Effects of Maternal Immunization on Birth Weight in Rural Cameroon

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Research Paper 413

AFRICAN ECONOMIC RESEARCH CONSORTIUM
CONSORTIUM POUR LA RECHERCHE ÉCONOMIQUE EN AFRIQUE

Bringing Rigour and Evidence to Economic Policy Making in Africa

Effects of Maternal Immunization on Birth Weight in Rural Cameroon

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AERC Research Paper 413
African Economic Research Consortium, Nairobi
January 2021

THIS RESEARCH STUDY was supported by a grant from the African Economic Research Consortium. The findings, opinions and recommendations are, however, those of the author and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat.

Published by: The African Economic Research Consortium
P.O. Box 62882 - City Square
Nairobi 00200, Kenya

ISBN 978-9966-61-108-6

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Abstract

This study investigated the effects of tetanus immunization on birth weight in rural Cameroon. Specifically, the study sought to: examine the determinants of mother's immunization in Cameroon; assess the impact of mother tetanus immunization on child health production; examine how birth weight production function can be estimated by area of residence and household income; and propose policy implications on the basis of the findings. To tackle these objectives, the study used the ordinary least square (OLS) model. Empirical results were based on pooled data from the 2004 and 2011 demographic and health surveys (DHS) collected by the government's statistics office. The results showed that maternal immunization during pregnancy was associated positively with birth weight, overall in rural and urban areas, and among poor and non-poor households. Other variables that were significantly associated with birth weight in rural Cameroon were: mother's education in years of schooling, mother's age, father's age, first twin birth, male child birth, non-poor, interaction of mother's and father's education and urban household residence. These results have implications for addressing child health concerns in the ongoing process of growth, employment and poverty reduction in terms of improving access to antenatal care and family planning in rural Cameroon.

Keywords: Effects, Maternal Immunization, Birth Weight, Ordinary Least Square, Rural Cameroon

1. Background

Child health has long been a major focus of the literature on human capital production function in development economics, where production functions have been estimated for child height given age, weight given age, weight given height, birth weight, gestation age and diarrhoeal incidence (Rosenzweig and Schultz, 1983). Health has generally been accepted as an important determinant of human capital along with education and hence factor productivity (Wilhelmson and Gerdtham, 2006). In this context, health provides utility not only directly but also indirectly as it is a key input into many production processes (Grossman, 1972).

Health conditions in utero have consequences for later life cycles (Victoria et al., 2008; Mwabu, 2009). According to Mwabu (2009), previous studies have shown strong correlations between low birth weight and infant mortality, high blood pressure, cerebral palsy, deafness and behavioural problems in adult life (Case et al., 2005). This implies that birth weight does not only affect child health but also have implications for health in adulthood where productivity can be strongly affected.

In Cameroon[2], the general health of the population has deteriorated considerably since the early 1990s. The mortality rate increased by 12% between 1991 and 1998, the chronic malnutrition rate for children aged 12 to 23 months old also rose from 23% to 29% and the rate of delivery attended by qualified practitioners (doctors and nurses) declined by 5% during the same period. Moreover, between 1991 and 2002, the rate of HIV/AIDS infection within the sexually active population rose alarmingly from 2% to 11.8% (Government of Cameroon, 2003). As a tool for improving child and maternal healthcare by 2008, the Government of Cameroon implemented a 5-year action plan in the Extended Program for Immunization (EPI), incorporating the following: (i) mobilizing additional resources for immunization, independence and introducing new vaccines; (ii) training/retraining staff and rehabilitating/renewing equipment; (iii) developing communication materials to promote behavioural changes; (iv) outsourcing programme implementation responsibilities to health districts; and (v) ensuring programme monitoring and evaluation activities (Government of Cameroon, 2011).

Table 1: Immunization profile—Cameroon (%)

Vaccine	1990	2000	2008	2009	2010	2011	2013
Vaccine for children (aged 0 to 5 years)							
Bacille Calmette-Guerin (BCG)	52	69	86	79	83	80	83
DTC3 = DTC+ HepB-reference antigen (DTC3)	36	53	84	80	84	82	86
Measles (VAR)	-	49	77	72	79	76	68
Poliomyelitis (VPO)	34	49	82	79	83	80	89
Yellow fever (VAA)	-	-	77	72	79	75	61
Diphtheria-tetanus-pertussis (DTP1)	-	54	93	88	92	90	91
Infection due to pneuoccocus (Pneumo)	-	48	88	84	78	80	79
Avitaminosis (VIT.A)	44	62	84	81	90	87	92
Vaccine for mothers							
Anti-tetanus for expectant mothers (VAT2+)	82	79	65	72	83	80	85
Tetanus toxoid (TT2+)	12	40	76	73	74	69	91

Source: WHO-UNICEF coverage estimates (2012 NOT IN REF LIST) and MPH (2014)

The focus of this study was maternal immunization using tetanus toxoid (TT2+). The evolution of this vaccine among women has been irregular, beginning in 1990 (12%), to 69% in 2011 with its peak in 2008 at 76%. Whereas vaccinating pregnant women may protect young infants from infectious causes of mortality by passive immunization and by reduced transmission to the neonate from mother (Klaugman, 2014), as noted by WHO (2006), the effectiveness of a vaccine programme largely depends on: (1) the proportion of susceptible individuals who have access to immunization services; (2) the vaccine failure rate (i.e., the proportion of individuals properly vaccinated but who fail to develop a protective response); (3) the vaccine efficacy (i.e., the proportion of individuals who may be expected to develop a protective response to the vaccine under optimal field conditions never 100%); (4) the effective procedures for preserving the vaccine at optimal temperature during transit; (5) the training of vaccinators to ensure proper administration of the vaccine; (6) the attitude of the vaccination staff; (7) the knowledge and attitudes of the population; and (8) the proportion of the population willing to submit to the vaccination schedule.

Further, the first time this vaccine was introduced, it caused many allergic reactions in the mothers and foetuses that created fear on the part of the women and so some became sceptical while others still took the vaccine because of the vaccination campaigns. Generally, vaccines can occasionally induce allergic reactions, ranging from mild to severe anaphylactic responses. Adverse responses may be due to components of the vaccine, for example, residues of materials used to prepare the vaccines, preservatives, etc. Specific recommendations with regard to allergic reactions are provided by the producers of each vaccine and should be heeded.

Excessive interpretation of contraindications (e.g., non-febrile mild acute illnesses, or mild illnesses with temperature elevations of 101°F or less) results in reduced uptake of vaccine. While severe illness should be viewed as contra-indicative of immunization, mild acute illness with or without low grade fever, current microbial therapy and the convalescent phase of an illness are not reasons to avoid or delay vaccination (WHO, 2006).

Following the Government of Cameroon (2011) and the respective demographic and health surveys (DHS), the trend and coverage of tetanus immunization have not been uniform, varying as follows: 71% in 1991, 82% in 1998, 79% in 2004 and 51% in 2011. The role of tetanus vaccination is to reduce the risk of the foetus contracting tetanus during birth, an outcome which motivates the mother to invest in better nutrition and behaviours that enhance foetal growth and, therefore, reduce the risk of her infant dying due to low birth weight. The central argument is not that tetanus vaccination directly increases birth weight, but that it is strongly correlated with healthcare consumption and behaviours that increase birth weight (Bategeka et al., 2009).

Despite these efforts, child healthcare literature for Cameroon is lacking (Ako et al., 2008). Training in reproductive health overall has not been a priority in the health sector. Current deliberations over approaches to reproductive health provide a window of opportunity to improve access to care to enable women to attain good health and maintain good health during their reproductive years. The cost of health services rose nearly three times as fast as the average inflation rate over the last 5 years, by some 70% and it is apparent that financial capacity has a considerable impact on demand for health services. Annual average health spending per capital is three times higher in urban than in rural areas and four times as high among the non-poor as among the poor. Moreover, health problems are concentrated among disadvantaged groups and these rates have stagnated or worsened over the past three decades (Government of Cameroon, 2011). All these factors are likely to result in low birth weight and high maternal mortality in most rural communities where medical services are inadequate in supply or entirely lacking in Cameroon.

