate that the hazard of neonatal, infant and under-five mortality is higher for women with previously terminated pregnancies, and high parity. Female infants and children have a lower likelihood of death compared to their male counterparts.

[Insert Table 5 here]

Panel B of Table 5 presents the mortality estimates for children living in urban communities. The results indicate that increasing the quality of prenatal care by one unit lowers the risk of neonatal, infant and under-five mortality by 1.0, 1.9, and 2.0 percentage points respectively. These results are all statistically significant at the 1% significance level. The decline in neonatal deaths following a one unit increase in the quality of prenatal care in urban communities represents an approximate 41.67% $(0.010 * 100/0.024)$ decline in neonatal fatalities given that nearly 2.4% of the children in our urban sample died before celebrating their first month of birth. Similarly, the 1.9 percentage point decline following a one unit increase the quality of received prenatal medical care represents an approximate 35.18% $(0.019 * 100/0.054)$ decrease in infant fatalities given that about 5.4% of the children in our urban sample died before celebrating their first ever birthday. Also, the rate of under-five mortality in urban areas is lowered by about 30.77% $(0.020 * 100/0.065)$ following an increase in the quality of prenatal care by one service. For the urban sample, we also found that the risk of child mortality increases for non-single births. We also found that the risk of infant death decreases with increasing number of under-five children within a household.

The bottom panel of Table 5 (panel C) shows the results for the rural sample. We find that, following an increase in the quality of prenatal care by one unit neonatal mortality declines by 0.9 percent points and statistically significant at the 1% level. This decrease represents an approximate 34.61% $(0.009 * 100/0.026)$ decrease in neonatal mortality given that nearly 2.6% of the infants living in rural communities died before reaching 28 days over the 1999-2010/11 period. Following a one unit increase in the quality of prenatal care, the probability of infant and under-five mortality by 1.6 and 1.8 percentage points respectively. The 1.6 percentage point decrease represents an approximate 27.17% $(0.016 * 100/0.059)$ fall in infant mortality given that nearly 5.9% of the children in our rural sample die before reaching 12 months. Similarly, the 1.8 percentage point decrease represents an approximate 25.35% decline in under-five mortality given that about 7.1% of the under-fives living in the rural areas die before reaching the age of five years.

The impact of individual prenatal care components on child mortality

To further understand the effect of the quality of prenatal care on infant mortality, we examined the impact of each service received during antenatal care on neonatal, infant, and under-five mortality. Table 6 presents the results of the influence of the prenatal care components on our child mortality outcomes. Panel D presents the results for the overall sample, Panel E for the urban sample and Panel F shows the results for the rural sample. Each row represents a separate probit regression model estimated to examine the impact of each prenatal care component on neonatal, infant and under-five mortality respectively.

[Insert Table 6 here]

The results from the overall sample reveal that women who receive blood pressure checks during prenatal care are 1.6 and 2.5 percentage points less liable to experience an infant and under-five death respectively. This finding is statistically significant at the 10% and 5% significance levels. Also, the results indicate that women who receive information on the dangers to look out for during prenatal care are about 0.9 percentage points less liable to lose their newborn child during the neonatal period (statistically significant at the 1% level). The impact on infant and under-five mortality was statistically insignificant. We failed to get a statistically significant impact of blood sample tests, sample urine checks and malaria tablets on child mortality outcomes.

The likelihood of neonatal mortality decreases by nearly 1.7 percentage points for women who take iron tablets during pregnancy. The impact of iron tablet consumption is even larger on infant and under-five mortality. Particularly, we find a 2.9 and 3.5 percentage reduction in infant and under-five mortality respectively. Also, we find that children born to mothers who receive tetanus vaccinations during pregnancy are 0.9, 1.5, and 1.9 percentage points less likely to die in neonatal, infant and under-five periods respectively.

The results for the urban sample presented in Panel E reveal an almost similar pattern as in the overall sample. We find that women who receive blood pressure checks during their pregnancy are 7.1 and 6.7 percentage points less likely to experience an infant and under-five death respectively. Also, women receiving iron tablets and tetanus vaccinations during prenatal care are less likely to experience a neonatal, infant and under-five death respectively, than their counterparts who never receive these services. We also could not find any statistically significant effect of sample blood checks, urine tests, pregnancy complications information on child mortality outcomes.

