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Prenatal Care Utilization and Infant Health in Botswana

by

David Mmopelwa

Abstract

Despite the freely and publicly provided health care in Botswana, the proportion of low birth weight infants increased from 8% to 13% during 2000-2007 period. The latter rate was among the highest in the WHO African region and upper middle-income countries and may question the effectiveness of care. Using the 2007/08 Botswana Family Health Survey data collected by Statistics Botswana, the paper jointly estimates the adequate prenatal care utilization (input demand) and infant birth weight (outcome) functions through the treatment effect model, which accounts for the binary nature of the endogenous regressor. As birth weight information is not available for all infants, we also estimate a Heckman sample selection model to account for potential bias. Estimating models for rural and urban samples separately, we find that lower levels of mother`s education reduces the likelihood to both adequately utilize prenatal care and report infant birth weight. The likelihood for prenatal care utilization increases with the probability of a care facility being sufficiently close and availability of care facilities. Adequate prenatal care utilization is positively associated with birth weight and failing to account for endogeneity reduces its effect. On average, birth weight increases by 0.67, 0.73 and 0.64 kg in full, urban and rural samples respectively.

JEL Classification: I11, I12, J13

Keywords: Prenatal care, infant health

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1. Introduction

The Botswana government`s developmental efforts has among others, been demonstrated through its public budget allocation to the health sector. During the period 1980-2013 for instance, public health expenditure share to total public spending increased from 4.6% to 10.7% (MFDP, various), real health spending grew by 9 per cent per annum and the share to GDP almost doubled. Such commitments are in part, based on the recognition of health as an important dimension of welfare (World Bank, 2001), and a major input for economic growth and development (Bloom and Canning, 2001). One important component in the production of both infant and mother's health is prenatal care[1], which in Botswana, has been provided since the 1980s (Fako et al., 2004). Prenatal care benefits both the infant and expectant mother through among others, identification of those who are at risk of poor infant health outcome as well as promotion of good nutrition and cessation of bad behaviour during pregnancy (WHO, 2016).

However, despite the publicly provided prenatal care in Botswana, which (should and) may arguably have contributed to the observed high utilization rates (see Table 1), the proportion of low birth weight (i.e below 2.5 kg) infants increased from 8% in 2000 to 13% in 2007/08 (CSO, 2009), making it among the highest in the World Health Organization African region and upper middle income countries during the said period (WHO, 2011). Since prenatal care utilization is recognized as an important input in reducing the likelihood of poor health risks (WHO, 2016), a pattern of increasing rates of low birth weight infants, given high care utilization rates might lead some to question its effectiveness. However, this is not to suggest that care has not been effective in Botswana, but we argue that such a pattern warrants investigation, carried out in this paper.

While Table 1 may be said to signal a possible paradox for Botswana compared with other countries (such as Angola and Nigeria), high rates of prenatal care utilization

1 This, also known as antenatal care, is defined as "care provided by skilled-health care professionals to pregnant women and adolescent girls in order to ensure the best health conditions for both the mother and baby during pregnancy" (WHO, 2016:1). According to World Health Organisation skilled "embraces qualified doctors, midwives, nurses and providers with equivalent level of skills".

could relate to mothers` health. Thus, either low risk mothers utilize care more because they recognize its important role or higher risk mothers utilize it more because of their poor health (Rosenzweig and Schultz 1982; Joyce, 1994). None of these possibilities is directly observed in the data, and are acknowledged as a source of bias affecting the effectiveness of care (Frick and Lantz, 1996). There is however, a consensus that prenatal care utilization should positively correlate with both mothers and infant health (WHO, 2016).

Table 1: Low Birth Weight and Prenatal Care Coverage; 2000-2009

Country/Region	Low Birth Weight (%)	Prenatal Care Coverage (%)
Angola	12	68
Botswana	13	94
Cameroon	11	82
Central African Republic	13	69
DRC	10	87
Eritrea	14	70
Ethiopia	20	28
Gabon	14	94
Gambia	20	98
Ghana	13	90
Kenya	8	92
Lesotho	13	92
Liberia	14	79
Madagascar	16	86
Malawi	14	92
Mauritius	14	-
Mozambique	15	92
Namibia	16	95
Nigeria	12	58
Senegal	19	87
Sierra Leone	14	87
South Africa	-	92
Swaziland	9	85
Togo	12	84
Uganda	14	94
Tanzania	10	96
Zambia	11	94
Zimbabwe	11	93
WHO Region		
African	13	74
Americas	8	95
South-East Asia	24	76
European	7	97
Eastern Mediterranean	21	68
Western Pacific	5	91

Source: Awiti (2014:2); WHO (2011).
Within each WHO region, countries are sorted by the latest available data since 2000 for coverage of at least one visit. Regional averages are also for coverage of at least one visit.

This paper investigates the role of prenatal care on birth weight in Botswana, through a health production function which identifies households and individuals as critical players, through "their health affecting consumption patterns, utilization of health care and their environment" (Wagstaff, 1986:3). Birth weight is one important indicator facilitating the examination of effective interventions towards better health outcomes. There is suggestive evidence that poor infant`s health is associated with poor future adult health and human capital development (Victora et al., 2008; Gajate-Garrido, 2013; Alexander et al. 2014). Among others, economic benefits of addressing low birth weight include reduced (i) infant mortality, (ii) costs of neonatal medical attention, (iii) costs of subsequent illness and related medical care for infants and children, and (iv) discounted lifetime productivity gain, and reduction in intergenerational impacts (Alderman and Behrman, 2006).

Although there is generally an agreement that low birth weight could result from either retarded growth or pre-term birth (short gestation period) or both (Kramer, 1987; Conway and Deb, 2005; Gajate-Garrido, 2013), there exists a debate and inconsistencies on the role of prenatal care utilization on birth weight in the literature. Such are due to bias from care utilization, preterm delivery, pregnancy resolution as well as treatment of distribution of health outcomes and measure of care itself (Rosenzweig and Schultz 1982, 1983; Grossman and Joyce, 1990; Warner, 1995; Fiscella, 1995; Frick and Lantz, 1996; Warner, 1998; Conway and Deb, 2005, Evans and Lien, 2005; Jewell, 2007; Abrevaya and Dahl, 2008; Mwabu, 2008; Habibov and Fan, 2011; Gajate-Garrido, 2013; Habibov, et al. 2017). Fiscella (1995:468), based on the review of the studies conducted during the period 1966-1994, concludes that "prenatal care has not demonstrated to improve birth outcomes conclusively".

Notwithstanding the above, existing evidence in Botswana (Letamo and Majelantle, 2001 and Okurut et al., 2013) consider care as an exogenous variable, a shortcoming which we address. Thus, the paper contributes to the debate on the role of prenatal care on birth weight, and highlights potential areas for policy intervention. We consider the self-reported level of use of prenatal care, since its impact does not only depend on occurrence, but intensity as well (Gajate-Garrido, 2013). However, due to data limitation, we are not able to control for the activities performed during care utilization. Moreover, information on the level of care utilization was collected as a categorical variable (i.e 1-3 & 4 or more visits), hence we only have a dummy for adequate care utilization as per the World Health Organization`s recommendation (WHO, 2016). It is also important to note that the survey does not have information on the child`s father, who may impact birth weight directly through biological factors or indirectly by affecting care utilization or contributing to household resources. The paper proceeds as follows. Section 2 provides an overview of related literature, while section 3 discuses data issues. Modelling and estimation issues are presented in section 4 and results in section 5. Section 6 concludes.