As established in the preceding paragraphs, child health deficiencies can lead to disability and illness, with long-term consequences on physical growth and development of children that manifest in adult life and can also lead to death. Based on this, child health literature has gained some grounds in sub-Saharan Africa (Kenya, Nigeria, Ghana and Ethiopia to name a few) but to the best of our knowledge limited effort has been made in Cameroon. The only studies that have attempted to shed some light on this domain are Baye and Fambon (2010) and Baye (2010) using the 2001 Cameroon household consumption survey data. Our study is therefore, bridging this gap by attempting to relate mother tetanus immunization to child health at birth using the 2011 Cameroon DHS data.

Considering these issues, it has become imperative for health researchers, governments and organizations to focus their attention on this domain of research. This is pressing since the job market needs both men and women and, most

importantly, a healthy population to increase productivity and reduce poverty. To fill this literature gap in Cameroon therefore this paper addresses the following research questions: (1) What are the determinants of the probability of mother's immunization in rural Cameroon? (2) What is the effect of a mother's immunization on birth weight? (3) What policy interventions can better be used to ameliorate child health?

On the basis of these research questions, the main objective of the study was to determine the effects of maternal immunization on child health at birth in rural Cameroon.

The specific objectives were :

1) To examine the determinants of mother's immunization in Cameroon.
2) To assess the impact of a mother tetanus immunization on child health production.
3) To decompose birth weight effects by area of residence and household income.
4) To propose policy implications on the basis of the findings.

2. Literature review

In modern literature, child health is the condition of the body or state of well-being from 0 to 59 months strongly determined by 4 indicators: genetics, parent lifestyles, environment and socio-economic status of guardians or parents. Generally, health has two distinct phases, positive health (well-being) and negative health (ill health). The positive phase comprises the qualitative aspects of health and human life in general, strongly associated with the concept of "fitness". The negative phases are determined by the presence or absence of disease, illness, deformity, unwanted states, injury, disability and handicap. The relationship between the two phases is not clear-cut (Downie et al., 1996) and they may not be systematically related at all.

Of particular relevance to our study, child health is measured by birth weight (Rosenzweig and Schultz, 1983). Birth weight is a good indicator of the health of the child in the womb because the weight is taken immediately after birth. As compared to birth weight, the Apgar score can be used. This is a sum of scores on physical tests conducted on a new born, typically 1–5 minutes after birth on the basis of heart rate, respiratory effort, muscle tone, reflex irritability and colour can also be used. However, the Apgar score may be subject to greater measurement complications whereas birth weight implies a malnourished foetus will be born with low birth weight; hence child health in this study is captured by birth weight (Mwabu, 2009). Other child health indicators are volatile and sensitive (such as height and weight) to the external (social and economic) environment, hence making birth weight a good indicator of child health.

Immunization against tetanus during pregnancy is used as a proxy for prenatal care services received by the mother. Immunization against tetanus is further assumed to be complementary to other inputs that improve the health of the child in the womb. It can be argued that women who were immunized against tetanus during the 2011 Cameroon health survey were more likely to engage in demand behaviour that increased birth weight than women who were not immunized. The essential argument is that while tetanus vaccination does not directly increase birth weight, the vaccination is strongly correlated with healthcare consumption and behaviours that increase birth weight (Ajakaiye and Mwabu, 2007). Other factors such as: nutritional status, age of the mother, areas of residence etc. which are proxies of availability of health care and nutrients, also affect the health of the child in the uterus.

The different anthropometric and annual monitoring indicators of child health appropriate for children aged 0 to 59 months stipulated in health literature include: weight-for-age (WAZ) standard scores; height-for-age (HAZ) standard scores (such as stunting, shortness and chronic malnutrition); weight-for-height (WHZ) standard scores (such as wasting, thinness and acute malnutrition) (WHO, 1986). According to the WHO Working Group (2006), WAZ is a contemporaneous measure combining both HAZ and WHZ. However, a consideration of the three measures is the best option. In addition, mortality and morbidity rates have also been commonly used as indicators of child health status (Bruce, 2003).

As empirically observed by Mwabu (2009), immunization of the mother against tetanus during pregnancy is strongly associated with improvements in birth weight. Ukwuani and Suchindran (2003) reiterated that low birth weight children have low health endowment, making them more vulnerable to infectious diseases and malnutrition in the short and the long run. Low birth weight is therefore a leading cause of neonatal mortality because infants are more likely to experience physical and developmental health problems or die during the first year of life than are infants of normal weight. Alderman and Behrman (2004) indicate that children with prenatal nutritional deprivation (low birth weight) are smaller than their peers. The children tend to start school later, progress through school less rapidly, have lower schooling attainment and perform less well on cognitive achievement tests when older. In this context, some of the evidence for impaired school performance has focused on children with birth weights below 2,500 g (Saigal et al., 2000). In Cameroon the rural population is higher than the urban population and there is evidence that low birth weight children require additional outpatient care and hospitalization during their childhood (Government of Cameroon, 2003). Thus, because of lack of medical centres in the rural community, most mothers spent their time in hospitals trying to take care of their children, hence fuelling poverty and deteriorating living standards in rural Cameroon.

Awiti (2012) cited several authors that contributed in this domain, for example higher prenatal care visits increase birth weight (Rous et al., 2004). An increase in the quality of prenatal care increases birth weight (Mwabu, 2009). Delay in seeking prenatal care increases the risk of low birth weight (Wehby et al., 2009). Early initiation of prenatal care leads to a reduction in low birth weight (Wehby et al., 2009). Inadequate use of prenatal care is associated with higher risk of low birth weight (Raatikainen et al., 2007). Prenatal care visits lost early in the pregnancy have a negative impact on birth outcomes (Evans and Lien, 2005) and low birth weight rates are elevated among women who receive inadequate prenatal care than among those who receive intensive prenatal care (Kotelchuck, 1994).

Associated to birth weight and maternal immunization, many authors have examined other factors affecting child health; they include maternal education, age and marital status (Thomas, 1994; Pongou et al., 2006); duration of breastfeeding (Alvarado et al., 2005; Frimpong and Pongou, 2007); birth spacing (Mozumder et al., 2000); and parental and household characteristics and biological factors (sex and age of child) (Behrman, 1988).

From the foregoing, we observed that the benefits due to improving child health are obvious and far reaching, yet health conditions, particularly for children, are worsening throughout sub-Saharan Africa despite the widespread promotion of immunization in the region (Mwabu, 2009). The health of the children aged under-five years old is critical for optimal growth and development (Mirvis and Chang, 2003). Better child health improves the timing of school entry, the number of years completed, the learning that takes place per year of schooling and the actual achievements in school, which are commonly shown to lead to increased lifetime earnings (Behrman and Rosenzweig, 2004).

This study is somehow related to those of Baye and Fambon (2010) and Mwabu (2009). Despite this relationship, our study is different from that of Baye and Fambon (2010) in that: (i) the data set is different; while Baye and Fambon (2010) used the 2001 Cameroon household consumption survey, we used the data set from the 2011 DHS; (ii) birth weight was used as a measure of child health while Baye and Fambon (2010) used WAZ; and finally (iii) Baye and Fambon (2010) were interested in evaluating spill-over effects of literacy on child nutritional status, however, we were interested in linking maternal tetanus immunization to child health at birth. Our study was also different from that of Mwabu (2009) mostly at the empirical level, since we used data from Cameroon data while Mwabu used data from Kenya. It is therefore interesting to estimate similar functions and compare the results.

