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Abstract

Despite free basic vaccines administered by the Expanded Programme on Immunization (EPI), there is still a fairly high death rate of children aged 0-5 worldwide due to vaccine-preventable diseases. Sub-Saharan Africa is the most affected region due to low levels of vaccination. This study analyses the effect of birth order on the immunization status of children in Cameroon, considering the contribution of cultural, economic and community factors. To do this, it uses data from the Demographic and Health Surveys of 1991, 1998, 2004 and 2011 produced by the National Institute of Statistics with the support of UNFPA, UNICEF, the World Bank and USAID. The EPI module was administered to 3,350, 2,317, 8,125 and 25,524 children under five in 1991, 1998, 2004 and 2011, respectively. The multinomial probit model makes it possible to find that birth order has a negative and highly significant effect on the full and timely immunization of children under five and the impact increases with birth order. Moreover, the impact of birth order increases after adjusting for cultural factors. This increase indicates that, beyond the effect of birth order, cultural factors are at the root of prejudices leading to the abandonment of children. Considering children under two years of age, and vaccines taken during the first four months, the corresponding birth order effect points to the benefits of routine immunization and response campaigns in promoting immunization of children under five.

Key words: Immunization, child health, birth order, multinomial probit

Classification JEL: I12, I18, J13, J18

1. Introduction

In its optimistic version, immunization appears as a medium and long-term investment because some vaccines protect children for a few years while others protect them for life.[1] According to Bloom et al (2005), immunization is one of the most effective and cost-effective public health interventions to reduce childhood morbidity and mortality worldwide.[2] Despite these virtues, immunization still struggles to gain the support of individuals such that in Cameroon, there is a full immunization rate of children aged 12-23 months of 64.4% (INS, 2014). The absence of immunization in the world in 2001 resulted in a death rate of 19% among children aged 0-5 years, with 99% of these deaths occurring in low-income countries. Sub-Saharan Africa is the region most affected by vaccine-preventable diseases. This region accounts for 59% of all measles cases, 41% of all tetanus deaths, 8% of yellow fever deaths and 58% of pertussis deaths (WHO, 2006). In Cameroon, the incidence of vaccine-preventable diseases is still noticeable even though vaccines are free under the Expanded Programme on Immunization (EPI). There were 1,809 cases of measles in 2015, 61 cases of yellow fever and 58 cases of neonatal tetanus in 2016, although the level of immunization coverage is increasing (Table 1).

In fact, microeconomic analysis suggests an inverse relationship between the resources used to meet the different needs of children and the quality of the latter (Maitra and Pal, 2008). These parental investments, which may be of various kinds, differ not only in terms of the household's financial resources, time available to women for childcare and parental characteristics, but also according to the specific characteristics of children, including birth order. That is how recent health and education studies show an inverse relationship between household size or birth order and inequalities in health and education (Black et al, 2005; Kantarevic and Mechoulan, 2006; Monfardini and See, 2012; Sandberg and Rafail, 2007). An explanation for this would be that birth order favours children with smaller birth orders primarily because they were born earlier and received more resources from their parents. This birth order advantage is felt before birth (antenatal visits), during birth (place of delivery) and the care received during the first years of the child's life which includes vaccination.[3]

This inability of parents to immunize their children may find an explanation in the high fertility rate and would require more effort from parents in terms of resources and time. In Cameroon, for example, every woman has an average of five children[4] at the end of her fertile life and 66% of women aged 15 to 49 interviewed in 2011 still wanted to have children (INS, 2012). It is therefore essential to find ways of improving the demand for immunization for children aged 0-5, and this improvement requires a better understanding of the relationship between household size, particularly the birth order of each child and their immunization status.

Table 1: Summary of immunization data

Vaccine	Vaccination Coverage				Incidence of Vaccine-Preventable Diseases in Children Under 5 Years of Age
	2016	2011	2004	1998	
Original EPI					
Bacillus Calmette–Guérin vaccine (BCG)	70%	80%	83%	63%	N/A
Diphtheria–tetanus–pertussis vaccine (DTP3)	85%	82%	73%	48%	58 Neonatal tetanus (2016)
Polio vaccine (Pol3)	83%	80%	72%	48%	13 Polio (2004)
Measles-containing vaccine (MCV)	78%	76%	64%	47%	1,809 Polio (2015)
Later-stage EPI					
Haemophilus influenzae type b vaccine (Hib3)	85%	82%	N/A	N/A	N/A
Hepatitis B vaccine (HepB3)	85%	82%	N/A	N/A	N/A
Yellow fever vaccine (YF)	78%	75%	59%	N/A	61 Yellow Fever (2016)
New vaccines					
Rotavirus vaccine (Rota2, Rota3)	87%	N/A	N/A	N/A	N/A
Pneumococcal conjugate vaccine (PCV3)	84%	70%	N/A	N/A	N/A

Source: WHO vaccine-preventable diseases: Monitoring system (2018 global summary). N/A=Not Applicable.

Studies on the demand for immunization of children around the world generally focus on taking antigens (Barham and Maluccio, 2009) or distinguish full immunization from incomplete immunization (Patra, 2006). In addition, the abundant literature in Africa and Cameroon particularly on children's health ignores immunization despite its importance, and investments made by states and development partners. These studies mainly focus on outcome indicators such as nutritional status (Baye and Fambon, 2010; Baye, 2010; Baye and Sitan, 2016; Fambon, 2004; Kasiwa, 2018; Tambi and Atemnkeng, 2018) and mortality (Mturi and Curtis, 1995; Ssewanyana and Younger, 2007).

