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Original Article

The impact of prenatal care quality on neonatal, infant and child mortality in Zimbabwe: evidence from the demographic and health surveys

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Abstract

The impact of the quality of prenatal care on child mortality outcomes has received less attention in sub-Saharan Africa. This study endeavoured to explore the effect of the quality of prenatal care and its individual components on neonatal, infant and under-five mortality. The empirical analysis uses data from the three most recent waves of the nationally representative Demographic and Health Survey for Zimbabwe conducted in 1999, 2005/06 and 2010/11. The results indicate that a one-unit increase in the quality of prenatal care lowers the prospect of neonatal, infant and under-five mortality by approximately 42.33, 30.86 and 28.65%, respectively. These findings remained roughly the same even after adjusting for potential mediating factors. Examining the effect of individual prenatal care components on child mortality revealed that women who receive information on possible complications arising during pregnancy are less liable to experience a neonatal death. Similarly, women who had blood pressure checks and tetanus immunizations were less likely to experience an infant or under-five death. We did not find any statistically meaningful impact on child mortality outcomes of blood and urine sample checks, iron tablet consumption, and the receipt of malarial tablets. Overall, our results suggest the need for public health policymakers to focus on ensuring high-quality prenatal care to enhance the survival prospects of Zimbabwe's infants.

Key words: Prenatal care quality; neonatal, infant and under-five mortality; sub-Saharan Africa; Zimbabwe

Key Messages

- This study found that a one-unit increase in the quality of prenatal care lowers the plausibility of neonatal, infant and under-five mortality by approximately 42.33, 30.86 and 28.65%, respectively.
- Women who receive information regarding the possible complications arising during pregnancy are less liable to experience a neonatal death.
- Having blood pressure checks and tetanus immunizations during pregnancy helps to reduce the prospect of infant and under-five mortality.
- Overall, our results suggest the need for public health decision makers in Zimbabwe to focus on ensuring high-quality prenatal care to enhance the survival prospects of Zimbabwe's infants.

Introduction

Previous research suggests that women seeking prenatal care during pregnancy are more likely to give birth to healthier babies and less liable to experience child deaths (Gajate-Garrido 2013; Habibov and Fan 2011, Liu 1998, Maitra 2004, Mwabu 2009, Wehby *et al.* 2009b). Much of the noted literature has focused on explaining this important connection especially in highly industrialized countries (Alexander and Korenbrot 1995, Conway and Kutinova 2006, Evans and Lien 2005, Liu 1998, Noonan *et al.* 2013, Reichman *et al.* 2009, Rosenzweig and Schultz 1983). However, the question of whether a causal relationship exists between prenatal care quality 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 conception up to but excluding the time for labour and delivery (Harris 1982). A clear understanding of the vital link between prenatal care quality and child health outcomes 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 mortality rates for children requires information on the effectiveness of prenatal care quality on infant mortality outcomes. 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 child health outcomes. This information is particularly useful in aiding decision making both in the short and long-run periods in the designing of cost-effective public health policies (Morris *et al.* 2007).

Health economics literature suggests numerous channels through which prenatal care might positively influence infant and child health outcomes. First, the behavioural education that women receive helps to discourage unhealthy behaviours such as smoking and drinking alcohol during pregnancy. Second, the various nutritional intake advice women receive during pregnancy contribute to improving their dietary habits and consequently the health of their unborn child. Third, women benefit from the parental advice they receive during prenatal care which helps to prepare them for motherhood. Lastly, previous studies have established that women who seek prenatal care are less liable to give birth to low birthweight babies (Alexander and Korenbrot 1995) and less likely to terminate their pregnancy (Lincetto *et al.* 2006). Low birth weight has long been widely regarded as a measure of early health and a prominent risk factor for mortality in children as well as an essential marker for consequent morbidity for surviving children (Chatterji *et al.* 2014, Martinson and Reichman 2016, Noonan *et al.* 2007).