Much of the child health literature in Cameroon is in the medical library (Ako et al., 2008). In an effort to close this gap and contribute to Cameroon child health literature, this study empirically linked tetanus immunization to child health at birth using birth weight as a measure of child health. This study also value added by examining the determinants of the probability of mothers immunization in rural Cameroon and proposing relevant policies geared towards improving child health in rural Cameroon. This contribution is pressing as the job market needs both men and women and, most importantly, a healthy population to increase productivity and reduce poverty.

3. Methodology

This study used a reduced form of reproductive health function (as proposed by Rosenzweig and Schultz (1983); Mwabu (2009) and Baye (2010) to study the determinants of child health in rural Cameroon. As structured by authors (Ajakaiye and Mwabu, 2007) in the health literature, the demand for child health services by a mother is analysed using a model in which child health production in utero is embedded in a utility maximizing behaviour of the mother. This implies the demand for child health care can be analysed within the framework of utility maximization behaviour of the mother.

However, child health and health in general provides utility not only directly but also indirectly, as it is a key input into many household production processes. Family health, especially child health, is an important component of economic growth and poverty reduction because it shapes both present and future human capital, as well as livelihood prospects. Thus, good health at childhood as argued, does not only affect the physical growth potential, risk of morbidity and mortality in later years of life; but also releases potential household savings, medical expenditures and extra time to adult household members to take more advantage of labour market opportunities, as well as a child's capacity to learn and prospects for better future standards of living (Baye, 2010). In this regard, children's health can be considered as an important input to the well-being production function of the household registering mainly indirect effects on household income via the extra time (Klaugman, 2014).

Here, we envisaged a framework in which household utility function encompasses child health, which is captured in this study by birth weight of children registered in the 2004 and 2011 Cameroon DHS data. As observed in Mwabu (2009), anthropometric measurements of child health/nutrition tend to be positively associated in many studies with a child's chances of survival, later health status, subsequent performance in school and eventually productivity as an adult worker. Also, the household provides the environment in which individuals produce and consume health and other goods and services. In addition to providing its members with an environment for production and consumption of private and public goods, the household also provides the mechanism for intra-household allocation of essential commodities such as health care, food, clothing and reproductive health services. This allocation mechanism is important because it determines the well-being of all household members (Ajakaiye and Mwabu, 2007). Thus, estimation of the parameters of the child health production

function requires knowledge of inputs into the process. Moreover, many studies have shown that economic development is a key determinant of health outcomes (Case et al., 2005).

Linking tetanus immunization to child birth weight

As implied earlier, the utility maximization behaviour of the mother given the reproductive health production function is subject to a budget constraint where health investment goods are purchased only to improve child health, so it enters the mother's utility function only through the health status of the child in utero. The child health production function has the property that it is imbedded in the constrained utility maximization behaviour of the mother; structurally this has been re-expressed to yield healthcare demand functions (Bategeka et al., 2009).

Generally, good health of household members is one of the critical components influencing the potential of households. It permits individuals in the household to increase their productivities, earnings as adults and so reduce poverty. The 2004 and 2011 DHS data permit joint estimation of models of child healthcare demand and health production, we estimated demand for maternal immunization simultaneously with a model of birth weight determination. Changes in prices of health-neutral goods also affect child health through the household budget constraint. Thus, policy makers need to know the parameters of both child health production technology and associated health input demands to predict health effects of changes in input prices. To obtain such information, health production and input demand parameters must be estimated simultaneously. Such estimation is complicated by the need to identify input demands from health production technology. In our case, the estimation is further complicated by the need to identify the birth weight effect of the sample selection rule to avoid biases in parameter estimates due to non-random selection of children into the estimation sample (Mwabu, 2009). However, this can also be done using the ordinary least square (OLS) in STATA 11.0.

As concerning measurement issues, Ajakaiye and Mwabu (2007) observed that birth weight is the appropriate indicator for measuring child health. This explains why in the birth weight model, maternal immunization is assumed to improve child health in line with the complementarity hypothesis. The key determinants of birth weight include nutritional status, age of the mother, the quantity and quality of prenatal care services received by the mother, mother's immunization against preventable diseases and behavioural change during pregnancy such as quitting smoking. Other factors such as areas of residence which are proxies for availability of health care and nutrients also affect the health of the child in utero.

In this case, vaccination against tetanus is endogenous to birth weight because it is a choice variable. As already mentioned, vaccination against tetanus is strongly correlated with health care consumption and behaviours that increase birth weight (Ajakaiye and Mwabu, 2007). By implication, the adoption of a specific behaviour or the uptake of a specific input improves health, creates incentives to engage in other

health-augmenting behaviours or consumption that improve birth weight (Nathan, 2009). Further, immunization against tetanus during pregnancy is used as a proxy for antenatal care services received by a woman. It is also documented in literature to be complementary to other inputs that improve the health of the child in the womb, such as presumptive malaria treatments and avoidance of risky behaviours. Dow et al. (1999) observed that "a woman will increase inputs into birth-weight when she believes that the Expanded Programme of Immunization (EPI) will be available to increase the child's chances of surviving." Tetanus vaccination for pregnant women is one of the major components of EPI, a worldwide vaccination initiative sponsored by the World Health Organization (WHO), which also provides maternal services to women such as safe delivery and post-natal care.

Following WHO (2006), tetanus immunization may be determined by factors such as: wealth index, mother's age at last birth, education, husband's occupation, ever using contraception, fertility preference, wanted last child, having permission to go to hospital/health centre, pregnancy complications and mass media exposure for receiving tetanus vaccination. Based on the factors that determine birth weight (nutritional status, age of the mother, areas of residence, etc.), the birth weight production function may take the structural form:

$$B = w + \varphi_1 \chi_1 + \varphi_2 \chi_2 + \varphi_3 \chi_3 + \varphi_4 \chi_4 \quad (1)$$

where B is birth weight and the outcome variable, predicted by multiple explanatory variables; w indicates the value of B when all values of the explanatory variables are zero. The χ of 1 to 4 simply refers to continuous explanatory variable (such as the mother (education, age), father (education, age), child (sex, twin birth) and household (social status, place of residence) characteristics) and may be represented using a line of best-fit, where the B is predicted, at least to some extent, by χ. Each φ parameter indicates the average change in B that is associated with a unit change in χ, whilst controlling for the other explanatory variables in the model. Equation 1 is the structural equation of interest that is the birth weight production technology whose parameters are to be estimated. The OLS model based on equations 1 will be estimated for the determinants of birth weight using the econometric software STATA 11.0. Holding to the ideas of O'Donnell et al. (2008), it is also relevant to establish if the factors that affect child growth have a different impact depending on whether the mother received incomplete immunization while pregnant. The OLS regression is particularly powerful as it is relatively easy to check the model assumption such as linearity, constant variance and the effect of outliers using simple graphical methods (Hutcheson and Sofroniou, 1999).

In addition to the model parameters and confidence intervals for φ, it is useful to also have an indication of how well the model fits our DHS data. Following Hutcheson (2011), our model-fit can be assessed through comparing deviance measures of nested

models. For example, the effect of variable χ_4 on B in model 1 can be calculated by comparing the nested models thus,

$$\begin{aligned} B &= w+\varphi_1\chi_1+\varphi_2\chi_2+\varphi_3\chi_3+\varphi_4\chi_4 \\ B &= w+\varphi_1\chi_1+\varphi_1\chi_2+\varphi_3\chi_3 \end{aligned} \quad (2)$$

The change in deviance between these models indicates the effect that χ_4 has on the prediction of B when the effects of χ_1, χ_2 and χ_3 have been accounted for (it is therefore the unique effect that χ_4 has on B after taking into account χ_1, χ_2 and χ_3). The overall effect of all the four explanatory variables on B can be assessed by comparing the models:

$$\begin{aligned} B &= w+\varphi_1\chi_1+\varphi_2\chi_2+\varphi_3\chi_3+\varphi_4\chi_4 \\ B &= w \end{aligned} \quad (3)$$

From this determination of our model-fit, the significance of the change in the deviance scores can be assessed through the calculation of the F-statistic and this is made possible through the STATA 11.0 software. Further, the software enables us to estimate the parameter for which indicates the predicted consumption when all explanatory variables are equal to zero; the parameters which indicate the average change in birth weight that is associated with each unit increase in the explanatory variable (Hutcheson, 2011). While the significance of the relationship between each explanatory variable and birth weight can be estimated by comparing the deviance statistics for nested models.