The purpose of this study is to analyse the effect of birth order on the full immunization of children under five years of age while examining differences due to cultural, economic and community factors. It bridges the existing gap in immunization-related studies of children under five, considering the temporal nature of each vaccine, and given the risk faced by the child as soon as his or her immune system becomes vulnerable.

The rest of the paper is structured as follows: Section 2 presents a brief review of the theoretical and empirical literature on the relationship between birth order, child health, and immunization; Section 3 presents the study data and variables used in the analysis; Section 4, the theoretical framework and methodology; Section 5 reports empirical results; and the conclusion and policy recommendations are made in section 6.

2. Literature review

Mechanisms underlying the birth order model

With the help of neo-classical economic models, Becker (1960), Becker and Lewis (1973) and Willis (1973) analysed the household as an economic unit in which fertility decisions are based on cost-benefit reasoning. In this context, the child is considered as a sustainable economic good having two main components: a quantity component linked to number and a quality component linked to his/her potential, his/her education and/or health. Thus, the decision to have a child results from an arbitration between the quality and quantity of children. In this case, an analysis of the effect of income shows that an increase in household income would push parents to improve on the quality of the child through an increase in investment in education and/or health rather than having other children. This analysis results in the superiority of income elasticity with respect to quality over that of income with respect to the number of children (Becker and Tomes, 1976). Immunization is the best investment in the health of young children because of its long-term effects and cost-benefit ratio. Investments in children can be broken down into inputs such as immunization, which improves their health.

Beyond income, children also represent an opportunity cost in time (Becker, 1965; Willis, 1973) which falls primarily on the mother. Women are subject to a time constraint because of having a total inextensible time which must be divided between professional and domestic activities, including childcare and leisure as well. This highlights competition between financial and time resources to improve the quality of the child. To have more financial resources, women must increase the time devoted to their professional activities, which reduces the time available to cater for children. This resource limitation assumption was used by Blake (1981) in the theory of dilution to analyse the effect of an increase in fertility on the health of children. According to this theory, the finite nature of parental availability means that the time devoted to each will be inversely proportional to the number of children. Ultimately, as the number of children increases, the resources allocated to each one diminishes, such that children of higher birth order end up with fewer resources than their older siblings at that age and, in terms of immunization, they will be less immunized than their elders.

This assumption of equality in the distribution of time between children is that the youngest have the same time as their elders. This time may seem insufficient, such that they do not have the same level of immunization as their elders. In the presence of discrimination in favour of the youngest (Hotz and Pantano, 2015), these could benefit from more time and consequently a better investment, including immunization. With the immunization schedule ending at nine months, if the minimum difference between two children is greater than or equal to nine months, then the discrimination in favour of the youngest would positively affect his/her immunization status during the first nine months while the health indicators of their elders will deteriorate because they will be a little neglected for the sake of the younger sibling.

Empirical review of the effect of birth order

Concerns about the verification of mechanisms by which birth order works have given rise to numerous empirical studies. With regard to certain health outcomes and noting that firstborn children are at a disadvantage at birth in relation to their younger siblings, Brenøe and Molitor (2018), from Danish registry data, studied the causes of improvement in health status of children of higher birth order. This relationship exists despite the fact that women go to the hospital more during the firstborn's pregnancy. They therefore conclude that there are biological differences according to birth order that could be caused by changes in the uterus as found by Khong et al (2003). However, these changes can nevertheless explain the reversal of the birth order effect that is seen later in life in terms of educational outcomes. On the contrary, taking into account the endowments at birth increases the effects of birth order on the results in adulthood as noted by Black et al (2011).

With regard to the risk of mortality at ages 0-1, 1-10, 20-54 and 55-80, Modin (2002) shows that the risk of death of individuals born in Sweden between 1915 and1929 is U-shaped during early childhood; it is highest for first-born children and children of birth order 5 and above. In all other ages, she finds a positive correlation between birth order and mortality risk. Moreover, in her analysis, she is not able to take into account the size of the family and the extent to which parents who choose to have a large family are different.[5] Correcting this limit, Barclay and Kolk (2015) note an increased risk of death and health problems in adulthood in children with higher birth orders. Using data from the Swedish registry, they find a higher risk of mortality between 30 and 69 years for people with higher birth orders and particularly for mortality due to respiratory system cancers and external causes. This high mortality risk for cadets is due to a poor state of health. Black et al (2016) studied self-reported health using Norwegian data results in birth order effects in different directions depending on the type of health problem. They find that children born later are more likely to smoke and their self-reported physical and mental health is worse in their 40s. In contrast, first-born babies are more likely to be overweight, obese and have high blood pressure. Unlike the last result, Barclay and Myrskylä (2014) found a monotonous negative effect

of birth order when studying the fitness of 18-year-old men in Sweden, which might suggest that children born later take less care of their health.

The finding that the difference in birth order results is not biological has been verified by several authors. For Price (2008), the negative effect of birth order on health outcomes is a consequence of the change that would take place in the home environment with births. These changes would require more time and attention from parents to make the same investments even in terms of health input such as immunization for children of higher birth orders than their elderly siblings. Thus, Monfardini and See (2012) have shown by eliminating the unobserved heterogeneity specific to households that the effect of the child's birth order is not due to the quality of maternal time, but to mechanisms of intra-household allocation of resources other than time.

In this regard, Gavrielov-Yusim et al (2012) studied the effect of birth order on voluntary immunization against chickenpox on 110,902 children under five years in Israel. They found that birth order is inversely correlated with voluntary varicella immunization and that its impact becomes very significant from birth order five. Similarly, in the case of India, Patra (2006) analysed the determinants of the full immunization of children aged 12-23 months using data from the second national survey of family health. He finds a negative effect of the child's birth order on the probability that he is fully immunized. For him, this is due to the fact that in India, individuals give the same level of attention to children regardless of birth order, thus invalidating the existence of any potential discrimination in the distribution of resources within the household (Hotz and Pantano, 2015).