While the connection between prenatal care and child health outcomes has received lots of attention in highly industrialized countries (Behrman and Rosenzweig 2004, Conway and Kutinova 2006, Joyce and Grossman 1990, Reichman *et al.* 2009, Rosenzweig and Schultz 1983), research for developing countries is surprisingly scarce. It is in the latter countries that child health outcomes have persistently remained unsatisfactory and yet empirical research still, lags behind (Makate and Makate 2016a, Obasola *et al.* 2015, UNICEF 2015). For instance, the under-five mortality rate in the SSA region stood at 83 deaths per 1,000 live births in 2015 compared to 7 deaths per 1,000 live births in the United States in 2015 (UNICEF 2015). This difference implies that child mortality rates in SSA are nearly 12 times higher than they are in developed countries like the United States. Existing studies for developing countries mainly focus on the impact of prenatal care on early child health as measured at birth (birth weight) (Awiti 2014, Celik and Younis 2007, Habibov and Fan 2011, Maitra 2004, Mwabu 2009, Todd Jewell and 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. 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 policymakers in developing countries.

Against this background, the primary focus of this study is on examining the impact of prenatal care quality on the prospect that a child dies within the first 28 days of life (neonatal mortality), first 12 months (infant mortality) and first five years of life (under-five mortality) in Zimbabwe. There are a few reasons why we should be focusing on examining the effects of prenatal care quality on mortality outcomes for children in Zimbabwe. First, Zimbabwe still has one of the highest mortality rates for children in SSA and the world (UNICEF 2015, WHO 2015). A cursory examination of the official mortality estimates reveals that the under-five death proportions in Zimbabwe (71 deaths per 1,000 live births) were nearly 1.18 times above the overall under-five mortality target for the SSA region of 60 deaths per 1,000 live births in 2015 (UNICEF 2015). Second, little is known about the effect of prenatal care quality on juvenile mortality outcomes in regions with high infant and under-five mortality rates such as in SSA. Lastly, recent survey data for Zimbabwe reveals that nearly 90% or more of pregnant women receive some form of prenatal care during pregnancy, and yet the country continues to witness unacceptably high and worsening child mortality rates (ZIMSTAT 2012). The coexistence of high antenatal care utilization and child death rates have prompted us to inquire about the important role played by the quality of received prenatal care on mortality outcomes.

Despite the importance of the subject matter, there is surprisingly limited information concerning the role of antenatal care quality on child mortality outcomes in developing countries. This study adds to the current discussions in low-income 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 for Zimbabwe that attempts to examine the critical role played by the quality of prenatal care on child survival in high mortality settings.

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 and 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 centres 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 km). 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 TMoHaCWoZ 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 improve mother and juvenile health outcomes. To date, many other initiatives targeted at improving parental and infant health have been implemented (MoHCW TMoHaCWoZ 2010).

Following the leadership of the World Health Organization, the Zimbabwe MNH program promotes a minimum of four prenatal care visits catalogued 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 unborn child. 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 three rounds of the nationally representative Zimbabwe Demographic and Health Survey (ZDHS) conducted in 1999, 2005/06 and 2010/11. We also used data from the 1994 ZDHS only for documenting the trends in child mortality outcomes. We excluded the 1994 survey from the empirical analysis because information on prenatal care quality is not available for this survey. 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 1992 and 2002. The initial stage comprised of 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.

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.

Our sample is a pooled cross-section of 11 288 women who gave birth to 14 452 children within the five years preceding each survey. We combined the three waves of the ZDHS to have a broader understanding of the data, 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 waves allows us to examine the trends in child mortality and prenatal care quality. To minimize the potential bias associated with pooling across multiple surveys, we adjusted the survey weights at the same time preserving the initial sampling probabilities 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/

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.

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% $((9/8.1-1)\times *100)$ 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% $((6/5.5-1)\times *100)$ difference.

Measures of child mortality and prenatal care quality

The ZDHS collects detailed birth histories for every interviewed woman of reproductive ages 15–49. This information includes the dates of birth for all alive children and the age (in months and days) at death for deceased children. We constructed three measures to indicate mortality of children in neonatal, infancy and under-five 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 constructed 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 of each survey and for which prenatal care information is non-missing.

The ZDHS asked each interviewed woman a series of questions related to their prenatal care utilization for the most recent pregnancy. These questions include whether she had sought prenatal care (yes or no) for her last pregnancy, whom she had seen (a doctor, nurse/midwife, auxiliary midwife, traditional birth attendant, community/village health worker and others), where she had received the care and the number of times she had visited the prenatal care center. 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 or services received. Each respondent was asked seven questions related to the specific elements she had received during her routine prenatal care visits. These services included; (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. We coded each response as 1 if a particular 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 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.