2. Related Literature

The correlates of birth weight include socio economic, demographic, biological, and behavioural factors (Kramer, 1987), evidence for which exists in both developed and developing countries, although with varying conclusions. For instance, using the 1968-97 waves of the Panel Study of Income Dynamics data, Lindo (2011) finds that husband`s job displacement (a measure of income shock) negatively affect child`s birth weight. On the other hand, Dehejia and Lleras-Muney (2004) find that the incidence of children born with low weight is reduced on infants conceived during the periods of high unemployment rate in the US. Contrary to the theoretical prediction that hard economic conditions may reduce consumption of health-related services like prenatal care, their results show that care use improves for both Black and White mothers. Moreover, they also demonstrate that fertility selection decisions play a role: the incidence of birth reduces among less educated Black mothers improving child health, while it increases among the less educated White mothers. Other insights are provided in the form of stressful economic news (Carlson, 2015), which affect birth weight through mothers` health (stress) or their coping risky behaviour. A positive association between mother`s education and infant birth weight has been found in Lithuania (Dickute et al., 2004), India (Joshi et al. 2005) and Pakistan (Khan et al. 2014). In Lesotho, Mathule et al. (2005) find that women more exposed to the hungry season (more pronounced food insecurity) during pregnancy are more likely to have low mean birth weight infants.

Behavioural factors include use of prenatal care and smoking (see Silles 2012 for a review), whose negative effect on birth weight is witnessed in among others, Alberta (Tough et al., 1999), Switzerland (Chiolero et al., 2005) and Nagpur (Deshmukh et al., 1998). In the following, we provide an overview of studies that consider prenatal care and birth weight, in both developed and developing countries.

Rosenzweig and Schultz (1982, 1983) find that delay in seeking prenatal care reduces birth weight in the US. Motivated by their observation, hence arguing that prior evidence had suffered from potential sample selection, inadequate control for endogenous health related behaviour, as well as failure to account for heterogeneity in unobserved characteristics that may affect infant health, Rosenzweig and Schultz control for these through the Two Stage Least Squares estimation technique. They find that unhealthy women started prenatal care earlier and that their babies had lower birth weight, confirming evidence of adverse selection. Grossman and Joyce (1990) control for the bias in both women`s resolution to give birth and use prenatal care services arguing that it is likely for unobservable factors influencing care use to influence birth resolution as well. They find evidence for both bias among black women only: a positive correlation between unobserved factors that increase the likelihood to give birth and unobservables that reduce delay in care initiation, which increases infant birth weight. Joyce (1994) considers prenatal care level (inadequate, intermediate and adequate) for New York City women aged at least 20 years in 1984, and finds that it positively affects birth weight. He demonstrates that the movement from inadequate to intermediate level of care improves birth weight more that moving from intermediate to adequate level.

Warner (1995) considers prenatal care delay and visits using data for the 1980-1990 black women`s births and finds that women receiving Medicaid initiate care earlier. Further, contrary to expectation, he finds that both delay and visits are negatively correlated with self-pay and Medicaid. While he finds that early initiation of care improves birth weight, no significant effect is evidenced for visits. Warner (1998) further considers the interaction of number of care visits with visits delay and finds that delay does not have an effect on fetal growth rate, concluding that the effect of prenatal care on birth weight is through visits rather than delay.

Using the 1984 data for the Commonwealth of Virginia, Liu (1998) finds that the effectiveness of prenatal care on birth weight is also affected by the failure to control for selection bias. Thus, selection bias emanating from the use of prenatal care reduces its effectiveness on birth weight and pregnancy resolution bias over estimates it. However, contrary to findings by Grossman and Joyce (1990), Liu`s estimates yield a negative coefficient for the bias correction term (Mill`s ratio), interpreted to imply that cost of abortion could be prohibitive of mother`s termination of unwanted pregnancies.

A similar approach of controlling for sample selection in pregnancy resolution and endogeneity of prenatal care use is adopted by Rous et al. (2003) who find that increased use of prenatal care improves child birth weight in Texas. They control for the bias through the discrete factor method, which they argue performs better since its estimators do not necessarily assume normal correlation between errors terms. Evans and Lien (2005) considers the *bus strike* as an instrument for prenatal care and find that the number of visits for care improve birth weight in Pennsylvania.

As indicated, the role of prenatal care on birth weight has been considered in developing countries. Guilkey et al. (1989 allow gestational duration to have an intermediate effect on infant birth weight and find that the frequent use of care is associated with few incidences of low birth weight in Philippines. Through their multivariate analytical approach, they find that geographical area, type of provider and facility affect the effectiveness of prenatal care on birth weight. Visits to public practitioners indirectly improve birth weight through behavioural changes while visits to private practitioners have effect only in urban areas and no effect in rural areas. They find that increased prenatal care visits (to public and traditional practitioners) improves birth weight in urban areas, while private urban care visits negatively affect it. Using data from Cebu Longitudinal Health and Nutrition survey, Gajate-Garrido (2013) finds that adequate level of prenatal care increases birth weight in urban areas.

In South America, Jewell and Triunfo (2006) and Jewell (2007) find that increased use of prenatal care positively affects birth weight, and that OLS under-estimates the effect of prenatal care on birth weight. Similar results are also found in Turkey (Celik and Younis, 2007). Lin (2004) arrives at the same conclusion in Taiwan controlling for both pregnancy resolution and endogeneity of care use by married women. Deb and Sosa-Rubi (2005) find that although number of care visits have a positive impact on birth weight in Mexico, timing of care has no impact. Using data from Azerbaijan demographic and health survey, Habibov and Fan (2011) find that quality of care (an index based on what mothers reported to have been carried out during visits) and visits improve birth weight and that there is no evidence of sample selection bias. The effect of care quality is larger than for the visits. In Tajikistan Habibov et al. (2017) finds that timing, visits and care quality improve birth weight.

A positive association between prenatal care and birth weight is found in Kenya (Awiti, 2014; Mwabu, 2008). Awiti considers adequate use of care while Mwabu considers vaccination against tetanus. In Botswana, to our knowledge, except for two studies (Okurut et al., 2013; Letamo and Majelantle, 2001), research on child health largely focused on either child mortality or anthropometric indicators for children aged 5 years and below. Okurut et al. (2013) explore the determinants of child birth weight with data for 1996, which is more than two decades ago. Since then, the proportion of infants with low birth weight increased. Their study also considers mothers` prenatal care utilisation as a binary exogenous variable, yet women would differ in their levels of care utilization. Letamo and Majelantle (2001) use a logistic regression approach for low birth weight and prematurity and consider care utilization as an exogenous variable as well.

While evidence regarding the role of prenatal care on birth weight exist in both the developed and developing countries, it emerges that the intensity (and perhaps approach) to research on this issue is affected by variability, complexity and difficulty in measuring the adequacy of its use and content (Alexander and Korenbrot, 1995). However, it is established that prenatal care covers such issues as timing, frequency, content of visit, as well as the type of provider. Lewit (1977) indicates that there is unclear mechanism through which prenatal care may affect child birth weight. According to the author, the mechanism might in part, be due to information sharing (health education), including issues such as the value of proper nutrition as well as hazards of risky behaviour like smoking. However, that this will be beneficial to the extent the mother puts the information to good use implies complementarity in the process (Mwabu, 2008). Mwabu and the study cited therein maintain for instance that receipt of injection against tetanus motivates mothers to further invest in care.

As the foregoing shows, mixed results on the effect of prenatal care are evidenced in the literature, to which we contribute. One factor affecting effectiveness of prenatal care in birth outcomes is the distribution in such outcomes (Conway and Deb, 2005; Deb and Sosa-Rubi, 2005). Conway and Deb caution about the approach to treat outcomes the same, yet some pregnancies are “normal” while some are “complicated”. They find that majority of factors affecting birth weight through 2SLS estimator have an effect only on normal pregnancies. The authors therefore conclude that an approach to combine these types of pregnancies leads to prenatal care appearing ineffective. Abrevaya and Dahl (2008) also find that prenatal care has larger effects on birth weight of lower quantiles of distribution in the two states of Washington and Arizona. We account for level of care utilization endogeneity, contributing specifically to Botswana`s literature and to the developing world`s, especially Sub Saharan Africa, which is generally characterized by poor child health indicators.