3. Study data and presentation of variables

Study data

The data used in this study are extracted from Demographic and Health Surveys (DHS) carried out by the National Institute of Statistics (INS) in 1991, 1998, 2004 and 2011. The survey is stratified to provide an adequate representation of urban and rural areas and the 12 fields of study corresponding to the 10 administrative regions and cities of Yaounde and Douala. The DHS provides information on fertility, family planning, maternal health, nutritional status of children, immunization status of children, and infant and child mortality.

DHS surveys are conducted by the NIS in collaboration with partners such as UNFPA, UNICEF, World Bank and USAID, and technical assistance from ORC Macro. In the survey, 3,538 households were visited in 1991, 4,697 in 1998, 10,462 in 2004 and 14,214 in 2011. In these households, 3,871, 5,501, 10,656 and 15,426 women aged 15-49 years were, respectively, surveyed. These women made it possible to obtain information on 3,350 children under 5 in 1991, 2,317 children under five in 1998, 8,125 children under five in 2004 and 25,524 in 2011. To analyse full immunization, we have limited our sample of children to those having at least 10 months; that is to say those supposed to have completed their mandatory immunizations. This allows us to have a sample of 18,935 children under five, and therefore 2,777, 1,469, 5,940 and 8,749 in 1991, 1998, 2004 and 2011, respectively.

Specification and measurement of variables

Dependable variable

The immunization system for children in Cameroon is organized in two parts: a paid and a free part that is managed by the Expanded Programme on Immunization (EPI). The free part, which started with WHO-recommended basic vaccines, evolved with the introduction of the yellow fever vaccine in 2004, the Hepatitis B vaccine in 2005, and the Haemophilus influenzae type b vaccine in its pentavalent form in 2009, the pneumococcal vaccine in 2011 and the rotavirus vaccine against diarrhoea in 2014. These vaccines are administered according to the schedule in Table 2.

Table 2: Immunization schedule of children less than 1

Diseases	Vaccine	Doses	Age
Tuberculosis	BCG	1	At birth
Poliomyelitis	VPO	3	6, 10, 14 Weeks
Diphtheria-Tetanus-Pertussis-Viral Hepatitis B-Haemophilus Influenzae type b	DTP-HepB-Hib	3	6, 10, 14 Weeks
Pneumococcal	VPC13	3	6, 10, 14 Weeks
Rotavirus diarrhoea	Rotarix	2	6.10 Weeks
Measles	VAR	1	9 months
Yellow fever	VAA	1	9 months

Source: PEV (2015)

From the entry into force of the EPI in 1976 as a pilot project coordinated by the Organization for the Control of Endemics in Central Africa (OCEAC) until 2004, the vaccines administered by the EPI were four in number. To be consistent from 1991 to 2011, our analysis will be based on the four vaccines[6] in effect since 1991. To be immune and free from diseases, the child should fully take the required vaccines within the recommended schedule since this schedule takes into account the susceptibility of the immune system. National and international institutions (WHO, World Bank and UNICEF) use the age groups of less than 12 months and 12-23 months to assess timely immunization and according to the recommendations for vaccine administration (Bolton et al, 1998; WHO, 2007). In our case, we can use the 9-59 month age group taking into account the immunization schedule that ends at nine months with VAR and the complementary immunization strategies of the EPI, which is to complete the immunization status of children until the age of five. In addition, the immunization is done according to a programme set up by health facilities. As a result, the child may be behind his immunization schedule, a delay we estimate at one month, which brings our working age group to between 10 and 59 months.

In line with the integration of child immunization into the policy of Integrated Management of Childhood Diseases, which consists of verifying the immunization status of children aged 0-59 months presenting for consultation, each vaccine has three possibilities as to its status. These possibilities take into account the criterion of compliance with the immunization schedule, which is evaluated from the dates of taking each vaccine. For vaccines with no date of intake, we consider that it was taken late, else the mother would have reported the date on which the child took this vaccine as the actual date of administration of the said vaccine. This gives us the following options: not administered, administered on time or administered late. Considering all vaccines, we end up with three alternatives: children who are not fully immunized, those who have not taken at least one vaccine and represent just over 50% of our sample; children who are fully immunized on time are the least represented (16.47%), but have changed over time from 5.33% in 1991 to 22.19% in 2011; and children who are fully immunized with at least one vaccine taken late.

Table 3: Distribution of the dependable variable

Analysis period	Immunization Status of the Child			Total
	Incomplete Immunization	All Vaccines Taken on Time	At Least One Vaccine Taken Late	
1991	59.31	5.33	35.36	100
1998	62.76	14.36	22.87	100
2004	55.40	13.79	30.81	100
2011	45.72	22.19	32.10	100
Total	52.07	16.47	31.45	100

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4

Table on health risk due to vaccine delay

EPI vaccines are basic vaccines that no child should ever do without. As a result, the immunization schedule is set up according to the susceptibility of the immune system of children. Actually, the child is born with passive immunization from the mother and his/her consumption of breast milk which loses its effectiveness as he/she ages. This loss of effectiveness of passive immunity must be compensated for by immunization which provides the child with active immunity. As such, when the date of taking a vaccine arrives, implying that the child can already catch the disease prevented by this vaccine, failure to take or delay in taking this vaccine is a health risk for the child (Dayan et al, 2006). Faced with this health risk problem, Bolton et al (1998) did not stop at full immunization but also took into account correct immunization through the respect of the schedule. Ultimately, health risk for the child varies according to whether the vaccines were: 1) not completely taken; 2) completely taken on time; and 3) completely taken, but with delays:

- When vaccines are not fully taken, the child faces a health risk that depends on the prevalence of the disease for which the vaccine was not taken. Therefore, he can contract the disease at any time. He will face this risk throughout the period for which this vaccine was supposed to protect him, perhaps even his whole life.