Econometric model

For us to understand the relationship between the quality of prenatal care and juvenile fatality outcomes, we estimate the following equation:

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

where H_i is a measure of juvenile fatality; $Prenat_i$ 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 and 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 standard errors. 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:

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

As in equation (1), we estimate equation (2) with cluster-robust standard errors at the primary sampling unit (Breusch and 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 and Fan 2011, Maitra 2004, Wehby *et al.* 2009a). In this study, we argue that mothers seeking 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 the 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). For brevity, we excluded the results for the demand for prenatal care quality (results available upon request) and focused instead on the implications of antenatal care quality on child health production. In any case, we are unable to conduct any strict demand analysis since data on the prices (cost of prenatal care) and income are not available.

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% $((3.0/2.9 - 1) \times *100)$ increase in the neonatal mortality rate over the 1999–2010/11 period. On the other hand, the infant mortality rate declined by an approximate 19.12% $((1 - 5.5/6.8) \times *100)$ over the same period. Regarding under-five mortality, the average death rate in 2010/11 was 6.9% representing an approximate 14.81% $((1 - 6.9/8.1) \times *100)$ decline from the 1999 under-five mortality rate. On the average, the number of women completing four or more prenatal care visits during pregnancy changed from 74.5% in 1999 to 73.1% in 2010/11, representing an approximate 1.88% $((1 - 73.1/74.5) \times *100)$ 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 and subsided in 2009 (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 component analysis (PCA) of the seven services received during antenatal care visits reveals that blood pressure checks, blood tests, and urine sample tests are the three top drivers of the overall quality of prenatal care (the results not shown here are made available upon request). 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 $P = 0.0000$).

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. The average age at birth of the women in our entire sample was about 25.8 years with a mean height of 159.7 centimetres. The percentage of women in gainful employment was 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 in our sample are females. Figure 1 displays the time trends in the overall mortality rates in our data by child's year of birth. The trends indicate a decline in infant mortality observed between 1990 and 1994 possibly due to the impact of the ESAP reforms implemented by the Zimbabwe government in 1991–1995. From 1995 to about 2001, we see a flat evolution in neonatal and infant mortality. Since 2001, juvenile mortality has been on an upward trend, peaking in 2005. To a large extent, this increase in child mortality is partly due to the impact of the 2000–2008 economic crisis together with the devastating effects of the HIV/AIDS epidemic. The droughts experienced during the mid-2000s period coupled with the loss of key health personnel partly contributed towards a deterioration in child health outcomes (Larochelle *et al.* 2014). Despite the observed overall declines in mortality, the average juvenile fatality rates are still unacceptably high in Zimbabwe.

Impact of prenatal care quality on child mortality outcomes

Table 4 presents the marginal probability effects of antenatal care quality on neonatal, infant, and under-five mortality in Zimbabwe. In panel A of Table 4, we first present the results from the models that estimate the impact of the frequency of prenatal care on child mortality outcomes. Here, prenatal care is measured using the binary indicator taking 1 if the woman completed four or more visits and 0 otherwise. The results indicate that completing four of more prenatal care visits during pregnancy lowers the prospect of neonatal, infant and under-five mortality by approximately 1.41, 2.01, and 1.97 percentage points, respectively. In all the specifications, we included controls for the age of the mother at survey date, age squared, height (in centimetres), education level, household wealth, religion, child's gender, child's year of birth, birth type, survey year and an indicator for urban residence. However, we interpret these results with caution since prenatal care is potentially an endogenous variable (Maitra 2004, Wehby *et al.* 2009b). We, therefore, focus on the results for the impact of prenatal care quality on child mortality.

Panel B of Table 4 displays the results from models examining the influence of antenatal care quality on juvenile mortality outcomes. All the specifications included cluster-robust standard errors and the same controls as mentioned earlier. The complete or full results corresponding to the summarized estimates represented in Panel B are furnished in Supplementary Material, Table S1 in the appendix. As noted earlier, antenatal care quality index is arguably exogenous since the index is calculated from exogenous indicators that women receive during each prenatal care visit. 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 0.80 percentage points. This

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.

outcome is statistically significant at the 1% significance level. Given that on the average 1.89% of the infants in our analytical sample died in the first month, the decrease in neonatal mortality following a one-unit increase in the quality of received prenatal care represents an approximate 42.33% ($0.008 \times *100/0.0189$) decrease in neonatal mortality. The results also suggest that a one-unit increase in the quality of received prenatal care lowers the probability of infant and under-five mortality by approximately 1.33 and 1.47 percentage points respectively. These results are all statistically significant at the 1% significance level. The decreases represent an approximate 30.86% ($0.0133 \times *100/0.0431$) and 28.65% ($0.0147 \times *100/0.0513$) declines in child mortality given that nearly 4.31% and 5.13% of the children in our analytical sample died before reaching the ages of one and five years, respectively.