3. Data and Summary Statistics

We use cross section data from the 2007/08 Botswana Family Health Survey (BFHS), which was conducted by the national statistics office, Statistics Botswana. This is the fourth (after 1984, 1988 and 1996) survey in the series. The survey collected information for under-five children, households and individual females aged 12-49 years. Additionally, for the first time, information facilitating the measure of adult nutrition was collected.

The under-five child data file had a total of 2825 observations, with 106 observations having missing information (of these, 44 were reported not to have been available for interview, 7 refused and 55 were for other reasons not specified). We excluded those children (N=717) whose respondents were not their mothers (and could not provide information for the mother) since we do not consider the characteristics of (non-mother) carers to be appropriate for the infant`s health production function. This reduced the sample to 2002 children. The sample was further reduced to 1986 after excluding 16 children whose mothers were aged more than 49 years, for whom data were unavailable (infants have to be merged with 12-49 aged female data). These children were identified by the availability of mother`s age variable in under-five child data file.

The individual female data file had a total of 7319 cases. However, according to the survey report "only 6916 women aged 12-49 years were successfully interviewed" (CSO, 2009: 12) suggesting that 7319 represented all women eligible for the interview. The rest had the interview result codes of 2,3,4,5, and 6 for present but not available for the interview, postponed, refused, partially completed and other, respectively. We excluded all except those with *completed* and *partially completed* interview outcomes, resulting in 6935 females. This file was then merged with the under-five children data file, because it contains mother`s variables whose effects on infant birth weight are investigated. After merging the two data files, it emerged that 36 children had some missing information for their mothers (i.e not matched from the master file). These could be those whose mothers had interview result codes of 2, 3, 4 and 6, whom we excluded because of lack of information. Such children were also excluded from the sample, resulting in a total sample of 1950 children matched to mothers.

The utilization of prenatal care information was sourced from the child and female questionnaires. On the child questionnaire, reference point was the five years preceding date of interview. However, through the female questionnaire, when investigating the level of care utilization by mothers, reference was made to the live births that occurred within two years prior to the interview date. The consideration of the latter resulted in the final sample of 1395 children.

An examination into the availability of infant birth weight information (which was extracted from the growth monitoring cards and is outcome of interest) reveals that 236 children had missing information. The question, as stated by Heckman (1979:154) remains “why are the data missing?” Of the 236 with missing birth weight information, 182 children had missing information because their cards were not seen by the interviewers while 54 children had missing information though their cards were seen. The reasons for the cards not seen include being either lost or burnt. Moreover, it could possibly have been due to such children being born at home and therefore not weighed at/after birth. Birth weight information availability may be linked to contact with health professionals (Mwabu, 2008). We explore this possibility by considering “assistance at delivery”, from which the infant`s place of birth can be inferred. Of the total 54 children, 22 were reported to have been assisted by relatives/friends, 16 assisted by nurse/midwife, 6 assisted by traditional birth attendants, 7 assisted by self, while 3 were said to have been assisted by doctors. From these, it may be concluded that those who were not assisted by professional health personnel are 35. These are the children who we may conclude were probably born at home because health professionals would not visit homes for birth assistance. The possible reason for the missing of birth weight information for those who were assisted by doctors and nurses, could be that they lost their first cards.

We also linked some health district level data (average retail food prices, distance to the nearest health facility as well per capita health care facilities) with the survey data. Monthly data on food prices is collected by Statistics Botswana from 46 areas, including cities and towns, urban villages and rural areas. Food prices are considered as they affect purchasing power with implications on mothers’ health and health care utilisation (Thomas, 2009). This is likely to be the case for Botswana, where majority of households are net food buyers. Their consideration is also worthy given that food purchases was identified as the most important household source of food, even among the subsistence agricultural households in the country (Mmopelwa and Seleka, 2012; Seleka and Lekobane, 2017). We used the average prices for cereals (the most consumed in Botswana).

Statistics Botswana also produced data on primary health care accessibility for the period 2006/2007. This shows the proportions of population who are within three categories of distance to the nearest health care facilities; 0-5, 5-8 and 8-15 kilometres in health districts (Statistics Botswana, 2012; 2017). The data reveals that at national level, 84 per cent of population were within the 5km radius, 11 per cent within 5 and 8km while the rest were within 8 and 15 kilometre radius. Moreover, the proportion at urban areas stood at 96 and 4 per cent for 0-5 km and 5-8 kilometres respectively, whereas 72, 17 and 11 per cent were in the 0-5, 5-8 and 8-15 kilometres range respectively in rural areas. We used this information to create dummy variable for the probability of care facility being sufficiently close, also factoring in rural-urban differences. For instance, we have a dummy of 1 if mothers resided in a district whose proportion of those in 0-8km is higher than 95% (observed at national level), otherwise 0. However, since it has been observed that in urban districts the proportion within 8km is 100, we consider 0-5km for the urban subsample. Thus, an urban district was assigned a value of 1 if proportion of those residing within 5 km radius is higher than that of all urban districts combined. Table 2 presents variable definitions.

Table 3 presents summary statistics, comparing (through two sample t-test) urban and rural areas, given the possible differences in characteristics between the two. An urban area is defined as “any settlement with a population of at least 5000 of whom 75% of the workforce is engaged in non-agricultural activities” (Republic of Botswana, 2014:3). However, since the district is larger, it is possible to find both urban and rural areas under the same district. The average birth weight is about 3 kilograms. Of the 95 per cent of infants who were taken for prenatal care during pregnancy, 73 per cent had adequate utilization, with higher average in urban areas. About 49 per cent of infants are males, and 83 per cent of infants had their birth weight reported. Possible reasons for this are explored in the preceding sub-section. The average shares for quarter of birth dummies are between 23 and 28 per cent, with third quarter dominating.

Table 2: Variable Definitions

Variable	Definition
A. Outcome variable	
Birth Weight	Infant`s weight at birth (in kilograms)
B. Instrumented Variable	
APC	Adequate Prenatal Care utilisation: Indicator for 4 or more visits (1=Yes)
C. Infant Characteristics	
Male	A dummy for sex of the infant (1=Male)
Birth weight reported	A dummy for availability of infant`s birth weight (1=Yes, 0 otherwise)
QoB1	An indicator for the infant born in January-March (1=Yes, 0 otherwise)
QoB2	An indicator for the infant born in April-June (1=Yes, 0 otherwise)
QoB3	An indicator for the infant born in July-September (1=Yes, 0 otherwise)
QoB4	An indicator for the infant born in October-December (1=Yes, 0 otherwise)
D. Mothers Characteristics	
Age	Mothers` age in completed years
Pre-Secondary	Dummy for mothers with pre secondary education (1=Yes, 0 otherwise)
Married	Dummy for married mothers (1=Yes, 0 otherwise)
Christianity	Dummy for Christianity as mother`s main religion (1=Yes, 0 otherwise)
Height	Height in centimetres
Rural	A dummy for mother residing in rural areas (1=Yes, 0 otherwise)
E. Variables at district level	
Rice price	Price for rice per kg
Maize price	Price for maize meal per 5kg
Sorghum price	Price for sorghum meal per 5kg
Proximity	Dummy for higher proportion within a certain distance radius than at national level
Care Facility	Number of fixed health care facility in health districts

The average mother`s age is 28 years. About 70 per cent of infants are born of mothers with secondary level of education, followed by 22 per cent of those with primary education level. The least share is accounted for by those whose mothers had non-formal education. In our estimation we re-define the education variable to have two categories pre-secondary and post-primary. This is because for child health, it has been found that primary education level is sufficient (Charmarbagwala et al., 2004). Only 17 per cent are from married mothers; the majority of infants were born to cohabiting and never married (single) mothers. About one per cent have either widowed, separated or divorced mothers. A pattern of relatively lower averages for *married* mothers evident in the table, has been observed in previous studies; a possible explanation is that cohabitation (which increased over time) serves as a temporary phase (i.e a prelude) before marriage (Mokomane, 2005). Thus, cohabitation is seen not as a substitute for marriage, but rather as delaying its timing. Indeed, there have been initiatives promoting marriage and creating awareness on the side effects of cohabitation (Morwaagole, 2013). The average for those residing in rural areas is 46 per cent. Average retail prices are higher in urban than in rural areas.