Panel F shows the results for women living in rural communities. The results indicate that women who receive blood pressure checks during prenatal care visits are 1.9 percentage points less likely to experience an under-five mortality death compared to their counterparts who do not receive such a service. This result is statistically at the 10% significance level. The risk of neonatal mortality was 1.0 percentage point lower for women who were provided with information on the dangers of pregnancy complications and where to seek help in the case of such experiences. Also, women who received iron tablets had a 1.6, 3.0, and 3.5 percentage point reduction in the risk of neonatal, infant and under-five mortality respectively. Receiving tetanus vaccinations during pregnancy was associated with a 1.7 percentage point reduction in under-five mortality. This result was statistically significant at the 10% significance level. We did not find any statistically significant effect of blood pressure checks, sample blood checks, urine tests, and malaria tablets on child mortality outcomes. Also, receiving tetanus vaccinations was not associated with a statistically significant reduction in the likelihood of neonatal and infant mortality.

Discussion

This study examines the effect of the quality of prenatal care on neonatal, infant and under-five mortality using data from the nationally representative ZDHS conducted in 1999, 2005/06 and 2010/11. The model for the demand for the quality of prenatal care is estimated using an OLS regression while the child mortality models are estimated using probit regressions. Since mortality rates for children and access to prenatal care might differ by rural/urban residence, we estimate separate models for the overall sample, urban and rural samples. The results indicate that a one-unit increase in the quality of prenatal care lowers the risk of neonatal, infant and under-five mortality by nearly 36%, 29.31% and 27.53% respectively for the overall sample. The hazard of neonatal, infant and under-five mortality is lowered by about 41.67%, 35.18%, and 30.77% respectively for women living in urban areas following a one-unit increase in the quality of prenatal care. For the rural sample, we found that a one-unit increase in the quality of prenatal care diminishes the risk of neonatal, infant and under-five mortality by nearly 34.61%, 27.12%, and 25.35% respectively. These findings are all statistically significant at the 1% significance level.

Additionally, we examined the impact of the individual prenatal care components on the probability of infant and child death. The results indicate that women receiving blood pressure checks during pregnancy have a significantly lower risk of experiencing an infant and under-five death compared to their counterparts not receiving such services. Also, we found that women receiving information on pregnancy complications arising during pregnancy are less likely to experience a neonatal death (statistically significant at the 1% level). Lastly, we also found that women who receive iron tablets and tetanus vaccinations are less liable to experience a neonatal, infant or under-five mortality. Broadly, our results corroborate previous other studies by Panis and Lillard (1994) for Malaysia and Maitra (2004) for India who found a protective effect of the frequency of prenatal care on child mortality outcomes. We differ from the India and Malaysian studies only in our focus on the role of individual prenatal care components on child mortality.

The results for the urban and rural samples suggest a slight urban advantage on the efficiency of high quality prenatal medical care. The finding that increasing the quality of prenatal care by one-unit lowers the risk of neonatal mortality by about 41.67% compared to 34.61% for rural communities supports this possibility of an urban advantage. This finding might be an artifact of the rural/urban differences in access to high-quality medical services. In Zimbabwe, the concentration of health facilities and resources is by far to the advantage of urban communities compared to rural areas (WHO 2010; ZIMSTAT 2011). It is plausible that urban areas simply possess superior health resources than rural communities hence the observed prenatal care efficiency and the observed child survival advantage. In a related study, Makate and Makate (2016) also found that non-poor households living in urban areas of Zimbabwe have better access to maternal health care services than their relatively poor and rural counterparts. Their analysis also reveals that access to maternal health care services such as prenatal care has declined over the years by larger margins for rural communities than for urban areas (Makate & Makate 2016).

The results from the effect of individual prenatal care components on child mortality outcomes reveal that women receiving blood pressure checks during pregnancy are less liable to experience an infant and under-five death. This finding highlights the importance of blood pressure checks during pregnancy. Routine blood pressure checks are an essential component of prenatal care visits since high blood pressure during pregnancy poses numerous risks to the mother and the unborn. For example, high blood pressure during pregnancy might result in decreased blood flow to the placenta which restrains the movement of oxygen to the baby which potentially retards growth (Obstetricians & Gynecologists 2013; Tranquilli et al. 2014). A high blood pressure might also result in premature delivery hence increasing the risks of infant death.