Presentation of the 2011 Cameroon demographic and health surveys[3]

In Cameroon, the Ministry of Economic Affairs, Programming and Regional Development is the executing agency of the DHS. The National Institute of Statistics collects the data. The fourth Cameroon DHS was realized in 2011 after the 1991, 1998 and 2004 surveys respectively. The 2004 and 2011 DHS were aimed at a national representative sample of about 11,732 children (0–59 months). While in 2004 there were 8,125 children (0–59 months) with women of reproductive age (15–49 years), alive and living within the selected zones of sample as well as a sub-sample of about

50% of households for the men (17–97 years). The results of these surveys were presented for Cameroon, Yaoundé and Douala (two great metropolitan cities), other towns, urban and rural zones and each of the 12 areas of study constituting the 10 regions plus Douala and Yaoundé. All the members of households drawn are registered in household questionnaire.

Considering the case of the child sample characteristics, our unit of observation was the child aged 0–59 months in 2004 and 2011 respectively. For each child, information is available on: weight, sex, size at birth, place of birth, age, siblings and height and on parents' characteristics. The data file for each child is linked to household-level characteristics such as landholding and the amount of time women spent per day to collect water or firewood. In addition, we linked information external to the household survey to the analytic sample. The key variables derived from external data included food prices, housing prices and transportation/communication prices.

Using the combined data sets of 2004 and 2011 DHS (see the Descriptive statistic, Table 2), an important feature of our sample is that birth weight information is missing for 8,247 children, comprising 42% of the total sample. This figure is consistent to that of Mwabu (2009) had (about 3,444 missing and comprising 46% of total sample) in the case of Kenya. The remaining 11,610 children or 58% of the sample had birth weight information. Birth weight is missing mainly for children born at home. In 2004, nearly 42% of the Cameroonian children were born at home while in 2011 it was 60%. The reporting or recording of birth weight during the household survey depended primarily on where the child was delivered. The birth weights were directly extracted from the growth monitoring cards of children, which also showed where the child was born.

The report of a birth weight in the household sample is assumed to be strongly associated with a mother's contact with a clinic or with the health personnel during or after birth. So we assumed that any child who was born at the clinic and had a missing birth weight also had a missing growth monitoring card at the time of the survey. The result of this survey was presented for Cameroon, 12 regions (Centre, Littoral, South West, North West, South, East, Far North, Adamawa, West, North, Douala and Yaoundé). The members of households drawn were registered in household questionnaire, among households selected for the women's sample and men (17–97 years) were interrogated.

The specific variables used in this study were: outcome variable (birth weight of children in kilogrammes); potentially endogenous determinants of birth weight (tetanus vaccination and age of mother at first birth); exogenous demographics (residence, mother's education in single years, father's education in complete years, sex of the child, mother's age, father's age, sex of household head, i.e., male or female head).

Missing birth weight of children and home delivery

As already established, birth weight is the first weight of the foetus or new born obtained after birth. For live births, birth weight should preferably be measured within the first hour of life, before significant post-natal weight loss has occurred.

UNICEF/WHO (2004) revealed that before 1990; most estimates of low birth weight for developing countries were based on data compiled from health facilities. However, such estimates are biased for most developing countries because most newborn children are not delivered in facilities and those that are delivered in health facilities are a selected sample of all births. As an alternative to facility-based data, information on birth weight has been collected systematically since about 1990 from mothers participating in nationally representative household surveys, mostly the United States Agency for International Development (USAID)-supported DHS and the UNICEF-supported Multiple Indicator Cluster Surveys (MICS) (UNICEF/WHO, 2004).

In Cameroon, the phenomenon of birth weight missing is still relatively high using the DHS data, especially among the rural population. According to the World Bank rural population refers to people living in rural areas as defined by national statistical offices; about 59.3% of the population of Cameroon lived in rural communities in 1990; 50.1% in 2000; 41.6% in 2010; and 41.3% in 2012. The rural community in this part of the world is characterized by inadequate supply of medical centres and services, poor road infrastructure and communication network and inadequate water supply.

Pregnant mothers in Cameroon have committed to immunization programs normally conducted on fixed days at the medical centres. This is due to the mass campaign for immunization awareness and the benefits of prenatal services carried out since 2008. However, most of the mothers take advantage of the tetanus toxoid (TT2+) to deliver their babies at home and so do not register the weight of their children. The presence of traditional birth attendants has equally increased home deliveries in rural Cameroon (Ako et al., 2008). The 5-year action plan of the EPI included a government initiative to train about a 1,000 traditional birth attendants; unfortunately, this has not been effective (Ako et al., 2008). This explained why the birth weights of children delivered at home were missing in the Cameroon DHS.

In this line of argument Tambi et al. (2014) in linking child health, maternal labour force participation and household asset endowments: what the people say, reveals that pregnant women in Cameroon are more conscious of vaccination immunization as compare to other possible interventions, such as mother and child feeding programs, well baby clinics, micro-nutrients supplementation, and even health and nutrition educational outreach. This might be caused partly by the lack of knowledge in prenatal care issues and partly because the ministry responsible for public health in Cameroon following the 2008 Action Plan has laid more emphasis on vaccination both during and after pregnancy.

Tetanus disease, tetanus toxoid and importance of maternal immunization

Tetanus is a bacterial infection that causes painful muscle spasms and can lead to death (WebMD, 2015). Generally, the bacteria which cause tetanus are commonly present in soil, dust and manure and can infect a person even through a tiny scratch. However, both children and adults are more likely to get tetanus through

deep punctures from wounds created by nails, blades, scissors, niddles and knives, especially during delivery. The bacteria travel through the blood or nerves of the infected person to the central nervous system. Tetanus is often called lockjaw; its symptoms are headache, and muscle stiffness, starting in the jaw then the neck, arms, legs or abdomen. Other symptoms include: problems swallowing, irritability and restlessness. Tetanus symptoms result from a toxin produced by the tetanus bacteria. Symptoms often begin around a week after infection. But this may range from three days to three weeks or even longer. The most common symptom is a stiff jaw, which can become locked, hence the name lockjaw. The infection is characterized by fever and sweating, high blood pressure and palpitation, and muscle spasms in the face, causing a strange-looking steady smile or grin; if not treated, tetanus can cause death from suffocation (UNICEF, 2010). Brennam (2015) noted that tetanus is a dangerous nerve ailment caused by the toxin from a common bacterium (Clostridium tetani). It may occur when bacterial spores enter the body by way of animal or insect bites, surgical wounds, needle injection, burns, splinters, ulcers and infected umbilical cords and by proverbial rusty nails, scissors and knives .

Brennam (2015) indicated that an estimated one million infants die of tetanus in developing countries each year because of poor hygiene. He added that since childhood immunization laws were passed in the US in the 1970s only about 50 cases of tetanus a year are reported in this country; about three-quarters are elderly people or people who have never been immunized. In Cameroon, childhood immunization laws are yet to be enforced, meaning that tetanus is still an issue of great concern, especially among rural inhabitants and poor households in general. Particular to this study, the immunization variable capture was simply a proxy for the broader issue of accessing prenatal healthcare services. Our tetanus immunization variable therefore not only captured the impact of receiving the tetanus vaccine but also the range of services associated with receiving the vaccine.