Table 3: Summary Statistics

	Full	Urban	Rural	Differences (Urban-Rural)
A. Outcome Variable				
Birth Weight	3.085	3.101	3.064	0.038
B. Instrumented Variable				
Adequate Prenatal Care	0.725	0.766	0.677	0.089***
C. Infant Characteristics				
Male	0.497	0.507	0.486	0.021
Birth weight reported	0.831	0.874	0.781	0.092**
QoB1	0.232	0.246	0.214	0.032
QoB2	0.241	0.244	0.239	0.005
QoB3	0.269	0.268	0.270	-0.003
QoB4	0.258	0.242	0.276	-0.034
D. Mother`s Characteristics				
Age	28.014	28.340	27.633	0.706**
Pre-Secondary	0.071	0.215	0.388	-0.172***
Married	0.170	0.209	0.124	0.084***
Christianity	0.801	0.827	0.781	0.046**
Height	161.432	162.021	160.744	1.278***
Rural	0.462			
E. Variables at District level				
Rice price	8.785	8.570	9.036	-0.466***
Maize price	21.906	21.468	22.416	-0.949***
Sorghum price	22.861	22.732	23.011	-0.279***
Proximity	0.832	0.874	0.784	0.089***
Care Facility	5.788	6.020	5.518	0.502

***: significant at 1%, **: significant at 5%

4. Model Specification

4.1 Theoretical Model

Behrman and Deolalikar (1988:637) state that “the proximate determinants of individual`s health and nutrition usually are decisions made by the individual or by the household in which he or she lives”. Moreover, since many individuals live in household consumption units, models have been constructed such that households maximize utility subject to given constraints, the framework standard utility function is specified as follows (Rosenzweig and Schultz, 1982):

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

In (1), X represents a neutral commodity (e.g. transport) that does not directly affect infant health; Y represents a health-related commodity (such as food) that influences infant health,[2] and H is infant`s health status. Infant health is further affected by household characteristics and other inputs (Z) acquired by the family, such as health care, as well as by family health endowments (μ), known to them (such as genetic or environmental factors) but over which they have no control. Therefore, an infant health production function is represented as follows:

$$H = F(Y, Z, \mu),\ F_y,\ F_z,\ F_\mu \neq 0 \tag{2}$$

The family maximizes utility represented by equation (1), given the health production (2), subject to the following budget constraint:

$$I = PxX + PyY + PzZ \tag{3}$$

Where I, P_x, P_y and P_z are income and prices of neutral good, health related good and health investment goods respectively. As food is the major component of household expenditure, especially in rural areas, in general P_xX is likely to have only a small effect. Health is not directly acquired and is regarded as "utility-augmenting" good. The health-related good (Y), has both a direct effect in augmenting utility and indirect effect on utility, through H, as captured by equation (2), while Z has only indirect effect and X has only direct effect on utility. The model can be represented as demand equations for the three commodities in terms of prices and income:

$$X = Dx(Px, Py, Pz, I, \mu) \tag{4}$$

$$Y = Dy(Px, Py, Pz, I, \mu) \tag{5}$$

$$Z = Dz(Px, Py, Pz, I, \mu) \tag{6}$$

Substituting the effect of changes in prices on infant health from equations (4-6) the change in infant health can be expressed as:

2 This good may still be consumed even if it happens that it has no effect on health at all, or if it severely affects health.

$$dH = FydY + FzdZ + F\mu d\mu \quad (7)$$

The next section explains the empirical specifications we use to test the model.

4.2 Empirical Model

Prior to presenting the empirical model(s), we discuss potential issues surrounding the estimation strategy. The first issue is *endogeneity*. As noted already, efforts to unravel the effect of prenatal care on infant birth weight may be affected by bias brought by the association of birth weight with prenatal care utilization, which is an outcome of the selection process partly determined by non-observable factors. The selection processes that may introduce bias when investigating the role of prenatal care on infant health may be classified into four types; favourable, adverse, estrangement and confidence selection (Frick and Lantz, 1996). Favourable selection process is said to occur when women at low risk of poor birth outcomes are also higher users of prenatal care, in which case there is potential to bias the effect of prenatal care upward, leading to its overestimation: "epidemiological literature has acknowledged that favourable selection may be a more serious source of confounding" (Grossman and Joyce, 1990: 984-985).

Adverse selection occurs when high risk women are higher users of prenatal care, potentially biasing the effect of prenatal care downwards. In this case, poor birth outcomes would be because of the factors that cause women to utilize care more, instead of the care itself. Joyce (1994) notes that studies that corrected for adverse selection showed larger effects of prenatal care than those that did not. With estrangement selection, some high-risk women (such as those who suffer from abuse) are among the lowest users of prenatal care, including those with no care at all. Lastly, confidence selection process implies that women of higher risk use care more, and it is similar to the adverse selection process (Frick and Lantz, 1996).

The second issue is that of *sample selection bias*, which is said to occur because of using a subset of a random sample, either because of the survey design or non-response on survey questions (Wooldridge, 2010:791; Heckman, 1979). As indicated in section 3, some infants had missing birth weight information, which is not an outcome of random process. According to Awiti (2014:4), "sample selection bias will occur if the unobservable factors affecting the decision to report birth weight of the child are correlated with the unobservable factors affecting the birth weight itself".

The above issues are addressed using an instrumental variable (IV) strategy and a control function approach (Angrist and Pischke, 2009; Wooldridge, 2010; Heckman, 1979). Provided the instrument is good, "IV methods solve the problem of missing or unknown control variables, much as a randomized trial obviates extensive controls in a regression" (Angrist and Pischke, 2009:115). We therefore use the two-stage regression to control for endogeneity in prenatal care utilization and Heckman selection model to control for potential sample selection bias. Instrumental variable strategy requires a variable or variables not affecting outcome directly (instruments) but that explain the endogenous regressor and requires assumptions for the purposes of casual interpretation. First, instrument(s) should have a clear effect on the endogenous variable (prenatal care use), implying that they should have a statistically significant effect or that they should be relevant. Second, their effect on birth weight should be through the first stage. The second assumption, known as exclusion restriction, has two components; instrument(s) should be such that they are not correlated with the error term in the birth weight equation, implying that they should be exogenous and that they have no effect other through the first stage (Angrist and Pischke, 2009).

Following Rosenzweig and Schultz (1982, 1983) and other studies influenced by their approach, the equation of interest (birth weight production function) may be described as follows:

$$H_{bwi} = \alpha_0 + \alpha_1 APC_i + \alpha_2 X_i + \varepsilon_1 \quad (8)$$

Where H_{bwi} is the birthweight for infant *i* (in Kilograms), APC_i is an indicator for the adequate level of prenatal care utilization by mother during pregnancy for infant *i*, X_i is a set of control variables for the mother and the infant and ε_1 is the stochastic error term. The first stage equation, which captures the effect of instruments (Inst) on adequately utilizing prenatal care is then specified as follows:

$$APC_i = \beta_0 + \beta_1 Inst_i + \beta_2 X_i + \varepsilon_2 \quad (9)$$

Since our endogenous regressor (APC) is a binary variable, we do not directly apply the two stage least squares (TSLS) estimator. This is because "the conditional expectation function (CEF) associated with the first stage is probably nonlinear, hence OLS first stage will be an approximation to the underlying nonlinear CEF" (Angrist and Pischke, 2009: 190). In such a case Angrist and Pischke caution against "forbidden regressions", which are situations in which either the fitted values from the non-linear (for instance, probit) first stage are substituted for actual values in the second stage equation or used as instruments. As they put it, "naively plugging in first stage fitted values in non-linear models is a bad idea" (pp.192).