The impact of individual prenatal care quality components on child mortality

To further understand the effect of antenatal care quality on child health outcomes, we considered the impact on juvenile fatality of each service received during antenatal care. As a first step, we checked to ensure that the various components of prenatal care are not highly collinear. A condition number of 9.06 gives us reason to believe that the fetal care components are not highly collinear (results available upon requests) (Belsley *et al.* 2005). We estimated equation (1), but this time replacing the quality index with all the components of prenatal care including the same controls as indicated earlier. The results, presented in Panel C of Table 4 show that women who receive information regarding complications arising during pregnancy are less liable to

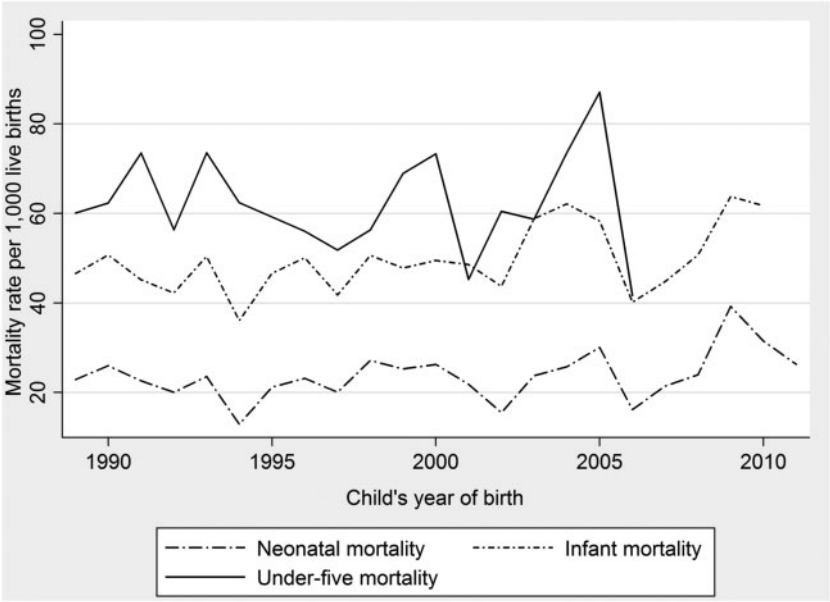

Figure 1. The time trends of child mortality rates. Source: Zimbabwe Demographic and Health Survey (ZDHS), 1994, 1999, 2005/06 and 2010/11

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.

experience a neonatal death than their non-informed counterparts. The prospect of neonatal mortality declines by 0.71 percentage points (statistically significant at the 5% level). Other prenatal care quality components did not meaningfully correlate with neonatal mortality. The results also indicate that mothers who receive blood pressure checks and tetanus vaccinations during pregnancy are less likely to experience an infant and under-five death. The probability of newborn mortality declines by 1.55 percentage points for children whose mothers received blood pressure checks and tetanus vaccinations during pregnancy. The chances of under-five death are reduced by 2.24 and 1.65 percentage points, respectively for children whose mothers received blood pressure checks and tetanus shots during pregnancy. These estimates are all statistically significant at the 5% significance level. Other prenatal care quality components did not have a notable influence on infant and under-five mortality.

Discussion

This study examined the effect of prenatal care quality on neonatal, infant and under-five mortality using nationally representative household survey data for Zimbabwe conducted in 1999, 2005/06 and 2010/11. We first observed that completing four or more visits

during antenatal care significantly lowers the plausibility of neonatal, infant and under-five mortality. However, we interpret these results with caution as prenatal care is potentially an endogenous variable. Next, we examined the impact of prenatal care quality on child mortality outcomes. The results revealed that the antenatal care quality significantly lowered the prospects of death among Zimbabwean infants. Notably, we demonstrated that a one-unit increase in the quality of prenatal care decreased the risk of neonatal, infant and under-five mortality by nearly 42.33, 30.86 and 28.65%, respectively. These findings suggest the need for public health policy makers in Zimbabwe to not only focus on increasing access to prenatal care alone, but also ensure its quality.