As a remedy for the tetanus, this study considered the tetanus toxoid vaccine as the appropriate cure for the disease. The variable tetanus immunization (coded as M1 in the DHS) simply refers to the number of tetanus toxoid injections given to a mother during pregnancy to avoid convulsions after birth. This variable indicated whether the respondent received a tetanus toxoid injection during the pregnancy for DHS-I countries. Tetanus toxoid is a passive immunization. A passive immunization involves the transfer of antibodies generated by one individual to another individual in an attempt to prevent or attenuate an anticipated infection. This method is less effective than and short-lived compared to active immunization but it has the advantage of being more immediately effective. This is an important strategy in the use of antibody preparations for prophylaxis against or treatment for tetanus, rabies, varicella and hepatitis A and B.

Toxoid is also one of the most important and cost-effective interventions that health systems can provide, especially since it is essential for saving children's lives. Coupled with others, toxoid is one of the most effective measures of public health in helping children attain better lives without any disability (UNICEF, 2010). An

active immunization is also available. It involves challenging the human immune system with a vaccine comprising modified pathogens. Since the immune system has a long-lasting memory for a wide range of specific infecting agents, vaccination provides the individual with long-term protection against a particular disease. Active immunization not only provides the individual with immune protection, but also reduces the circulation of the infecting agent in the population, thereby protecting unvaccinated individuals as well.

Maternal immunization is important in that cutting an infant's umbilical cord and dressing the wound, creates opportunities for tetanus infection if high standards of cleanliness are not maintained. Maternal vaccination against tetanus, however, creates antibodies that are passed on to the child in utero, giving protection to the disease in newborn children. The effects of maternal vaccination (toxoid) on infant mortality have already been examined (see, Koenig, 1998). A substantial reduction in mortality in the first month of life (neonatal mortality) is recorded among children of women who received the tetanus toxoid, with a decline in the neonatal mortality rate from around 70 per 1,000 to around 40 per 1,000 (see Canning et al., 2010). Further Gupta and Keyl (1998) also revealed that complete prenatal immunization with tetanus toxoid during pregnancy (two doses 1 month apart) is associated with an 88% reduction in the risk of neonatal tetanus among the newborn children. They also noted that in multivariable analysis only complete immunization and the use of clean instruments for cutting the umbilical cord are independently associated with a reduction in risk of neonatal tetanus.

4. Empirical results

The findings are divided into five sub-sections. First we report the descriptive statistics followed by the reduced form estimates of endogenous variable; birth weight production function; and finally the birth weight production function by household location and income.

Weighted sample descriptive statistics

In this section, we examine: (1) sample statistics of children with birth weight and children without birth weight (2) sample statistics of place of residence (rural and urban sub-samples) and socio-economic status of households (poor, middle and rich sub samples).

Sample statistics of children with and without birth weight and potential bias from missing birth weight

The mean birth weight for all children with birth weight in 2004 and 2011 was 3.6 kg, with a low birth-weight incidence of 0.6 kg (600 g) following the minimum and maximum values of the descriptive statistics. The same data set revealed only slight differences in incidence of low birth weights based on reported and measured weights. In response to birth weight questions, mothers said 15% of their newborn children were smaller than an average child (perceived to be less than 3.6 kg but greater than 2.5kg) while the highest birth weight registered in the clinics was about 6.6 kg.

The birth weight information of many children was missing; approximately 58.46 was available with 58.41% and 58.52% respectively for the female and male children and was used in our analysis. The missing birth weights were caused either by missing record cards at the time of data collection or home delivery. From the statistical table below, 5,724 of children never had birth weight recorded. This introduces potential bias as the study faced a selection problem. Despite this, the study used a weighted OLS, which cannot handle this bias. This type of bias is handled using an instrumental variable approach in terms of measurement and the Heckman model in terms of selectivity. Generally, the principal disadvantages of this birth weight missing value are that: it reduces statistical power; it does not

use all information and estimates will be biased. It creates room for error when specifying the model; reduces variability; and weakens covariance and correlation estimates in the data (because it ignores the relationship between variables). These disadvantages result in biased estimates.

The 2004 DHS shows that most mothers had their first child at age 18 years; this age remained relatively constant throughout 2004 and 2011. However, the youngest mother had her first child at 12 years old while the oldest had her first child at the age of 40. As noted in literature, the age of the woman at first birth has implications on the antenatal services demanded before and after delivery. Considering the community effect (see Table 2), over 63.6% of pregnant women received the vaccination against tetanus at least twice during their last pregnancy for children whose birth weight information was available and 63% for those whose birth weight information was missing. This result from Cameroon DHS is lower than rates obtained by previous studies in most developing countries. For example, Dow et al. (1999) reported tetanus vaccination rates of higher orders of magnitude for Malawi, Tanzania, Zambia and Zimbabwe over the period 1986–1994 while Mwabu (2009) in Kenya realized that about 73% of pregnant women in Kenya obtained tetanus vaccination for their previous pregnancy.

Concerning other exogenous demographics, about 49.3% of the newborn children were male for birth weight and 83.5% for children without birth weight. This is equal to the percentage of female children in terms of birth weight proportions, while about 64.3/85.3% of men in the sample population in 2004 and 2011 were family head. About 40.1% (2004) and 38.2% (2011) of the households in the sample lived in urban centres with an average mean age of 39 and 28 years for the male and female parents respectively, having at least 4 years of education. Taking into consideration that education of the mother is expected to increase both the intake of antenatal care and independently affect the birth weight of the new born child, while age effects are difficult to predict a priori. Still within the statistical variables we observed that about 4.3% (2004) and 4.2% (2011) of births were first twin births. The time dummy variable revealed that the coefficient of change between 2004 and 2011 was positive (58.8% for children with birth weight and 44% without birth weight).

Rural residence information reveals that 60.2% and 61.7% of households lived in rural communities in 2004 and 2011 respectively as opposed to 40.1% and 38.2% in urban centres. This may be because many more households in Cameroon live in the rural communities. Statistics from the government indicate that the rural population in 2011 was far greater than that of other years due to the mass campaign conducted to sensitize people to the problems associated with rural exodus. Table 2 also shows that about 73.7% (2004) and 46.9% (2011) of households had a higher socio-economic index Meanwhile, 47.2% (2004) and 50.4% (2011) of households were poor, 21% (2004) 21.8% (2011) were average rich and 31.7% (2004) 27.6% (2011) were rich.

Table 2: Weighted sample statistics of birth weight (BW) and no birth weight children

Variable	BW children		No BW children	
	Mean	SD	Mean	SD
Birth weight_mpu in grammes	3,404.727	769.724	3,415.007	368.194
Immunization status_mpu (= 1 if mother atleast immunized, 0 otherwise)	0.636	0.097	0.630	0.091
Mother's age at first birth_mpu	18.368	1.572	18.216	1.467
Mother's education in years of schooling_mpu	4.528	3.211	4.105	3.031
Mother's education squared_mpu	36.112	3.842	31.078	29.989
Mother's age_mpu	27.913	2.096	27.850	2.100
Mother's age squared_mpu	826.236	124.786	823.544	125.228
Father's education in years of schooling (_mpu)	38.712	4.057	4.817	2.908
Father's education squared_mpu	5.123	3.027	45.118	36.131
Father's age_mpu	49.444	39.011	38.824	4.129
Father's age square_mpu	1,613.557	403.037	1,628.657	419.781
Mother's education * Father's education (_mpu)	36.047	24.916	33.767	23.631
First twin birth_mpu	0.043	0.067	0.042	0.066
Male child gender_mpu	0.493	0.115	0.853	0.150
Socio-economic ndex_mpu	2.737	1.232	2.469	1.137
Male HH head_mpu	0.643	0.067	0.853	0.150
2011 dummy	0.588	0.492	0.440	0.496
HH place of residence				
Rural HH residence_mpu	0.602	0.388	0.617	0.377
Urban HH residence_mpu	0.401	0.490	0.382	0.486
HH socio-economic status				
Poor HH_mpu	0.472	0.412	0.504	0.402
Middle HH_mpu	0.210	0.225	0.218	0.227
Rich HH_mpu	0.317	0.465	0.276	0.447
Sample size	11610	5724		