However, this binary variable may be viewed as a treatment indicator, resulting in the estimation of the treatment effect model (Cameron and Trivedi, 2010; Wooldridge, 2010). The model we consider specifically "estimates average treatment effect and the other parameters of linear regression model augmented with an endogenous binary treatment variable" (StataCorp, 2017:36), thus allowing for correlation between the unobservables that may affect treatment and unobservables that only affect potential outcomes. We maintain the stable unit treatment value assumption (SUTVA), that is, adequate utilization of prenatal care by one mother should not affect the infant birth weight for the other mother. Another important assumption in the estimation of average treatment effect is that of ignorability or unconfoundedness (Morgan and Winship, 2007). The assumption states that conditional on observable covariates, assignment to treatment is independent of potential outcomes. However, because differences in mothers` health awareness is unobserved, we hypothesize that assignment to treatment (adequate utilization of prenatal care) and outcome (infant birth weight) may not only be determined by observable variables, hence we may not assume conditional independence between the two. Formally, the model, which uses both equations (8) and (9), where assignment to treatment is through an unobservable latent variable, is re-specified as follows:

$$H_{bwi} = \alpha_0 + \alpha_1 APC_i + \alpha_2 X_i + \varepsilon_1$$

$$APC_i = \begin{cases} 1 & if \quad APC^*_i > 0 \\ 0 & otherwise \end{cases} \tag{10}$$

The Heckman selection model, which in addition to the infant birth weight production function and adequate prenatal care demand equation (equations 8 and 9), has the following (probit) selection equation:

$$BWR_i = \theta_0 + \theta_1 X_i + \varepsilon_3 \quad (11)$$

Where BWR_i is a dummy variable with a value of 1 if the infant`s birth weight information is available and 0 otherwise. The error terms, ε_1 and ε_3 in equations 8 and 11 may be correlated (Hartman, 1991; Cameron and Trivedi, 2010) which, as indicated, assumes unobserved heterogeneity. This implies the use of latent variable determining availability of birth weight information resulting in a similar formulation as in equation (10). Estimation of the Heckman model is done using two approaches; (i) the two-step approach and (ii) one step (full information maximum likelihood) approach. The first step of the two-step approach involves generating a correction factor (inverse of Mills ratio) from the probit estimates of the birth weight report model (equation 11). In the second step, an OLS model is estimated with inverse of the Mills ratio as an additional regressor. While this approach is said to be consistent, it is less efficient than the full information maximum likelihood approach (Wooldridge, 2010; Hartman, 1991), which we adopt. According to Mwabu (2008), when above issues are considered, and given that they cannot be determined a priori, birth weight equation (8) may be re-specified as follows:

$$H_{bwi} = \alpha_0 + \alpha_1 APC_i + \alpha_2 X_i + \gamma_i E_i + \Psi_i (E_i \times \ APC_i) + \lambda_i \beta_i + \varepsilon_1 \quad (12)$$

where the correction terms E, ($E \times APC$) and β represent residuals of the endogenous treatment variable, possible non-liner interaction of the residual with the endogenous treatment, and inverse Mills ratio respectively. The rest of the variables are as previously defined and α, γ, Ψ, and λ are parameters to be estimated. The residuals account for the unobserved factors that might be correlated with utilization of prenatal care (Mwabu, 2008; Heckman and Robb, 1985). Interacting the residual with health care input accounts for the possible non-linear interaction of unobservable factors with other factors affecting infant birth`s weight.

Together with the approach to variables in previous studies (Rosenzweig and Schultz, 1982, 1983; Habibov et al., 2017) as well as those cited in Awiti (2014) and our assumptions, we instrument for adequate prenatal care utilization with the probability of care facility being sufficiently close and availability of care facilities in health districts. Higher probability of being close to the nearest health care facilities are expected to increase the likelihood to utilize prenatal care. The distance variable was found to determine hospital births in Netherlands (Daysal et al., 2015) and prenatal care utilization in Kenya (Awiti, 2014). While there could be worries that mothers may choose to reside nearer to the health care facilities because of some unobserved factors (Rosenzweig and Schultz, 1982), we believe our measure for distance addresses that. Firstly, as per the land allocation system, one does not necessarily choose where to be allocated. An application for plot of residence is submitted and the final decision lies with the land board department, hence the effect of being close to the heath care facility does not lie with the mother. Secondly, we consider distance at health district level, and argue that even if mothers were to choose to be nearer care facilities, this would not be a simultaneous decision for all of them. We also separate rural and urban samples since migration is likely to be from rural to urban areas (CSO, 2009a).

In the context of access to care, the policy for health care facility distribution can be argued to be exogenously determined by the suppliers (private and public). Although some mothers may temporarily migrate to urban areas when pregnant, there is more likelihood that they will still utilize public health care facilities, services from which are provided freely. To our knowledge, no study has been conducted in Botswana to examine the pregnancy-induced migration. However, studies conducted elsewhere find no statistically significant effect of migration in response to the expanded care (Schwartz and Sommers, 2014).

5. Results and Discussions

Three models are estimated; ordinary least squares, linear regression with endogenous treatment accounting for endogeneity of prenatal care utilization and Heckman sample selection model, which accounts for potential sample selection bias and heterogeneity. Table 4 presents results for adequate prenatal utilization (treatment variable for the treatment model) estimated using the maximum likelihood estimator. The table shows that having pre-secondary education compared to post-primary education (the reference category) reduces the likelihood to adequately utilize prenatal care. This implies that mother`s education is an important factor in influencing demand for care as has been observed in the literature (Simkhada et al., 2007; Awiti, 2014; Mwabu, 2008). Moreover, the higher probability of care facility being close and availability of care facilities are positively associated with likelihood for adequate prenatal care utilization. Rural residence reduces the likelihood to adequately utilize prenatal care.

Table 4: First Stage Regression Results

Variable	Full	Urban	Rural
Age	0.021	-0.018	0.049
	(0.054)	(0.058)	(0.088)
Age squared	-0.000	0.001	-0.000
	(0.001)	(0.001)	(0.002)
Married	-0.030	0.071	-0.268
	(0.111)	(0.094)	(0.279)
Male	0.064	0.046	0.090
	(0.076)	(0.110)	(0.099)
Height	0.005	0.002	0.010
	(0.007)	(0.009)	(0.011)
Pre-Secondary	-0.241**	-0.216	-0.254
	(0.116)	(0.155)	(0.211)
Other religion	-0.299	-0.286	-0.277
	(0.224)	(0.233)	(0.273)
No religion	0.081	0.115	0.038
	(0.144)	(0.204)	(0.283)
Proximity Likelihood	0.455***	0.226**	0.578***
	(0.085)	(0.110)	(0.087)
Care Facility	0.041***	0.046*	0.059***
	(0.011)	(0.026)	(0.019)
Rural	-0.269***		
	(0.081)		
Joint Significance (Chi2)	36.35***	42.17***	49.44***

***: significant at 1%, **: significant at 5%, *: significant at 10%
All standard errors, in the parenthesis, are clustered at fixed effects

Table 5 reports the ordinary least squares and second stage regression results. Age of the mother is associated with birth weight in full and urban samples only. While mother`s age carries a positive sign, age squared carries a negative sign suggesting that the likelihood of either impaired intrauterine growth or gestational duration increases for aging mothers. By implication, reproductive health stock depreciates with mother`s age. The incidence of being married is positively associated with birth weight in full and rural samples. Such effect might signal the role played by husbands, which is through their characteristics that may add on to the mother`s socio-economic environment. In Kenya for instance, husband`s education was found to have an effect on the likelihood of vaccination against tetanus (Mwabu, 2008). Warner (1995) also found that the relation of the child`s parent benefited the infant. Due to data limitations we are not able to investigate the effect of husband`s characteristics on either infant birth weight or utilization of prenatal care. While BFHS interviewed males in the 12-49 age category, there is no variable indicating that they were the fathers of these children aged below 5 years or husbands to the women considered by the survey. Furthermore, the 12-49 aged female questionnaire made no reference to the characteristics of husbands.