- When the child is fully immunized on time, the child runs no risk of contracting one of the diseases for which he has been immunized.

- When the child takes at least one vaccine late, he runs a health risk during the period of the delay which can be fatal. When immunization is done during the incubation period, which is long enough for preventable diseases (1-12 weeks), this could be fatal for the child.

Explanatory variable

The variable of interest here is the birth order of the child. Previous studies on child health have considered birth order in terms of categorical variables while taking the first child as the reference category (Gavrielov-Yusim et al, 2012; Lundberg and Svaleryd, 2017; Monfardini and See, 2012). The distribution of birth order in Demographic and Health Surveys (DHS), which ranges from one to 15 with more than 85% of children who are at most sixth in order of birth, leads us to limit our variable to 7 categories. In addition, parents start to run out of childcare when the first child starts school, and this usually corresponds to three years when the child is already talking in an understandable way. The school-beginning age coupled with the modal interval between births, which is two years, makes us retain as categories of reference birth orders 1 and 2 because by the time the first child is going to school, its little sibling is already one year old and is supposed to have already finished taking its vaccines. The birth order of the child will have seven categories ("order 1 and 2", "order 3", "order 4", "order 5", "order 6", "order 7 and more") with orders 1 and 2 being the reference categories.

The other independent variables will be grouped into: demo-biological characteristics (the child's gender, the health of the child at birth measured by his/her weight and multiplicity of birth), socio-cultural characteristics (the person in charge of the child, the mother's age, religion, marital status and media exposure), socio-economic characteristics (mother's level of education, access to electricity and access to drinking water) and community characteristics (place of residence, rural area per period and household size). The specification of the variables is made in Table 4. However, there are two important points to note regarding the endogeneity of certain variables and the interaction variable capturing the effect of mobile immunization strategies in rural areas.

The possible endogeneity of access to water and electricity has led us to use community averages (clusters) instead of individual observations. Specifically, non-self-mean clusters were calculated on variables, "has electricity" and "has access to clean water". This method involves assigning an individual i from a larger community N the average of $N-i$ other members of the community, which completely eliminates the possibility for an individual to be affected by his/her personal preferences. Unobserved factors at both the household and community levels that affect fertility choices also affect immunization, thus making the household size endogenous. This endogeneity of household size is corrected by using non-self-mean clusters. To cancel the scale effects, the household size variable will be composed using logarithm.

The "rural environment per period" interaction variable captures the effect that the EPI strategies have had over time on households located more than 5 km from health facilities and where mobile immunization strategies are implemented. This variable is obtained from the interaction between rural membership (1 if the individual resides in rural areas and 0 otherwise) and the period of analysis (1991, 1998, 2004, and 2011) which are also dichotomous variables.

Table 4: Descriptive statistics of variables

Variables	Categories	Definitions	Proportion by Immunization Status		
			Incomplete immunization	Timely complete immunization	At least one vaccine taken late
Observation number			9.860	3.119	5.956
Demo-biological characteristics					
Child's birth order	Order 1 and 2	1 if the child is of Order 1 or 2; 0 otherwise	0.394 (0.005)	0.482 (0.009)	0.424 (0.006)
	Order 3	1 if the child is of Order 3; 0 otherwise	0.145 (0.004)	0.176 (0.007)	0.150 (0.005)
	Order 4	1 if the child is of Order 4; 0 otherwise	0.124 (0.003)	0.116 (0.006)	0.124 (0.004)
	Order 5	1 if the child is of Order 5; 0 otherwise	0.098 (0.003)	0.084 (0.005)	0.097 (0.004)
	Order 6	1 if the child is of Order 6; 0 otherwise	0.078 (0.003)	0.055 (0.004)	0.073 (0.003)
	Order 7	1 if the child is of Order 7; 0 otherwise	0.162 (0.004)	0.087 (0.005)	0.132 (0.004)
Sex of the child	Female	1 if the child is of Order 3; 0 otherwise	0.501 (0.005)	0.514 (0.009)	0.499 (0.006)
	Male	1 if the child is male: 0 otherwise	0.499 (0.005)	0.486 (0.009)	0.501 (0.006)
Health at birth[7]	Good health	1 if the child is born with more than 2500g; 0 otherwise	0.417 (0.005)	0.778 (0.007)	0.587 (0.006)
	Poor health	1 if the child is born with more less than 2500g; 0 otherwise	0.060 (0.002)	0.095 (0.005)	0.080 (0.004)
	Not weighed	1 if the child was not weighed at birth: 0 otherwise	0.468 (0.005)	0.103 (0.005)	0.281 (0.006)
	Does not know	1 if the mother does not know the child's weight: 0 otherwise	0.055 (0.002)	0.024 (0.003)	0.051 (0.003)
Multiplicity of births	Alone	1 if the child is born alone: 0 otherwise	0.969 (0.002)	0.948 (0.004)	0.954 (0.003)
	Twin	1 if the child is of multiple birth; 0 otherwise	0.031 (0.002)	0.052 (0.004)	0.046 (0.003)