Source: Computed by the author from the pooled data of 2004 and 2011 Cameroon DHS

Sample statistics of place of residence and economic status of households

Sample of place of residence of household

Most mothers resident in rural and urban communities were immunized before they gave birth. However, the value of urban women was greater than that of rural women by 68.8%. This may be because most medical facilities are located in urban areas and are, therefore, more accessible to urban than to rural dwellers. Access to education and information through the media (television, newspaper, radio, Internet, etc.) also had an effect on the decision of women in the urban zones to attend vaccination programmes. Ironically, birth weights for children in rural areas were higher than those in urban areas. Following Tambi et al (2014) This result is possible, according to Tambi et al. (2014) who conducted a focus group discussion study based on the theme: "Linking child health, maternal labour force participation and household asset endowments in Cameroon: What the people say". These authors observed child health at birth has many determinants such as nutrition, provision of medical services, counselling and education talk and hygiene, not just maternal immunization.

The number of educated men and women living in urban areas was greater than that of the rural community; they were also richer by far than those of the rural zones. The idea of schooling may be motivated by availability of many and low-cost schools in urban Cameroon and by the high level of enlightenment. Most people in rural Cameroon are occupied with farm activities/agriculture that require little or no education while in urban centres people are more engaged in white collar jobs which pay more. Women gave birth much earlier in rural than urban areas. This may partially be due to low education, and early marriage promoted by culture and poverty. However, we observed a high number of older mothers and fathers living in the villages and semi-villages of Cameroon. In most parts of Cameroon, many people choose to retire in the villages, especially those who were unable to build houses or set up income-generating businesses in urban areas.

More twins were born in the rural than in the urban areas. This is a natural phenomenon, though traditionally people believe that through local forest herbs one can increase the number of children in the womb; scientifically, this has not been proven. Many male children were born in urban communities and following the 2011 time dummy, the birth weight of children in rural Cameroon was better in 2011 than otherwise. Most households in the rural areas were headed by the men as compared to the case in the urban community. This analysis is clearly illustrated in Table 3.

Table 3: Sample statistics of place of residence and economic status of households

Variable	HH residence				HH socio-economic status					
	Rural		Urban		Poor		Middle		Rich	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Birth weight_mpu in grams	3467.444	434.320	3382.535	284.588	3463.875	425.175	3429.264	71.649	3429.541	366.592
Immunization status_mpu (= 1 if mother at least immunized, 0 otherwise)	0.608	0.080	0.676	0.105	0.612	0.081	0.639	0.097	0.644	0.097
Mother's age at first birth_mpu	17.924	1.195	19.029	1.815	17.91	1.220	18.41	1.570	18.48	1.619
Mother's education in years of schooling_mpu	3.284	2.740	6.380	2.959	3.333	2.675	4.712	3.155	4.965	3.184
Mother's education squared_mpu	22.029	22.034	57.092	37.32	22.39	21.55	37.60	33.57	40.48	34.76
Mother's age_mpu	28.007	2.052	27.774	2.154	27.97	2.048	27.92	2.101	27.87	2.087
Mother's age squared_mpu	833.51	122.24	815.41	127.7	831.3	121.8	826.9	125.3	823.1	124.2
Father's education in years of schooling (_mpu)	3.962	2.585	6.853	2.803	4.070	2.531	5.288	2.984	5.544	2.994
Father's education squared_mpu	32.840	26.018	74.177	41.93	34.27	25.93	51.16	38.82	54.75	39.71
Father's age_mpu	39.116	4.199	38.110	3.756	39.18	4.094	38.67	4.078	38.61	4.111
Father's age squared_mpu	162.143	45.434	141.183	35.053	165.991	42.604	1608.305	404.985	1601.945	412.050
Mother's education * Father's education (_mpu)	27.138	18.544	49.318	27.19	27.96	8.411	37.57	24.23	40.35	24.44
First twin birth_mpu	0.041	0.060	0.047	0.076	0.039	0.058	0.044	0.068	0.045	0.070
Male child gender_mpu	0.491	0.097	0.496	0.138	0.492	0.102	0.494	0.116	0.493	0.119
Socio-economic ndex_mpu	1.929	0.775	3.979	0.617	88.86	2.022	2.848	1.202	3.033	1.203
Male HH head_mpu	0.873	0.145	0.795	0.167	0.869	0.144	0.837	0.161	0.833	0.158
d2011 dummy	0.595	0.491	0.577	0.493	0.557	0.496	0.572	0.494	0.559	0.496

continued next page

Table 3 Continued

Variable	HH residence				HH socio-economic status					
	Rural		Urban		Poor		Middle		Rich	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
HH place of residence										
Rural HH residence_mpu	1.000	0.000	0.217	0.285	0.755	0.306	0.582	0.387	0.526	0.381
Urban HH residence_mpu	0.000	0.000	1.000	0.000	0.168	0.374	0.421	0.493	0.478	0.499
HH socio-economic status										
Poor HH_mpu	0.730	0.301	0.086	0.202	0.669	0.330	0.444	0.404	0.390	0.397
Middle HH_mpu	0.194	0.218	0.235	0.234	0.223	0.231	0.222	0.226	0.227	0.226
Rich HH_mpu	0.074	0.263	0.677	0.467	0.107	0.309	0.332	0.471	0.382	0.486
Sample size	12006	7851	13623	19066	16603					

Source: Computed by the author from the pooled data of 2004 and 2011 Cameroon DHS

Sample statistics of socio-economic status of households

Rich and middle class households in Cameroon have higher birth weight children than the poor households. The rich and the middle class have access to better nutrition, and medical and prenatal services that give them an advantage in rearing their children. In the same way, more rich and middle class mothers were immunized during pregnancy than their poor counterparts; this accounts for the higher birth weight of their children. Many of these non-poor live in urban communities as they are involved in more rewarding jobs than those in the rural community.

The percentage of male and female-headed households was the same for the poor and non-poor (rich and middle class), however, the non-poor were more educated, younger and stronger than the poor households. The poor gave birth more to first twin children; while the non-poor had more of male children the poor had female children. More of the rich lived in urban areas in 2011 as compared to the poor.

Determinants of mother's tetanus immunization status

Table 4 presents the results of a linear probability model of mother's demand for tetanus vaccination. There is a strong correlation of mother's age at first birth, mother's education in complete years of schooling, father's age, first twin birth and non-poor households, interaction of mother's and father's education and urban residence with demand for tetanus vaccination. The positive coefficient on these variables depends on the extent of the relationship with tetanus vaccinations in terms of maternal demand for health services.

Generally, in Cameroon the first child of a mother irrespective of her age at first birth and mother's pregnant with first twin is always looked upon as a mystery. First pregnancy has been noted to be troublesome, some of the women suffer from morning sickness, and others suffer from all sorts of illnesses. As revealed in the medical literature all these ailments are normal because as the mother's system adapts to the pregnancy. The changes in the woman's system can be traumatizing and so urging the mother to take every precaution possible to protect her unborn child by participating in tetanus vaccination programs. The experience is also very common for mothers with first twin babies; in Cameroon culturally twins are believed to be super normal children with extraordinary powers.