Table 5: OLS and Second Stage Regression results

	OLS			Treatment Effect Model		
	Full	Urban	Rural	Full	Urban	Rural
Age	0.017**	0.015	0.019*	0.017**	0.016**	0.015
	(0.007)	(0.009)	(0.009)	(0.007)	(0.008)	(0.011)
Age squared	-0.000**	-0.000	-0.000*	-0.000**	-0.000**	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.042**	0.027	0.072**	0.043**	0.023	0.083***
	(0.018)	(0.026)	(0.021)	(0.018)	(0.023)	(0.027)
Male	0.028***	0.023*	0.029**	0.022**	0.018	0.024
	(0.009)	(0.013)	(0.013)	(0.010)	(0.015)	(0.016)
Height	0.003***	0.004***	0.002**	0.003***	0.003***	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Pre secondary	0.007	0.000	0.016	0.023*	0.013	0.032*
	(0.011)	(0.021)	(0.010)	(0.012)	(0.021)	(0.018)
Rice price	0.038***	-0.008	0.055***	0.045***	0.018	0.058***
	(0.009)	(0.014)	(0.008)	(0.008)	(0.012)	(0.008)
Maize Price	-0.007*	0.020***	-0.026***	-0.017***	0.007	-0.034***
	(0.004)	(0.006)	(0.004)	(0.004)	(0.007)	(0.007)
Sorghum price	-0.003	0.002	-0.006	-0.006	-0.007	-0.001
	(0.003)	(0.007)	(0.004)	(0.004)	(0.007)	(0.004)
QoB1	-0.019	0.000	-0.038*	-0.020	-0.002	-0.034*
	(0.013)	(0.022)	(0.017)	(0.013)	(0.023)	(0.017)
QoB2	-0.033	-0.029	-0.037	-0.033	-0.025	-0.038*
	(0.021)	(0.033)	(0.024)	(0.020)	(0.031)	(0.023)
QoB4	-0.004	0.022	-0.037*	-0.005	0.023	-0.037*
	(0.014)	(0.022)	(0.021)	(0.013)	(0.022)	(0.021)
APC	0.038***	0.032*	0.049**	0.216***	0.237***	0.209***
	(0.012)	(0.018)	(0.019)	(0.048)	(0.039)	(0.076)
Other religion	-0.003	0.060	-0.055	0.012	0.080*	-0.044
	(0.027)	(0.036)	(0.055)	(0.019)	(0.042)	(0.043)
No religion	0.014	0.021	0.016	0.011	0.009	0.017
	(0.011)	(0.018)	(0.015)	(0.012)	(0.020)	(0.022)
Proximity	0.003	0.005	0.006			
	(0.009)	(0.011)	(0.014)			
Care Facility	0.000	0.000	0.002			
	(0.000)	(0.000)	(0.001)			
Rural	-0.007					
	(0.014)					
/athrho				-0.633***	-0.684***	-0.645*
				(0.200)	(0.173)	(0.371)
/lnsigma				-1.644***	-1.578***	-1.751***
				(0.049)	(0.055)	(0.082)
rho				-0.560	-0.594	-0.569
				(0.137)	(0.112)	(0.251)
sigma				0.193	0.206	0.174
				(0.010)	(0.011)	(0.014)
lambda				-0.108	-0.122	-0.099
				(0.031)	(0.027)	(0.051)
Observations	1159	656	503	1159	656	503

All standard errors, in parenthesis, are clustered at fixed effects
***: significant at 1%, **: significant at 5%, *: significant at 10%

Male infant is positively associated birth weight, although in full sample only. Kramer (1987) reviews studies whose conclusions were that infant`s sex did not affect either gestational age or prematurity. Nonetheless, they found that male infants were found to have larger weight and lower risk of intrauterine growth rate. Mother's height is also positively associated with birth weight across all the samples.

For full and rural samples, having pre-secondary education is positively associated with birth weight. It is not easy to interpret this effect given that pre secondary education also reduces the likelihood for adequate prenatal care utilization. While it has been found that pre-secondary education may be enough for child nutrition (Charmarbagwala et al., 2004), Celik and Younis (2007) find that education has no direct effect on birth weight. In fact, Rosenzweig and Schultz (1982) maintain that "it is doubtful that the schooling can affect the production of health without being associated with some alteration in an input" (pp59). They argue that the effect of education is through the changing perceptions of the relation between health and its inputs. Warner (1998) also finds no effect of mothers' education for black mothers and small effect for white mothers. From that, he also concludes that the pattern was also suggestive of Rosenzweig and Schultz`s view.

With regards to average retail food prices, since we do not observe whether households produced the considered food, results are likely to remain ambiguous. Theoretically, changes in food prices might affect household food security and mothers' nutrition. However, their effects would vary depending on several factors, including household food price change sensitivity, coping strategies as well as food source diversity, which might in part be affected by benefiting from food transfers. Nonetheless, the price for rice positively correlate with birth weight across all the samples. This, could in part reflect the fact that rice is not locally grown in the country and has no import restrictions, unlike maize and sorghum. Maize meal price is negatively associated with birth weight in full and rural samples. In Kenya, Grace et al. (2014) also found that maize prices alone did not have an effect on birth weight, but became significant when interacted with vegetation index. Overall, it would appear that perhaps food prices are capturing some of the unobserved variation in district/community characteristics.

Table 5 further shows that against the third quarter of birth dummy, all other quarters reduce (at 10% level) infant`s birth weight in rural sample. This might suggest some temperature and precipitation effects, which we do not observe in our data. In their study, Grace et al. (2015) provide literature, although with inconclusive results, with some effects of weather on birth weight. From such review (i) the effect of extreme temperature has been found to be more than that of seasonal temperature variation, (ii) low birth weight was observed to be more frequent in autumn-winter periods and (iii) high precipitation could lead to low birth weight (Grace et al., 2015). Adequate prenatal care utilization increases birth weight, and failing to account for endogeneity reduces its effect. From the treatment effect model results, moving from inadequate to adequate care utilization increases birth weight by 22, 24 and 21 percent in full, urban and rural samples respectively. These translate to respective increases in birth weight by 0.67, 0.73 and 0.64 kg compared to 0.12, 0.10 and 0.15 kg when endogeneity is unaccounted for.

5.1 Testing for Regressor Endogeneity

Treatment effect model produces a parameter that captures the relationship between unobservables determining assignment to treatment and unobservables affecting potential outcome, which is represented by rho (ρ). Other parameters are sigma (σ) and lamda (ρσ). According to Cameron and Trivedi (2010) /athrho (=0.5*ln[1+ρ]/[1-ρ]) and /lnsigma reported in the bottom of Table 5 are transformed outcomes, that ensures $\hat{\sigma} > 0$ and $|\hat{\rho}| < 1$. Regressor endogeneity is tested against the null hypothesis that ρ=0. Across all the samples, the null hypothesis of no correlation between these unobservables is rejected through the Wald test, at 1 per cent level for full and urban samples, and at 10 percent level for rural sample. We therefore conclude that the adequate prenatal care utilization is indeed an endogenous variable. The negative signs for the rhos in Table 5 (-0.560, -0.594, -0.569), imply that unobservables that raise birth weight occur with unobservables that lower adequate prenatal care utilisation.