We also found that women receiving iron tablets during pregnancy are less likely to lose their child in the neonatal, infancy and under-five periods. Consumption of iron tablets during pregnancy helps lower the risks of experiencing stillbirths, low birth weight, premature and newborn deaths (Lincetto et al. 2006). Previous research has established that premature births and low birth weight births account for nearly 30% of global neonatal deaths (Bryce et al. 2005) as well as high malnutrition rates (Abu-Saad & Fraser 2010). The consumption of iron and folic acid supplementations during pregnancy helps reduce the impact of anemia (Lincetto et al. 2006), one of the threats to child survival (Wendland 2012).

The finding that women who receive tetanus vaccinations during pregnancy have important implications for public health policy. In developing countries particularly SSA, tetanus kills nearly 70,000 newborns every single year with 6% of these deaths being neonatal deaths (Lincetto et al.

2006). The consumption of tetanus vaccinations during pregnancy becomes a critical component of any effective public health policy.

According to Unicef (2015), nearly 13,000 infants died within the first 28 days of life in 2015, representing a neonatal mortality rate of 24 deaths per 1,000 live births. Putting our findings into a broader perspective and making the assumption that every needy pregnant woman has equal access to high-quality prenatal care, our results imply substantial mortality reductions. Our findings suggest that nearly 4,875 $(9 * 13000/24)$ neonates would have been saved had all the women received equal and adequate quality prenatal care. Similarly, given that the infant mortality rate was 47 deaths per 1,000 live births (25,000 deaths), the 1.7 percentage point reduction in infant mortality we found implies that nearly 9,042 $(17 * 25000/47)$ children out of the 25,000 who died in 2015 would have survived had all the women received adequate and equal high-quality prenatal care. Finally, given that a total of 38,000 children died in 2015, the 1.9 percentage points reduction in under-five deaths implies that approximately 10,169 $(19 * 38000/71)$ children would have survived in 2015 if all the mothers had received all the required components of prenatal care during pregnancy.

Our analysis is not without limitations. We acknowledge the fact that the study is only limited to the most recent birth for each woman that occurred within the five years before each survey for which we observe prenatal care information. This data limitation is potentially problematic as it makes it difficult for us to generalize the results to broader contexts. It would be interesting to analyze the within-women differences in prenatal care use on the survival probabilities among siblings. Also, the restriction to the most recent birth might pose a sample selection bias which could potentially impact our estimates. However, since these limitations are a result of the data collection methodology adopted by MEASURE DHS, we are unable to examine any within-sibling differences in survival. Besides the noted concerns, our estimates are still a significant contribution to the literature.

Conclusion

This study examines the impact of prenatal care on neonatal, infant and under-five mortality in Zimbabwe, a country still experiencing poor pregnancy outcomes. Our results suggest that increasing the quality prenatal care lowers the likelihood of neonatal, infant, and under-five mortality even after controlling for various confounders. There is a need for public health policy makers to ensure that pregnant women receive all the essential components of an essential prenatal care program which include the receipt of blood pressure checks, blood sample tests, urine sample tests, information regarding pregnancy complications, malaria tablets, iron tablets and tetanus vaccinations. Overall, our results suggest the need for public health policy makers in Zimbabwe to focus on ensuring high-quality prenatal care especially in low-income and rural segments of the population to save Zimbabwe's children.