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Table 4 Continued

Variables	Categories	Definitions	Proportion by Immunization Status		
			Incomplete immunization	Timely complete immunization	At least one vaccine taken late
Observation number			9.860	3.119	5.956
Socio-cultural characteristics					
Care of the child	Mother	1 if the child is cared for by his/her mother; 0 otherwise	0.883 (0.003)	0.975 (0.003)	0.911 (0.004)
	Another person	1 if the child is cared for by another person 0 otherwise	0.117 (0.003)	0.025 (0.003)	0.089 (0.004)
Mother's age	15 -19	1 If the mother is of the 15-19 age group: 0 otherwise	0.086 (0.003)	0.048 (0.004)	0.067 (0.003)
	20 -24	1 If the mother is of the 20-24 age group: 0 otherwise	0.278 (0.005)	0.247 (0.008)	0.252 (0.006)
	25 -29	1 If the mother is of the 25-29 age group: 0 otherwise	0.261 (0.004)	0.319 (0.008)	0.276 (0.006)
	30 -34	1 If the mother is of the 30-34 age group: 0 otherwise	0.184 (0.004)	0.205 (0.007)	0.200 (0.005)
	35 -39	1 If the mother is of the 35-39 age group: 0 otherwise	0.115 (0.003)	0.122 (0.006)	0.126 (0.004)
	40 -44	1 If the mother is of the 40-44 age group: 0 otherwise	0.058 (0.002)	0.046 (0.004)	0.064 (0.003)
	45 -49	1 If the mother is of the 45-49 age group: 0 otherwise	0.018 (0.001)	0.012 (0.002)	0.014 (0.002)

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Table 4 Continued

Variables	Categories	Definitions	Proportion by Immunization Status		
			Incomplete immunization	Timely complete immunization	At least one vaccine taken late
Observation number			9.860	3.119	5.956
Socio-cultural characteristics					
Religion	Traditional Christian	1 if the religion is catholic or protestant: 0 otherwise	0.618 (0.005)	0.803 (0.007)	0.733 (0.006)
	Reformist	1 if the religion is Islam or another: 0 otherwise	0.310 (0.005)	0.147 (0.006)	0.203 (0.005)
	No religion	1 if the family has no religion: 0 if not	0.072 (0.003)	0.049 (0.004)	0.064 (0.003)
Marital status	In a relationship	1 if the mother is in a relationship: 0 otherwise	0.881 (0.003)	0.863 (0.006)	0.877 (0.004)
	Not in a relationship	1 if the mother is single: 0 otherwise	0.119 (0.003)	0.137 (0.006)	0.123 (0.004)
Media exposure	No exposure	1 if the mother has no media exposure: 0 otherwise	0.438 (0.005)	0.179 (0.007)	0.333 (0.006)
	Limited exposure	1 if the mother has limited media exposure: 0 otherwise	0.271 (0.004)	0.256 (0.008)	0.254 (0.006)
	High exposure	1 if the mother is exposed to the media: 0 otherwise	0.292 (0.005)	0.566 (0.009)	0.413 (0.006)

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Table 4 Continued

Variables	Categories	Definitions	Proportion by Immunization Status		
			Incomplete immunization	Timely complete immunization	At least one vaccine taken late
Observation number			9.860	3.119	5.956
Socio-economic characteristics					
Level of education	No level	1If the mother has no level of education: 0 otherwise	0.359 (0.005)	0.087 (0.005)	0.207 (0.005)
	Primary	1If the mother has a primary level of education: 0 otherwise	0.399 (0.005)	0.422 (0.009)	0.450 (0.006)
	Secondary	1If the mother has a secondary level of education: 0 otherwise	0.233 (0.004)	0.441 (0.009)	0.325 (0.006)
	Higher education	1If the mother has higher level of education: 0 otherwise	0.009 (0.001)	0.049 (0.004)	0.018 (0.002)
Electricity	Access	Cluster average	0.385 (0.286)	0.513 (0.302)	0.427 (0.299)
Drinking water	Access	Cluster average	0.534 (0.256)	0.595 (0.274)	0.540 (0.265)
Community characteristics					
Place of residence	Urban	1 if the child resides in an urban area: 0 otherwise	0.355 (0.005)	0.591 (0.009)	0.446 (0.006)
	Rural	1 if the child resides in a rural area: 0 otherwise	0.645 (0.005)	0.409 (0.009)	0.554 (0.006)

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Table 4 Continued

Variables	Categories	Definitions	Proportion by Immunization Status		
			Incomplete immunization	Timely complete immunization	At least one vaccine taken late
Observation number			9.860	3.119	5.956
Community characteristics					
Rural residence per period	Rural_1991		0.098 (0.003)	0.008 (0.002)	0.054 (0.003)
	Rural_1998		0.062 (0.002)	0.025 (0.003)	0.032 (0.002)
	Rural_2004		0.220 (0.004)	0.105 (0.005)	0.182 (0.005)
	Rural_2011		0.265 (0.004)	0.272 (0.008)	0.286 (0.006)
Household size	Household size	Cluster average	2.089 (0.196)	2.028 (0.206)	2.075 (0.197)
Analysis period	1991	1 if the child is of period 1986 -1990; 0 otherwise	0.167 (0.004)	0.047 (0.004)	0.165 (0.005)
	1998	1 if the child is of period 1993 -1997; 0 otherwise	0.094 (0.003)	0.068 (0.004)	0.056 (0.003)
	2004	1 if the child is of period 1999 -2003; 0 otherwise	0.334 (0.005)	0.263 (0.008)	0.307 (0.006)
	2011	1 if the child is of period 2006 -2010; 0 otherwise	0.406 (0.005)	0.622 (0.009)	0.471 (0.006)

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4. Values in parentheses are standard deviations

Descriptive statistics

The descriptive statistics and the specification of each explanatory variable are summarized in Table 4. These variables were grouped according to the demo-biological characteristics of the child, the socio-cultural characteristics of the mother, the socio-economic characteristics of the household, and community characteristics.