Additionally, we examined the impact of the individual prenatal care components on the probability of neonatal, infant and under-five mortality. The results indicated that women who received information regarding pregnancy complications arising during pregnancy are less liable to experience a neonatal death. Given that only 56.4% of the pregnant women interviewed during the 2010/11 survey reported receiving information regarding pregnancy complications during pregnancy, our results highlight the need for health providers in Zimbabwe to step-up efforts to educate pregnant women on the potential dangers that might arise during pregnancy. This information is critical as it helps to lower neonatal fatalities in the country. We also found that women who receive blood pressure checks and tetanus vaccinations during pregnancy are less liable to lose their children before they reach the age of one or five years. Broadly, our results corroborate previous other studies in developing countries that have established the beneficial effects of prenatal care on child health outcomes (Gajate-Garrido 2013, Habibov and Fan 2011, Maitra 2004, Panis and Lillard 1994).

The finding that blood pressure checks and tetanus vaccinations during pregnancy are instrumental in lowering infant and under-five mortality emphasizes the need for public health providers to focus on the content of prenatal care as it helps to save lives. 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 child. 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 (American College of Obstetricians and Gynecologists; Task Force on Hypertension in Pregnancy, 2013, Tranquilli *et al.* 2014). A high blood pressure might also result in premature delivery and low birth weight baby which all contribute to adverse health outcomes including infant death (Centers for Disease Control 2016, Lincetto *et al.* 2006).

The finding that women who receive tetanus vaccinations during pregnancy are less liable to experience an infant or under-five death has important implications for public health policy. Tetanus shots during pregnancy help protect pregnant women and their unborn child from neonatal tetanus. 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 provision of tetanus vaccinations during pregnancy becomes a critical component of any effective public health policy.

According to UNICEF (2015), nearly 13 000 Zimbabwean 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 4,333 ($8 \times 13000/24$) 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 1.33 percentage point reduction in newborn fatality we found implies that nearly 7,074 ($13.3 \times 25000/47$) 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 1.47 percentage points reduction in under-five deaths implies that approximately 7,868 ($14.7 \times 38000/71$) children would have survived in 2015 if all the mothers had received all the required components of prenatal care during pregnancy.

Overall, our findings suggest the need for public health policymakers in Zimbabwe to carefully review existing public health policies especially those concerning maternal health care. As the southern African nation continues to struggle to implement sustainable macroeconomic policies amidst a deepening economic crisis, the health sector together with other areas has continued to suffer from a lack of funding. Efforts to improve the quality of received services during prenatal care in Zimbabwe have often been thwarted by the deterioration in health infrastructure coupled with outmigration of key health personnel (Osika *et al.* 2010).

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 the 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 analyse 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. Lastly, we ought to accentuate that our estimates might still be minimally biased by potential endogeneity arising from the voluntary nature of the prenatal care decision. Besides the noted concerns, our analysis provides an important and significant contribution to the recent discussions in less-industrialized countries on the importance of prenatal care on child health outcomes.

Conclusion

This study examined the impact of antenatal care quality on neonatal, infant and under-five mortality in Zimbabwe - a country still experiencing poor maternal and child health outcomes. Our results suggest that improvements in prenatal care quality lower the prospect of neonatal, infant, and under-five mortality even after controlling for other mediating factors. We also found that educating women on the potential dangers or complications to expect during pregnancy helps to lower neonatal mortality. Similarly, receiving blood pressure checks and tetanus shots during pregnancy diminishes the plausibility of infant and under-five mortality. From a policy standpoint, there is a need for public health decision makers to ensure that pregnant women receive all the essential components of a basic prenatal care program. To a certain extent, our results also call for the need for policymakers in Zimbabwe to address the current challenges faced by the health sector of deteriorated infrastructure and outmigration of key health personnel. Overall, our results suggest the need for public health policymakers in Zimbabwe to focus on ensuring high-quality prenatal care as it helps to save Zimbabwe's children.

Supplementary Material

Supplementary data are available at *HEAPOL* online.

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Appendix

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.