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Table 1: Characteristics of women with missing prenatal care information by year of DHS survey, Zimbabwe 1994-2011

Variables	1999		2005/06		2010/11	
	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)
Total number of interviewed women*	2818	-	4073	-	4397	-
Total number of children*	3643	-	5246	-	5563	-
Children with missing prenatal care*	1171	-	1223	-	1227	-
Women with missing prenatal care*	1008	-	1080	-	1116	-
Less than primary education	28	45	37	48	17	37
Complete primary education	25	43	7	26	21	41
More than primary education	47	50	55	50	62	49
Height of mother (centimeters)*	160	6	159	8	160	7
Age at birth*	25	6	24	6	24	6
Employed	51	50	32	47	31	46
Married	97	17	99	12	98	14
Low wealth	37	48	55	50	50	50
Reads newspapers at least once a week	38	48	29	46	31	46
Listens to the radio at least once a week	58	49	46	50	49	50
Watches television at least once a week	30	46	24	43	36	48
Family planning	59	49	65	48	65	48
Urban resident	35	48	22	41	26	44
Terminated pregnancy	10	30	11	32	9	29
Child ever born*	3	2	4	2	3	2
Child is dead in neonatal	11	32	12	33	14	34
Child is dead in infancy	4	19	5	22	6	23
Child is dead before age five	9	29	11	31	10	30

Notes: Except for the variables with an asterisk, all other variables are expressed in percentages. Low household wealth consists of individuals in the two lowest wealth categories as defined in the ZDHS. All estimates are weighted to be nationally representative. SD = Standard Deviation.

Table 2: Services received during prenatal care visits

Prenatal care components	Less than primary education		Complete primary		More than primary school		Low wealth		Average wealth		High wealth	
	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)
Tetanus vaccinations	75	44	78	41	83	37	78	42	80	40	83	38
Iron tablets	36	48	37	48	41	49	37	48	37	48	42	49
Blood pressure check	78	41	80	40	88	32	80	40	82	38	91	29
Urine sample check	56	50	57	50	70	46	54	50	62	49	77	42
Blood sample test	59	49	67	47	77	42	61	49	68	47	83	37
Received information on pregnancy complications	37	48	42	49	56	50	40	49	49	50	59	49
Malaria tablets	8	27	9	28	9	29	11	31	10	29	7	25
Observations	4739		2878		9053		7732		3056		5882	

Notes: Except for the variables with an asterisk, all other variables are expressed in percentages. Low household wealth consists of individuals in the two lowest wealth categories as defined in the ZDHS. All estimates are weighted to be nationally representative. SD = Standard Deviation.

Table 3: Definitions and summary statistics of all the variables used in the analysis