Children of order 1 and 2 are the most represented and the proportion of children decreases with birth order. Regarding the child's gender, there are as many girls as boys among children who are not fully immunized and those who are fully immunized late. In contrast, girls are more numerous among children who are fully immunized on time. This finding is confirmed by the proportion test whose results are summarized in Table 5. A higher proportion of children born in poor health are fully immunized on time. Similarly, of all the alternatives, twins are more numerous among children who are fully immunized on time. This is because twins have a particular consideration in the Cameroonian society. This consideration goes from the names attributed to the parents of twins and rites done in almost all the tribes. As a result, they receive special attention and are therefore more immunized.

Table 5: Proportion test of the gender variable

Variables	Incomplete immunization	Timely full immunization	At least one vaccine taken late
Gender			
Female	0.501 (0.005)	0.514 (0.009)	0.499 (0.006)
Male	0.499 (0.005)	0.486 (0.009)	0.501 (0.006)
Student's statistics	-0.399	-2.254	0.110
p-value	0.690	0.012	0.913

Source: From DHS 1, 2, 3 and 4. Values in parentheses are standard deviations

Children are more dependent on the mother. This is about 10% higher for those who are fully immunized on time compared to children who are not fully immunized. Regarding the age of the mother, mothers aged 45-49 are fewer in all alternatives. Those aged 20-24 are more likely to not fully immunize their children. Full timely and late immunization is much more carried out by women aged 25-29. For religion, traditional Christians (Catholics and Protestants) are more represented in all alternatives while those who do not have a religion are the least represented. Mothers are more than 86% in relationships, with a slight advantage for those who do not fully immunize their children. Mothers who are not exposed to the media are more likely to not fully immunize their children. Those who are highly exposed are more likely to fully immunize their children on time as well as late.

Mothers with a primary level of education are more represented in all alternatives and those with a lower level of education are less represented. Access to electricity and water is higher in households where children are fully immunized on time. Most of the children not fully immunized (64.5%) and fully immunized, though late (55.4%) are in rural areas. In terms of household size, children who are not fully immunized are usually found in high-size households followed by those who are fully immunized late.

4. Theoretical framework and methodology

Theoretical Framework

The household behaviour model derived from both the household production model (Becker, 1965) and the farm household model (Nakajima, 2012; Sen, 1966; Tanaka, 1951) assumes that the household has preferences that can be represented by a utility function, which depends on a set of arguments characterizing each household member. To analyse the relationship between the quantity and quality of the child, Becker and Lewis (1973) retain as argument the number of children, the quality of each child, and the total amount of all other products. As a result of this analysis, Becker and Tomes (1976) assume that the quality of the child is not only the result of household expenditure, but also an additive function taking into account the initial endowments of the child.

Thus, the production function of the quality of the child can be written as a function of inputs from the household in terms of goods and time and his/her initial endowments. Many authors have approximated the quality of the child with school results (Blake, 1981; Conley and Glauber, 2006; Hanushek, 1992; Hill and O'Neill, 1994; Rosenzweig and Wolpin, 1980), with pay or participation in the labour market as an adult (Kessler, 1991; Olneck and Bills, 1979; Wachtel, 1975). Meanwhile, immunization provides the child with physical, mental and social well-being in childhood and in adulthood. It is considered the best investment by parents in the quality of their child given its cost-effectiveness. Therefore, immunization status of the child can be retained as a good indicator of his/her quality.

Methodology

The modelling of the effect of birth order on the child's immunization status is based on the hypothesis of heterogeneity between children in relation to their demo-biological characteristics, the socio-cultural characteristics of the mother, the socio-cultural characteristics of the child, and family and community characteristics. Parents can choose the immunization status of their children noted V as follows:

$$V = \begin{cases} 0 \rightarrow Full\ immunisation \\ 1 \rightarrow Timely\ full\ immunisation \\ 2 \rightarrow At\ least\ a\ vaccine\ taken\ late \end{cases}$$

This choice is subordinated to the fact that the preferences of individuals in preventive health are represented by a utility function, since the actions of prevention are seen like the consumption of goods, which affects the risk of disease (Cohen, 1984). In the child, this utility function is estimated by a comparison between the benefit and the perceived cost of the act of prevention by the parents (Brito et al, 1991; Cohen, 1984; Coudeville, 2004). When the child i benefits from health coverage j, the utility he/she derives from this choice takes the form:

$$U_{ij} = X_{ij}\beta_j + \varepsilon_{ij} \quad (1)$$

where U_{ij} is the child's utility i $(i = 1,...,n)$ when the parent adopts a preventive behaviour j, $X_{ij}\beta_j$ is the deterministic component of the utility function ε_{ij} and its stochastic component. If parents make an alternative choice j for their child i, it means that the alternative j is that which gives them the highest utility. This problem may be in the form of probability as follows:

$$P_{ij} = \Pr ob\left[U_{ij} > U_{ik}, j = 1,...,k,...,J; j \neq k\right] \quad (2)$$

The operationalization of Equation 2 can be done by the logit or probit model depending on whether the stochastic component of Equation 1 is assumed to follow a logistic law or a normal distribution (Greene, 2003). Because of the potential for violation of the non-relevant alternative independence assumption associated with multinomial logit, we will use the multinomial probit model to estimate the effect of birth order on the immunization status of children under the age of five. This is equivalent to assuming that disturbances in the utility function of the choice model of the immunization level follow a normal distribution. Equation 2 can be reworded as follows:

$$\Pr(V = j \mid j \in \{0,1,2\}; X) = \Phi(\beta_0 + \sum_{k=1}^{7} \beta_k Rang_k + \sum_{h=8}^{m} \beta_h X_h) \quad (3)$$

where V is an indicator of the choice of the child's immunization status made by his/her parents. The reference category is the absence of full immunization. Φ is the distribution function of the normal law. X is the vector of explanatory variables, $Rang$ is the child's birth order and β_k and β_h are the vector of the parameters associated with $Rang$ and other control variables that the child's choice of immunization status model will estimate by the maximum likelihood method. This estimate will assume that the residual term ε_{ij} is not correlated with the exogenous variables.