5.2 Relevance and Validity of Instruments

Literature acknowledges the difficulty in identifying good and strong instruments (Bound et al., 1995; Crown et al., 2011). According to Crown et al. (2011) there is likelihood for strong and valid instruments to be also correlated with unobservables. This therefore presents a trade-off, resulting in the use of weak instruments, which at the same introduces larger bias. Instruments are termed good if they are exogenous (not correlated with the error term of the structural equation) and relevant (being statistically significant for the endogenous regressor). However, the possibility of weak but relevant, and exogenous but irrelevant instruments have been observed (Stock et al., 2002). According to Stock et al. (2002), instruments are not relevant if their joint significance on an endogenous explanatory variable is statistically not different from zero. Table 4 shows the overall effect (joint significance) of our excluded instruments and suggest that they are valid and relevant. We also find no evidence of direct association between instruments and birth weight, with the highest correlation coefficient of 0.43 between the probability of health care facility being sufficiently close and birth weight in rural sample.

5.3 Robustness Checks

Establishing the validity and strength of instruments is difficult, especially when the endogenous variable is binary (as applies for APC). Moreover, the treatment effect model has been questioned for the assumption of joint normality of errors and non-allowance of the calculation of casual effects under observed heterogeneity (Cerulli, 2014). Our results have so far demonstrated relevance of the instruments on the basis of their statistically significant effect on adequate prenatal care utilization. As we do not directly apply 2SLS from which we could derive the F statistic for joint significance in the first stage, we appeal to two alternative techniques; control function approach and the Two-Step IV model (Wooldridge, 2010; 2015). The control function approach we employ here requires the use of instrumental variables and is estimated in two steps. The first step involves estimation of the probit model for adequate prenatal care (APC) utilisation and obtaining the generalised residual as follows (Wooldridge, 2015).

$$\widehat{gr}_i = APC_i\lambda(Inst_i\gamma) - (1 - APC_i)\lambda(-Inst_i\gamma) \qquad i=1, \ldots, N. \qquad (13)$$

where as in the previous, APC_i is adequate prenatal care utilisation and $Inst_i$ is a set of instrumental variables. The second step involves OLS estimation of birth weight with the generalised residuals as an additional regressor. Statistical significance of the residuals suggests that the considered endogenous variable is indeed endogenous. Along equation 12, residuals could be interacted with this endogenous variable. Table A1 shows that for full and urban samples the generalised residuals are significant, while in the rural sample it is the residual-care utilisation interaction that is significant.

Although the control function approach is considered efficient even with weak instruments (Wooldridge, 2007), it may equally be argued that it could be sensitive to the specification of the first step probit model (Wooldridge, 2015). For that reason, we also consider the Two-step IV model. With this model, we first estimate a probit model by maximum likelihood, obtain fitted probabilities, and estimate the second step by IV using fitted probabilities and exogenous variables. This method is robust to misspecification of the first (probit) stage model, i.e., it has the property of robustness: as predicted probabilities are used as instruments there is no strict requirement for a correct specification of the probit model (Wooldridge, 2010). This is different from using fitted values of the endogenous regressor in place of the actual values, which is inappropriate (Angrist and Pischke, 2009). As evident in Table A2, birth weight increases by about 13, 34 and 11 per cent in full, urban and rural areas respectively (See results in Appendix).

5.3.1 Quality of Care

It is not possible to explore quality of prenatal care due to data limitations. We do not observe, for instance, the detailed contents of care as well as the time during which it was initiated. The complementary hypothesis suggests that mothers may invest more in care when they believe it to be beneficial (Mwabu, 2008). By implication, some may decide to alter their subsequent recommended visits. One possible effect is being vaccinated against tetanus, which has been found to positively correlate with birth weight in Botswana (Okurut, et al. 2013). Hypothesising that vaccination may in part reflect quality, we constructed a dummy variable of 1 if care was adequately sought simultaneously with receipt of injection against tetanus and re-estimated models. For full sample, this increases birth weight by about 3 percentage points (coefficient is 0.232 as opposed to 0.216), above the effect when injection against tetanus is not considered for the treatment effect model (See Table A3). While the channel of the effect may not be known with certainty, the conclusion on care effectiveness still holds.

5.3.2 Sample Selection

As not all infants had birth weight information recorded in their growth monitoring cards, estimating for only infants with birth weight information may introduce selection bias (Heckman, 1979). However, applying the Heckman sample selection model revealed no presence of bias in rural and urban areas separated (see Table A4). While the absence of birth weight information is generally linked to the absence of health professionals at the birth (i.e. home births), these results suggest that this may not always be the case; for example, mothers could lose the growth monitoring cards from which birth weight information is extracted during the surveys. For Botswana this is relevant given that the surveys are conducted months after birth to collect information on the three anthropometric indicators (wasting, underweight and stunting) of child nutrition. In the full sample, of the 54 infants whose birth weight information was not available although their cards were seen by the interviewers, only 35 were possibly born at home since assistance at delivery was from non-health professionals.

6. Conclusion

This paper investigates the role of prenatal care utilization on infant birth weight in Botswana, following an increase in the proportion of low birth weight infants, which was among the highest in the WHO African region and upper middle income countries. Using two stage regression, we account for potenatial endogeneity in prenatal care utilisation, whose effect on infant health has been debatable. We also account for the possible sample selection bias since birth weight information is not available for all infants. Age of the mother, mother`s incidence of being married, male infant, mother’s height, are positively associated with infant birth weight. The effect of age declines as age increases, implying a decrease in the reproductive health stock for the aging mothers. Maize meal price negatively associates with birth weight, while price for rice consistently carries a positive sign. However, given that we do not observe whether mothers (or their households) produced food, the effect of food prices would remain ambiguous. Thus, perhaps food prices are capturing some unobserved variation in districts or community characteristics.

The effect of adequate prenatal care utilization is evidenced to be reduced if endogeneity is un-accounted for, consistent with what has been observed in the literature. We derive two implications from these results. First, mothers should be encouraged to adequately utilize prenatal care to improve infant health. Secondly, and most importantly, it would appear that since care utilization works for birth weight as demonstrated in the literature, perhaps a possible policy issue relates to the quality of prenatal care. We do not rule out possibilities of both favourable and adverse selection, as not all variables affecting care use are observed in our data. However, previous reviews of administrative data on maternal mortality suggest that there were issues of substandard care, including delayed referrals, intervention and inappropriate management (Republic of Botswana, 2013, 2015). While we have not been able to control for the activities performed during care visits due to data limitation, results call for an enhanced audit of the quality of care as it could seemingly, be among the major contributors. Therefore, further investigation on care quality should be carried out in order to gauge the nature and extent of inadequacies for cost effectiveness.