Variables	Definition of the variables	Overall		1999		2005/06		2010/11	
		Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)
Outcome variables									
Neonatal mortality	=1 if child died within the first 28 days of life; 0 otherwise	2.6	15.9	2.9	16.7	2.3	15.0	3.0	17.1
Infant mortality	=1 if child died within the first 12 months of life; 0 otherwise	5.9	23.6	6.8	25.2	6.1	24.0	5.5	22.7
Under-five mortality	=1 if child died before reaching the age of five years; 0 otherwise	7.1	25.6	8.1	27.4	6.9	25.3	6.9	25.4
Four or more prenatal care visits	=1 if woman completed 4 or more prenatal care visits during pregnancy; 0 otherwise	73.5	44.1	74.5	43.6	71.9	45.0	73.1	44.3
Quality of prenatal care*	Prenatal care quality index (see text for details)	3.2	2.3	3.3	2.3	3.1	2.2	3.2	2.3
Components of prenatal care quality index									
Tetanus vaccinations	=1 if woman had tetanus vaccinations during pregnancy; 0 otherwise	80.2	39.8	79.3	40.5	79.8	40.2	80.4	39.7
Iron tablets	=1 if woman received iron tables during pregnancy; 0 otherwise	39.0	48.8	46.6	49.9	33.6	47.2	39.2	48.8
Blood pressure check	=1 if woman had a blood pressure check during pregnancy; 0 otherwise	84.8	35.9	89.1	31.2	87.9	32.6	79.2	40.6
Urine sample check	=1 if woman had a urine check during pregnancy; 0 otherwise	64.5	47.8	80.5	39.6	65.1	47.7	54.0	49.8
Blood sample test	=1 if woman had a blood sample test during pregnancy; 0 otherwise	71.4	45.2	75.2	43.2	64.4	47.9	75.4	43.1
Pregnancy complications	=1 if woman received information regarding pregnancy complications during pregnancy; 0 otherwise	49.5	50.0	42.1	49.4	47.1	49.9	56.4	49.6
Malaria tablets	=1 if woman received malaria tablets during pregnancy; 0 otherwise	8.9	28.4	0.6	7.4	8.6	28.0	14.3	35.0
Age at survey date	Age of the mother (in years) at the time of the survey	27.6	6.6	27.7	6.8	27.5	6.5	27.5	6.3
Age at birth*	Age of the mother at the time of child birth (recent pregnancy) (in years)	25.8	6.4	25.7	6.6	25.6	6.3	25.7	6.3
Age squared*	Age of the mother squared	706.4	365.2	706.3	378.5	695.1	358.6	700.0	351.1
Height (centimeters)	Height of the respondent in centimeters	159.7	6.7	159.6	6.5	159.7	7.1	159.9	6.3
Less than primary school	=1 if woman had less than primary education; 0 otherwise	27.4	44.6	28.6	45.2	34.4	47.5	14.6	35.3
Complete primary school	=1 if woman completed primary education; 0 otherwise	16.7	37.3	23.6	42.5	6.4	24.5	19.6	39.7
More than primary school	=1 if woman completed more than primary education; 0 otherwise	55.9	49.6	47.8	50.0	59.2	49.2	65.9	47.4
Employed	=1 if woman was employed at time of survey; 0 otherwise	41.1	49.2	51.8	50.0	35.4	47.8	34.8	47.6
Child is female	=1 if child is female; 0 otherwise	49.4	50.0	48.7	50.0	49.0	50.0	49.7	50.0
Christian	=1 if the woman is Christian; 0 otherwise	50.5	50.0	80.7	39.5	42.2	49.4	39.4	48.9
Low wealth	=1 if low household wealth (ZDHS wealth quintiles 1 and 2); 0 otherwise	43.3	49.5	39.2	48.8	45.7	49.8	43.9	49.6
High wealth	=1 if high household wealth (ZDHS wealth quintiles 4 and 5); 0 otherwise	38.3	48.6	41.8	49.3	36.9	48.3	37.0	48.3
Urban resident	=1 if woman lives in urban community; 0 otherwise	29.6	45.6	32.6	46.9	28.9	45.3	29.8	45.7

Notes: All estimates are weighted to be nationally representative. SD = Standard Deviation. Variables marked with asterisks are non-binary and thus the averages are not expressed in terms of percentages.

Table 4: Marginal probability effects of prenatal care on neonatal, infant and under-five mortality in Zimbabwe

	Neonatal mortality		Infant mortality		Under-five mortality	
	(1)		(2)		(3)	
Panel A						
Four or more prenatal care visits	-0.0141***	(0.0034)	-0.0201***	(0.0046)	-0.0197***	(0.0047)
Panel B						
Prenatal care quality index	-0.0080***	(0.0007)	-0.0133***	(0.0011)	-0.0147***	(0.0012)
Panel C						
Blood pressure check	-0.0045	(0.0047)	-0.0155*	(0.0070)	-0.0224**	(0.0077)
Blood sample test	-0.0014	(0.0033)	-0.0030	(0.0055)	-0.0025	(0.0060)
Urine sample test	-0.0002	(0.0032)	0.0055	(0.0048)	0.0074	(0.0051)
Told about pregnancy complications	-0.0071**	(0.0025)	-0.0030	(0.0038)	-0.0022	(0.0042)
Received Malaria tablets	0.0025	(0.0042)	0.0118	(0.0068)	0.0110	(0.0073)
Received iron tablets	-0.0046	(0.0024)	-0.0042	(0.0037)	-0.0075	(0.0040)
Tetanus vaccinations	-0.0068	(0.0037)	-0.0155**	(0.0056)	-0.0165**	(0.0061)
Observations	10682		10682		10682	
Mean of the dependent variable	0.0189		0.0431		0.0513	

Notes: ***Significant at 1% level; **significant at 5% level; *significant at 10% level. All estimates are based on robust standard errors (shown in parentheses) and account for clustering at the primary sampling unit. All regressions include the following controls (suppressed for brevity) age of the mother at survey date and its square, mother's height (in centimeters), mothers education level, household wealth, religion, child's year of birth, child's gender (=1 if female), birth type (=1 if non-single birth), year of survey, and a dummy indicator for urban residence.