The effect of birth order on the child's immunization status will be analysed through four models, each model distinguishing the contribution of other characteristics to the relationship. Model 1 will analyse the impact of the child's birth order on his immunization status by the sole control of the demo-biological characteristics. In model 2, socio-cultural characteristics are introduced to analyse the association between immunization status and birth order, all other things being equal. This second model thus makes it possible to distinguish the direct effects of birth order on his/her immunization status from its indirect effects through the cultural and social status. To test the influence of socio-economic factors, in a third model, we introduce proxy indicators of the socio-economic situation of the household. Finally, model 4 will add community characteristics to the analysis of the impact of public provision on the existing relationship between birth order and child immunization.

5. Econometric results

Effect of birth order on immunization of children under the age of five

Tables 6 and A2 give us the results of the estimation of the effect of birth order on the immunization of children. All four models are globally significant at the 1% threshold. These models present the results of estimating the effect of birth order on immunization of children after adjusting for gender, health status at birth, and twin status (model 1), then control by socio-cultural (model 2), socio-economic (model 3) and community characteristics (model 4).

The results of model 1 indicate that after controlling for demo-biological characteristics, birth order has a significant and negative influence on the probability of the child being fully immunized on time. This effect increases with birth order rising from 3.1% for order 4 to 8.6% for order 7 compared to orders 1 and 2 children. This result is similar to that of Patra (2006) in the case of India and can be explained by the absence of discrimination between children of different birth orders. The equal treatment of children creates a problem of inequity between the first children and their little siblings as they need more attention. As expected, the probability of being fully immunized increases when the child is born in poor health and when he is a twin. The effect is much more significant for timely full immunization. This is because children born with poor health, and twins, focus the attention of parents which leads them to be constantly in health facilities during their first years of life and thus increases their probability of being immunized on time. On the other hand, there is no discrimination due to the child's gender.

After adjustment by socio-cultural factors (model 2), the effect of the child's birth order remains negative and significant. Birth order reduces the likelihood of timely full immunization of children at a higher intensity compared to model 1 (2.9% for order 3 and 12.7% for order 7). This result suggests a specific effect of birth order regardless of the mother's cultural and social situation. However, the increase in the value of the marginal effect associated with the different orders between models 1 and 2 indicates that cultural factors are at the root of some prejudices, leading to the abandonment of children.

Model 2 results are in line with previous studies on the immunization of children (Babalola, 2009; Gavrielov-Yusim et al, 2012; Ibnouf et al, 2007; Steele et al, 1996). Contrary to late full immunization, almost all socio-cultural variables have a significant effect on the probability of a child being fully immunized on time. The fact that a child is dependent on someone other than his/her mother greatly reduces their full immunization by 19.5%. The mother's age, which is a proxy of her experience in childcare, has a positive and significant effect on timely full immunization. In the reference age group (15-19), pregnancies that are usually early are not accompanied by better immunization follow-up. This follow-up improves from ages 20 to 39, which corresponds to the age at which the woman enters the menopausal phase, before reducing to a smaller effect. Compared to Catholicism and Protestantism, belonging to reformist religions including Islam, reduces by a little more than 6% the probability for a child to be fully immunized. Exposure to the media increases the chances of a child being immunized on time. The effect is 8% for those whose mothers have little exposure and approaches double for those whose mothers have high media exposure (13.2%). This result is contrary to that of Gauri and Khaleghian (2002) who did not find a significant effect of media exposure on the immunization of children.

The inclusion of socio-economic factors in model 3 mitigates the extent to which socio-cultural factors contribute to the relationship between birth order and the probability of being fully immunized. Birth order remains significant, suggesting again a specific effect on the immunization status. Birth order reduces the likelihood of full immunization, but with a lower impact compared to model 2 (2% for order 3 to 8.7% for order 7). Everything happens as though the improvement of the standard of living of individuals through education makes it possible to better understand the importance of immunization and thus reduces the extent of cultural prejudices.

Model 3 results confirm the influence of socio-economic factors on the immunization status of children (George and Nandraj, 1993; Islam and Islam, 1996; Patra, 2006). Education promotes knowledge of the immunization schedule and an understanding of the importance of immunization for child survival. Without education, women generally do not know how to read and will find it difficult to immunize their child either on time or late. From the primary level, a significant non-negligible effect of 8.5% is seen directly on the child's probability of being fully immunized on time and late by 5.5%. This effect increases by 2.4% (from 8.5% to 10.9%) when the mother has a secondary level of education and by 8% (from 8.5% to 16.5%) for higher education. Access to electricity, which presupposes the

existence of infrastructure, has a positive and significant effect of 4.3% on timely full immunization. Similarly, having access to clean water means granting importance to one's health, which therefore implies the importance of the health of children, including their immunization. Thus, the fact that a household has access to drinking water increases the probability of timely full immunization of children by 4.9%. Moreover, results relating to the impact of socio-cultural factors remain fairly close to those of the second model. The child is always very disadvantaged as concerns timely immunization when he is dependent on someone other than his/her mother, and the mother's age increases timely immunization until the age of entry into the menopausal phase.