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Appendix: Results for Robustness Checks

Table A1: Control function approach (Probit Reduced Form) results

	Full		Urban		Rural	
Age	0.017**	0.017**	0.018*	0.018*	0.018*	0.017*
	(0.007)	(0.007)	(0.009)	(0.009)	(0.009)	(0.009)
Age squared	-0.000**	-0.000**	-0.000*	-0.000*	-0.000*	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.043**	0.042**	0.025	0.026	0.077***	0.074***
	(0.018)	(0.017)	(0.029)	(0.029)	(0.021)	(0.020)
Male	0.025***	0.025***	0.017	0.017	0.029**	0.028**
	(0.009)	(0.009)	(0.013)	(0.013)	(0.013)	(0.013)
Height	0.003***	0.003***	0.003***	0.003***	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Pre secondary	0.021	0.019	0.026	0.025	0.027*	0.022*
	(0.014)	(0.014)	(0.024)	(0.022)	(0.015)	(0.015)
Rice price	0.040***	0.040***	0.039	0.039	0.058***	0.061***
	(0.007)	(0.007)	(0.023)	(0.024)	(0.007)	(0.008)
Maize price	-0.014***	-0.013***	-0.003	-0.002	-0.029***	-0.027***
	(0.005)	(0.005)	(0.012)	(0.013)	(0.005)	(0.005)
Sorghum price	-0.005	-0.005	-0.007	-0.006	-0.002	-0.003
	(0.003)	(0.003)	(0.010)	(0.009)	(0.003)	(0.003)
QoB1	-0.018	-0.019	-0.006	-0.005	-0.037*	-0.039*
	(0.013)	(0.013)	(0.023)	(0.023)	(0.017)	(0.018)
QoB2	-0.033	-0.033	-0.023	-0.024	-0.037	-0.039*
	(0.021)	(0.021)	(0.032)	(0.032)	(0.024)	(0.024)
QoB4	-0.004	-0.005	0.027	0.026	-0.037*	-0.040*
	(0.014)	(0.014)	(0.023)	(0.022)	(0.020)	(0.020)
APC	0.168**	0.183**	0.304*	0.307*	0.130**	0.146***
	(0.063)	(0.066)	(0.146)	(0.150)	(0.059)	(0.052)
Other religion	0.004	0.005	0.067*	0.067*	-0.049	-0.050
	(0.027)	(0.027)	(0.037)	(0.038)	(0.055)	(0.055)
No religion	0.013	0.013	0.011	0.012	0.017	0.019
	(0.011)	(0.010)	(0.021)	(0.021)	(0.015)	(0.014)
Rural	0.007	0.005	-	-	-	-
	(0.016)	(0.017)				
GR	-0.079**	-0.103**	-0.156*	-0.164*	-0.057	-0.095**
	(0.036)	(0.045)	(0.083)	(0.091)	(0.037)	(0.037)
GR*APC	-	0.053	-	0.029	-	0.104
		(0.058)		(0.090)		(0.072)
Observations	1159	1159	656	656	503	503

Standard errors in parenthesis
***: significant at 1%, **: significant at 5%, *: significant at 10%
GR: generalized residual

Table A2: Two Step IV regression results

	Full	Urban	Rural
Age	0.017**	0.019*	0.017*
	(0.007)	(0.010)	(0.009)
Age squared	-0.000**	-0.000*	-0.000*
	(0.000)	(0.000)	(0.000)
Married	0.043***	0.024	0.076**
	(0.015)	(0.020)	(0.024)
Male	0.025**	0.017	0.028**
	(0.011)	(0.014)	(0.013)
Height	0.003***	0.004***	0.002**
	(0.001)	(0.001)	(0.001)
Pre secondary	0.016	0.033***	0.022
	(0.015)	(0.011)	(0.013)
Rice price	0.042***	0.057***	0.059***
	(0.014)	(0.018)	(0.007)
Maize price	-0.013*	-0.013	-0.028***
	(0.008)	(0.009)	(0.005)
Sorghum price	-0.005	-0.008***	-0.002
	(0.005)	(0.002)	(0.003)
QoB1	-0.018	0.015	-0.038*
	(0.015)	(0.014)	(0.017)
QoB2	-0.036**	-0.028	-0.040
	(0.015)	(0.019)	(0.025)
QoB4	-0.002	0.044***	-0.040*
	(0.015)	(0.015)	(0.020)
APC	0.134*	0.343***	0.108*
	(0.064)	(0.076)	(0.065)
Other religion	0.005	0.086*	-0.052
	(0.028)	(0.051)	(0.049)
No religion	0.012	0.007	0.015
	(0.015)	(0.031)	(0.016)
Rural	0.001	-	-
	(0.014)		
Observations	1159	656	503

Standard errors are in parenthesis
***: significant at 1%, **: significant at 5%, *: significant at 10%

Table A3: Second Stage Regression results for proxy care quality

	Full	Urban	Rural
Age	0.013	0.007	0.015
	(0.008)	(0.011)	(0.012)
Age squared	-0.002*	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
Married	0.051**	0.040	0.078**
	(0.023)	(0.033)	(0.039)
Male	0.023*	0.018	0.023
	(0.012)	(0.016)	(0.018)
Height	0.003***	0.003***	0.002
	(0.001)	(0.001)	(0.001)
Pre secondary	0.023	0.011	0.040
	(0.015)	(0.024)	(0.019)
Rice price	0.041***	0.011	0.055***
	(0.007)	(0.011)	(0.010)
Maize price	-0.018***	0.008	-0.037***
	(0.004)	(0.008)	(0.005)
Sorghum price	-0.007*	-0.006	-0.003
	(0.004)	(0.006)	(0.006)
QoB1	-0.018	-0.001	-0.026
	(0.013)	(0.023)	(0.017)
QoB2	-0.030	-0.026	-0.033
	(0.020)	(0.032)	(0.021)
QoB4	-0.003	0.026	-0.037*
	(0.013)	(0.022)	(0.020)
APC*Injection	0.232***	0.229***	0.281***
	(0.046)	(0.061)	(0.038)
Other religion	0.011	0.076	-0.043
	(0.021)	(0.050)	(0.036)
No religion	0.020	0.017	0.032
	(0.013)	(0.019)	(0.028)
Rural	0.008	-	-
	(0.015)		
Observations	1159	656	503

Standard errors are in parenthesis
***: significant at 1%, **: significant at 5%, *: significant at 10%

Table A4: Results for Sample Selection Model of infant birth weight availability

	Full		Urban		Rural	
	Coff.	SE	Coff	SE	Coff	SE
Birth Weight						
Age	0.015*	0.008	0.014*	0.008	0.018**	0.009
Age squared	-0.000*	0.000	-0.000	0.000	-0.000**	0.000
Married	0.048***	0.015	0.026	0.026	0.070***	0.022
Male	0.029***	0.009	0.022*	0.013	0.030**	0.013
Height	0.003***	0.001	0.004***	0.001	0.002**	0.001
Pre secondary	0.025*	0.013	-0.000	0.020	0.012	0.011
Rice price	0.028***	0.006	-0.007	0.014	0.062***	0.007
Maize price	-0.008***	0.003	-0.019***	0.006	-0.024***	0.003
Sorghum price	0.000	0.004	-0.003	0.003	-0.003	0.003
QoB1	-0.022	0.013	-0.001	0.022	-0.037**	0.017
QoB2	-0.037*	0.020	-0.029	0.032	-0.037	0.024
QoB4	-0.012	0.013	0.022	0.022	-0.037*	0.020
APC	0.039***	0.011	0.032*	0.018	0.048***	0.019
Other religion	-0.006	0.028	0.062*	0.035	-0.054	0.054
No religion	-0.001	0.012	0.020	0.018	0.016	0.014
Birth weight report						
Age	0.011	0.041	0.027	0.065	-0.024	0.053
Age squared	-0.000	0.001	-0.000	0.001	0.000	0.001
Married	-0.099	0.134	-0.035	0.135	-0.136	0.304
Male	0.015	0.054	-0.005	0.094	-0.022	0.104
Height	0.003	0.005	0.001	0.009	0.007	0.010
Pre secondary	-0.238**	0.109	0.095	0.198	-0.485***	0.164
Other religion	-0.020	0.166	-0.144	0.157	0.220	0.228
No religion	0.159	0.156	0.701***	0.230	0.038	0.197
Proximity	0.431***	0.112	0.488***	0.100	0.518***	0.118
Care Facility	0.032***	0.010	0.026***	0.009	-0.003	0.016
Rural	-0.421***	0.099				
/athrho	-1.117***	0.146	-0.004	0.079	0.117	0.158

All standard errors, are clustered at fixed effects
***: significant at 1%, **: significant at 5%, *: significant at 10%