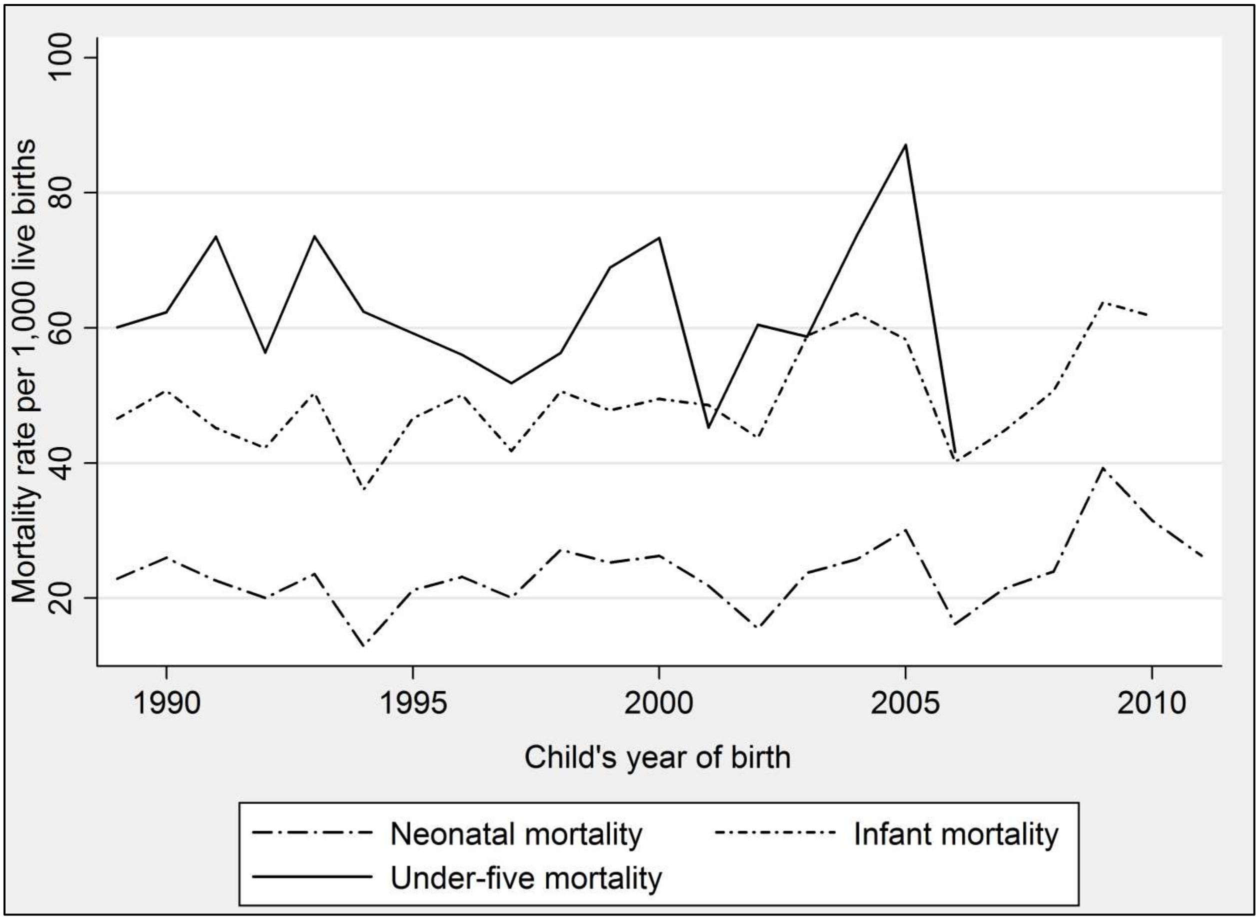

Figure 1: The time trends of child mortality rates. Source: Zimbabwe Demographic and Health Survey (ZDHS), 1994, 1999, 2005/06 and 2010/11.