Mother's education plays a major role in vaccination intake. The more knowledge one has the more health conscious one becomes. Information is power, so mothers who are well-informed through the media, health training programmes, circular education and newspapers will be more likely to attend or take vaccinations. However, mother's age is negatively correlated with tetanus vaccination. Traditional wisdom says age is experience: what an aged person can see most often the young cannot. However, this depends on the context. Since the older mothers know the dangers of delivery, they will always encourage pregnant mothers to take all measures necessary

to ensure the safety of their children. However, the younger mothers full of excitement and anxiety may even abort the child, especially in the case where they are unmarried ..

Table 4: Reduced-form parameter estimates for tetanus immunization (= 1 if immunized, 0 otherwise)

Variables	Coefficient	Standard error	Robust T-statistics
Mother's age at first birth_mpu	0.0078***	0.0007	10.50
Mother's education in years of schooling_mpu	0.0076***	0.0013	5.90
Mother's education squared_mpu	0.0001	0.0001	1.67
Mother's age_mpu	-0.0717***	0.0027	-26.51
Mother's age squared_mpu	0.0012***	0.0000	27.04
Father's education in years of schooling (_mpu)	-0.0061***	0.0013	-4.59
Father's education squared_mpu	0.0002***	0.0000	2.67
Father's age_mpu	0.0038***	0.0008	4.32
Father's age square_mpu	-0.0000***	8.21e-06	-5.32
Mother's education * Father's education (_mpu)	0.0001***	0.0001	3.04
First twin birth_mpu	0.3501***	0. 0111	31.64
Male child gender_mpu	-0.0190***	0.0061	-3.10
Socio-economic ndex_mpu	0.0215***	0.0015	13.85
Male HH head_mpu	-0.1054***	0.0051	-20.67
Urban HH residence_mpu	0.0123***	0.0027	2.65
Constant	1.4564***	0.0401	36.31
R^2 /pseudo- R^2	0.4334	n/a	n/a
F-stat [df; p-val]	597.37 [15, 11716); 0.0000]	n/a	n/a
Observations	11732		

Notes: ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; N/B: dependent variable is birth weight in grams
Source: Computed by author using pooled 2004 and 2011 survey data and STATA 11

Another strong determinant of maternal immunization is wealth status: non-poor parents are more conscious of their health condition. This may be explained by the accessibility to money that enables them to visit any medical centre or any medical service they desire. This factor explains why urban residence is negatively correlated with vaccination intake because it is not all sufficient to live in a city but one should have the available means to access the hospital. Often, hospitals in cities are more expensive than those in the suburbs. Tetanus vaccination is also negatively correlated with father's education in complete years of schooling, male household head and male child. We also observed that many mothers in urban households took vaccination in

2004 and 2011 during their last pregnancy. This might have been due to the massive participation of pregnant women in vaccination and other health programmes as the Government of Cameroon followed the action plan as defined by the Ministry of Health in collaboration with WHO to promote vaccination in Cameroon.

Estimates of child health production function

This section presents the results of OLS. The OLS estimates were based on the assumptions that: (a) the unobservable variables were linearly correlated with the outcome variable; and (b) the estimation sample was randomly selected among children of age 0 to 59 months. The results of the OLS approach are presented in Table 5.

Considering OLS estimates, we observed that the tetanus vaccination was positively associated with birth weight. As seen in the literature, Dow et al. (1999) observed that tetanus vaccination is assumed to be complementary to prenatal care in the production of birth weight. Thus, the estimate of mother's immunization in Table 5 clearly confirms this relationship. The results as seen in the OLS approach simply indicate that babies born to immunized mothers were heavier than babies born of mothers who had not received the vaccination. However, the estimated gain in birth weight in this case cannot be attributed to tetanus immunization alone since the complementarity hypothesis states that the gain comes from a mother's actions in areas of prenatal and general healthcare induced by vaccination during pregnancy.

The estimated coefficients on mother's age at first birth was negative and significant, implying that mother's age at first birth does not correlate with birth weight. This result shows that delaying the age at which the first birth occurs is associated with a decrease in birth weight. This result is consistent with the observation of Tambi (2014) that mother's age at first birth is negatively correlated with birth weight; further, evidence by age group suggests that rates of adverse perinatal outcome such as low birth weight and stillbirth are linked to maternal age 35–39 years old.

Other variables which were positively correlated with birth weight include: mothers education in years of schooling, mother's age, father's age, first twin birth, male child birth, non-poor, interaction of mother's and father's education and urban household residence. Of these, the education and age of parent created serious awareness on the value of life and the need for prenatal care during pregnancy. This finding is consistent with a joint report UNICEF and WHO which states: "for the same gestation age, girls weigh less than boys, first born infants are lighter than subsequent infants, and twins weigh less than singletons" (UNICEF/WHO, 2004). The report further states that a baby's low birth weight is a result of pre-term birth (before 37 weeks of gestation) or of restricted foetal (intrauterine) growth, the mother's own foetal growth and her diet from birth to pregnancy.

Table 5: Parameter estimate of birth weight production function

Variable	Method used: Weighted OLS		
	Coefficient	Standard error	Robust T-statistics
Immunization status_mpu (= 1 if mother at least immunized, 0 otherwise)	385.3338***	44.3725	8.68
Mother's age at first birth_mpu	-39.7874 ***	3.6663	-10.85
Mother's education in years of schooling_mpu	52.6652***	6.2380	8.44
Mother's education squared_ mpu	-4.2669 ***	0.4868	-8.76
Mother's age_mpu	75.9429***	13.6018	5.58
Mother's age squared_mpu	-1.1092***	0.2241	-4.95
Father's education in years of schooling (_mpu)	36.2327***	6.6691	5.43
Father's education squared_ mpu	2.0962***	0.4568	4.59
Father's age_mpu	26.9651***	4.3096	6.26
Father's age square_mpu	-0.442***	0.0393	-11.22
Mother's education * Father's education (_mpu)	0.637***	0.2415	2.62
First twin birth_mpu	108.381***	54.9856	1.97
Male child gender_mpu	213.693***	29.6687	7.20
Socio-economic ndex_mpu	43.445***	7.5409	5.76
Male HH head_mpu	281.723***	24.8153	11.35
Urban HH residence_mpu	26.545**	12.9495	2.05
Constant	4585.391***	204.9231	22.38
R -squared			
0.1208	n/a	n/a	
F-stat [df; p-val]	95.49 [16, 11123; 0.0000]	n/a	n/a
Uncensored observations	11,140		

Notes: ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; N/B: dependent variable is birth weight in grams
Source: Computed by author using pooled 2004 and 2011 survey data and STATA 11

The effect of the complementarity hypothesis is clearly observed here in the sense that male child, father's age and mother's age that were negatively correlated with tetanus immunization were now correlating with birth weight. This proves that other prenatal factors interact to increase the birth weight of the child rather than tetanus immunization. Estimates show that the presence of male-headed household does not influence the birth weight of the child ceteris paribus. There is a possibility that the father takes care of some of the household

chores and family affairs, allowing the mother to pursue the antenatal care services that directly correlate with birth weight. However, according to our results, this depends on the educational level of the household head. This also explains why father's education strongly correlates with birth weights. We also observed that birth weight of babies in urban areas was higher than otherwise and that male infants were heavier than female infants.

Birth weight production function by area of residence and household income

This section examines the birth weight production function by area of residence and household socio-economic/income status using OLS estimates. Table 6 presents the results of the correlates of rural and urban households and the correlates of poor and non-poor (middle class and the rich) households of the birth weight production function by area of residence and household income respectively.

Correlates of rural and urban households

The tetanus immunization status for rural and urban households positively correlated with birth weight at 1% level of significance. In terms of magnitude, the result shows that urban residence had more children vaccinated in the 2004 and 2011 DHS years than rural residence that also correlated with birth weight. This result reflects the problem of opportunity cost, substitution effect and standard of living. Generally, the social infrastructure of rural community such as hospitals, communication and road network are inadequate and poorly constructed, making it difficult for pregnant women to attend prenatal care. At times, pregnant rural women may not be vaccinated against tetanus due to the long distance to the medical centre or a complete lack of well-equipped hospitals in rural areas. In another sense, long distances to the medical centre means most mothers would prefer to work in the farms or take the opportunity to do other things that will yield them revenue, than risk of attending vaccination programs, given their low standard of living.

Other women will substitute medical care for traditional practices. On the other hand, due to the awareness of the importance of tetanus immunization gotten from radio, television or news paper as well as the availability of medical centers and qualified personnel in the urban community, most pregnant women will take this opportunity to take the tetanus vaccination and so giving birth to children with better birth weights. Other variables significantly associated to birth weight for urban residence includes; mother's age, father's age, first twin birth, interaction of mother and father's education, birth of male child, wealth index and presence of male household head.

Table 6: Parameter estimate of birth weight production function: Place of residence and economic status of households

Variable	Ordinary least square (OLS)				
	HH geographic residence		HH socio-economic status		
	Rural	Urban	Poor	Middle	Rich
Immunization status_mpu (= 1 if mother at least immunized, 0 otherwise)	123.8767*** (4.74)	423.2937*** (5.33)	211.838*** (6.03)	318.001*** (7.51)	462.872*** (9.87)
Mother's age at first birth_ mpu	-61.1122*** (-10.45)	7.2906*** (2.00)	-74.5131*** (-10.23)	-3.431*** (-0.97)	-13.742*** (-3.54)
Mother's education in years of schooling_mpu	164.952*** (15.32)	-30.669 (-4.87)	197.871*** (11.94)	42.786 (6.91)	37.616 (5.72)
Mother's education squared_ mpu	-15.7467*** (-14.11)	1.4419*** (3.30)	-18.472*** (-9.53)	-5.3602*** (-10.70)	-3.534*** (-7.14)
Mother's age_mpu	79.53375*** (3.81)	-230.830*** (-16.32)	113.253*** (4.37)	-98.545*** (-7.45)	-142.21*** (-9.61)
Mother's age squared_mpu	-1.3753*** (-4.02)	3.4083*** (14.65)	-1.9203*** (-4.51)	1.361*** (6.27)	2.032*** (8.38)
Father's education in years of schooling (_mpu)	-151.509** (-13.30)	73.1987** (10.63)	-175.745*** (-12.07)	35.693*** (5.26)	10.672** (1.53)
Father's education squared_ mpu	8.547867 (9.04)	-3.222079 (-7.42)	8.7758*** (6.61)	-1.538*** (-3.18)	.691 (1.49)
Father's age_mpu	21.69529 (3.32)	36.9142*** (7.99)	-34.877*** (-4.20)	22.102** (4.99)	40.304*** (8.86)
Father's age squared_mpu	-.1037712 (-1.77)	-.287736*** (-6.49)	-.0145 (-0.20)	-.252*** (-5.86)	-0.518* (-12.68)
Mother's education * Father's education (_mpu)	3.1901*** (6.59)	-1.2207 *** (-5.95)	3.305*** (4.95)	-.502*** (-2.12)	0.2311*** (21.53)
First twin birth_mpu	448.7775*** (5.13)	311.937*** (5.74)	944.915*** (7.64)	143.923*** (-2.91)	14.254*** (0.26)
Male child gender_mpu	363.4824 (6.74)	167.802* (6.43)	553.058*** (8.29)	219.116*** (7.61)	268.859*** (9.04)
Socio-economic ndex_mpu	-2.9827 (-0.26)	54.244*** (6.09)	(-4.893) (-0.27)	33.350*** (4.74)	71.828*** (9.28)
Male HH head_mpu	294.4596 (7.32)	143.599*** (5.82)	338.409*** (6.30)	206.784*** (8.81)	316.349*** (12.10)
Urban HH residence_mpu	n/a	n/a	101.174*** (2.81)	28.742*** (2.72)	50.095*** (3.93)
Constant	3947.146*** (12.97)	5754.625*** (25.70)	3826.665*** (9.92)	4223.969*** (21.51)	4740.248*** (20.98)
R -squared	0.1912	0.1834	0.2181	0.1094	0.1288
F-stat [df; p-val]	101.39 [5, 6433; 0.0000]	70.00 [15, 4675; 0.0000]	81.62 [16, 4683; 0.0000]	61.03 [16, 7952; 0.0000]	83.48 [16, 9030; 0.0000]
Uncensored observations	6449	4691	6956	7969	9047

Notes: ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; N/B: dependent variable is birth weight in grams; absolute value of robust t-statistics in parentheses beneath estimates
Source: Computed by author using pooled data of 2004 and 2011 survey data and STATA 11

Correlates of poor, middle and rich households

Mother's tetanus immunization was strongly correlated with birth weight among non-poor (middle and rich class) households was significant at 1% and for poor households at 1% significance level. This reveals that both the poor and non-poor households have become conscious of their health, especially during pregnancy. Covariates positively associated with birth weights in non-poor households include mother's education, father's education, father's age, first twin birth, male child, mother's age, urban residence and male household head and wealth index of households.

Tetanus was strongly correlated with birth weight in non-poor households because of the easy accessibility to good and well-equipped medical centres coupled with other prenatal care services. Ceteris paribus, the non-poor were more conscious of their health situation as well as the poor especially when they are educated. The non-poor households equally had the necessary means to hire the services of qualified medical nurses/doctors and other prenatal services while the poor used the opportunity offered by the government.

5. Conclusion: Summary and policy implication

Summary

This study investigated the effects of a mother's tetanus immunization on the health of a child at birth. The structural model of birth weight for Cameroon was estimated using the 2004 and 2011 DHS data in STATA 11.0. The data were from the pooled data from 2004 and 2011 DHS.

From the OLS estimates, the results show that tetanus vaccination during pregnancy is associated with increase in birth weight. This finding strengthens the tetanus complementarity hypothesis reported in the literature on birth weight production functions. For example, zinc supplementation of diet during pregnancy increases birth weight in randomized trials (Castillo-Duran and Weisstaub, 2003).

We observed that mother immunization status for household residence was positively correlated with birth weight in urban residence, implying that children in both the rural and urban community had a better birth weight for the 2004 and 2011 DHS. In another result, mother immunization for non-poor and poor households was strongly correlated with birth weight.

Policy implications

From an economic perspective, policy makers could reduce low birth weight through obligatory and low-cost maternal immunization. This can result in reduced infant mortality, neonatal care and costs of infant illness; increased productivity gain from reduced stunting and from increased ability; and intergenerational benefits. Hence, investing in child health at birth, given the right conditions, can engender income growth, reduce poverty and initiate the process of accumulation of human capabilities. The decision makers should therefore, intensify immunization campaigns through the media and social groups with emphasis on the rural areas. In relation to area of residence and economic status, we recommend that policies and strategies for better child health at birth should place particular emphasis on the poor households and on a community based approach so as to meet the need of all, especially those in rural Cameroon.

Notes

1. The author acknowledges the financial support from the African Economic Research Consortium (AERC) and the Hewlett Foundation, and the useful comments of the resource persons and peer researchers.

2. The population of Cameroon is estimated at 18 million of which 49% and 51% are men and women respectively. The population of women of reproductive age (WRA) is 23% or 4 million in absolute terms. The annual population growth rate is 2.83%. The mean fertility rate is 6.1 children per WRA. The crude birth rate is 42.5 per 1,000 population while the crude mortality rate is 17.5 per 1,000 population (Ako et al., 2008). Life expectancy is expected to increase from the current 54.5 years and 59 years to 55 and 65 for men and women respectively, and infant mortality is expected to decrease from 126 per 1000 to about 100 or less (Government of Cameroon, 2003, 2011).

3. For a complete description of the demographic and health survey in general and Cameroon in particular, see Tambi (2014)

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