Supplementary material

Table S1: Marginal probability effects of prenatal care on neonatal, infant and under-five mortality in Zimbabwe

Variables	Neonatal mortality		Infant mortality		Under-five mortality	
	(1)		(2)		(3)	
Prenatal care quality index	-0.0080***	(0.0007)	-0.0133***	(0.0011)	-0.0147***	(0.0012)
Maternal/household-level variables						
Age at survey date	-0.0010	(0.0017)	-0.0013	(0.0024)	-0.0014	(0.0025)
Age squared	0.0000	(0.0000)	0.0000	(0.0000)	0.0000	(0.0000)
Height (in centimeters)	-0.0004	(0.0002)	-0.0009**	(0.0003)	-0.0009**	(0.0003)
Less than primary education	-0.0007	(0.0043)	0.0009	(0.0062)	-0.0021	(0.0065)
Completed primary education	0.0016	(0.0046)	0.0033	(0.0060)	0.0019	(0.0066)
Religious beliefs (Christian)	-0.0009	(0.0032)	-0.0087	(0.0045)	-0.0142**	(0.0050)
Wealth quintile 1 (poorest)	-0.0062	(0.0067)	-0.0110	(0.0093)	-0.0010	(0.0101)
Wealth quintile 2	0.0014	(0.0069)	0.0015	(0.0091)	0.0103	(0.0099)
Wealth quintile 3	0.0001	(0.0065)	-0.0009	(0.0087)	0.0081	(0.0098)
Wealth quintile 4	0.0082	(0.0049)	0.0011	(0.0070)	0.0069	(0.0074)
Child-level variables						
Child is female	-0.0079**	(0.0027)	-0.0130***	(0.0039)	-0.0140**	(0.0044)
Birth type: Non-single	0.1197***	(0.0213)	0.1561***	(0.0242)	0.1479***	(0.0239)
child_yob_1994	-0.0188	(0.0169)	0.0049	(0.0234)	0.0205	(0.0245)
child_yob_1995	0.0086	(0.0161)	0.0383*	(0.0181)	0.0664***	(0.0186)
child_yob_1996	0.0058	(0.0157)	0.0536**	(0.0184)	0.0756***	(0.0193)
child_yob_1997	0.0135	(0.0155)	0.0491**	(0.0169)	0.0633***	(0.0174)
child_yob_1998	0.0381*	(0.0168)	0.0909***	(0.0186)	0.0974***	(0.0189)
child_yob_1999	0.0163	(0.0161)	0.0429*	(0.0176)	0.0455*	(0.0177)
child_yob_2000	-0.0862**	(0.0262)	-0.0026	(0.0393)	0.0484	(0.0462)
child_yob_2001	-0.0565*	(0.0265)	0.0021	(0.0362)	0.0371	(0.0393)
child_yob_2002	-0.0628*	(0.0262)	0.0108	(0.0361)	0.0455	(0.0389)
child_yob_2003	-0.0444	(0.0266)	0.0370	(0.0364)	0.0693	(0.0393)
child_yob_2004	-0.0433	(0.0264)	0.0377	(0.0363)	0.0645	(0.0393)
child_yob_2005	-0.0428	(0.0252)	0.0110	(0.0352)	0.0349	(0.0382)
child_yob_2006	-0.0072	(0.0151)	0.0102	(0.0165)	0.0357*	(0.0175)
child_yob_2007	0.0039	(0.0150)	0.0229	(0.0162)	0.0428**	(0.0164)
child_yob_2008	0.0105	(0.0151)	0.0357*	(0.0162)	0.0602***	(0.0169)
child_yob_2009	0.0292	(0.0160)	0.0579***	(0.0169)	0.0592***	(0.0168)
child_yob_2010	0.0211	(0.0153)	0.0365*	(0.0156)	0.0364*	(0.0156)
Urban resident	0.0021	(0.0056)	0.0066	(0.0066)	0.0117	(0.0079)
Observations	10682		10682		10682	
Mean of the dependent variable	0.0189		0.0431		0.0431	

Notes: ***Significant at 1% level; **significant at 5% level; *significant at 10% level. All estimates are based on robust standard errors (shown in parentheses) and account for clustering at the primary sampling unit. All regressions include the child's year of birth and survey fixed effects (suppressed for brevity). Reference categories: higher education; higher wealth (quintile 5); survey year=2010/11. child_yob = Child's year of birth.