The addition of community variables in model 4 further mitigates the birth order effect of socio-cultural factors. The effect of birth order on timely immunization of children is negative and significant, but its impact goes from 1.8% for order 3 to 7.9% for order 7. This reinforces the idea of the birth order's own effect on timely immunization. Model 4 confirms the influence of community characteristics on immunization of children (Padhi, 2001; Patra, 2006; Pebley et al, 1996). The low penetration of the health system coupled with displacement difficulties means that living in rural areas reduces the likelihood of timely full immunization by 9.2% and by 13.1% for late full immunization. Given these limitations, the efforts made by the EPI in terms of mobile immunization strategies to reach populations remote from health facilities have led to late immunization. These efforts captured by the interaction variable between the rural environment and the year of analysis translate into an impact that is significant for late full immunization (20.6% in 1998, 14.8% in 2004, and 14.3% in 2011). Household size reduces the probability of timely full immunization by 6.4%. Finally, there is near-stability concerning socio-economic and socio-cultural factors in terms of influence on full immunization. It should be noted that in 1998, children were more likely to be fully immunized on time than during the other two periods (2004 and 2011).

Table 6: Results of multinomial probit estimates of the immunization of children under the age of 5 (marginal effects)

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Demo-biological characteristics									
Child's birth order	Order 3	0.001 (0.07)	-0.009 (-0.87)	-0.029 (-3.64)***	-0.028 (-2.64)***	-0.020 (-2,50) **	-0.029 (-2.68)***	-0.018 (-2,24) **	-0.030 (-2.82)***
	Order 4	-0.031 (-3.60)***	-0.004 (-0.39)	-0.069 (-7.42)***	-0.037 (-3.04)***	-0.052 (-5.58)***	-0.037 (-3.02)***	-0.047 (-5.08)***	-0.040 (-3.24)***
	Order 5	-0.041 (-4.26)***	0.0001 (0.01)	-0.086 (-8.09)***	-0.045 (-3.22)***	-0.065 (-5.97)***	-0.045 (-3.15)***	-0.059 (-5.44)***	-0.049 (-3.45)***
	Order 6	-0.063 (-5.63)***	-0.005 (-0.36)	-0.109 (-8.76)***	-0.063 (-3.92)***	-0.083 (-6.55)***	-0.062 (-3.78)***	-0.076 (-6.06)***	-0.066 (-4.03)***
	Order 7	-0.086 (-9.67)***	-0.019 (-1,81) *	-0.127 (-10.44)***	-0.085 (-5.48)***	-0.087 (-7.05)***	-0.080 (-5.04)***	-0.079 (-6.40)***	-0.084 (-5.30)***
Gender of the child	Male	-0.005 (-1.01)	0.005 (0.76)	-0.007 (-1.34)	0.004 (0.66)	-0.008 (-1.49)	0.004 (0.62)	-0.008 (-1.49)	0.004 (0.59)
Health at birth	Poor health	0.038 (3.93)***	0.033 (2,52) **	0.023 (2,49) **	0.023 (1,79) *	0.013 (1.35)	0.019 (1.50)	0.011 (1.17)	0.018 (1.41)
Multiplicity of births	Twin	0.054 (4.11)***	0.051 (2.98)***	0.042 (3.36)***	0.045 (2.63)***	0.034 (2.71)***	0.041 (2,38) **	0.033 (2.69)***	0.040 (2,36) **
Socio-cultural characteristics									
Care of the child	Another person			-0.195 (-15.44)***	0.004 (0.35)	-0.192 (-15.44)***	0.004 (0.32)	-0.193 (-15.52)***	0.004 (0.34)
Mother's age	20 -24			0.049 (4.20)***	0.009 (0.64)	0.044 (3.75)***	0.010 (0.70)	0.042 (3.65)***	0.010 (0.70)
	25 -29			0.098 (8.10)***	0.040 (2.61)***	0.086 (7.14)***	0.042 (2.74)***	0.081 (6.71)***	0.042 (2.79)***
	30 -34			0.119 (9.00)***	0.073 (4.31)***	0.100 (7.49)***	0.075 (4.38)***	0.093 (6.97)***	0.077 (4.52)***
	35 -39			0.146 (9.89)***	0.093 (4.88)***	0.121 (8.10)***	0.095 (4.96)***	0.112 (7.49)***	0.098 (5.12)***
	40 -44			0.122 (6.86)***	0.121 (5.42)***	0.101 (5.65)***	0.126 (5.58)***	0.094 (5.26)***	0.129 (5.75)***
	45 -49			0.133 (5.13)***	0.064 (1,95) *	0.107 (4.09)***	0.074 (2,26) **	0.101 (3.86)***	0.081 (2,47) **

continued next page

Table 6 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Socio-cultural characteristics									
Religion	Reformist			-0.067 (-10.04)***	-0.061 (-7.38)***	-0.034 (-4.69)***	-0.039 (-4.41)***	-0.036 (-4.95)***	-0.037 (-4.11)***
	No religion			-0.030 (-2.70)***	-0.009 (-0.63)	-0.011 (-0.96)	0.006 (0.41)	-0.008 (-0.72)	0.002 (0.15)
Marital status	In a relationship			-0.005 (-0.65)	0.012 (1.12)	0.003 (0.38)	0.017 (1,64) *	0.002 (0.28)	0.018 (1,75) *
Media exposure	Limited exposure			0.080 (11.28)***	-0.005 (-0.54)	0.048 (6.59)***	-0.016 (-1,76) *	0.044 (6.02)***	-0.019 (-2,06) **
	High exposure			0.132 (20.51)***	0.029 (3.48)***	0.078 (10.79)***	0.013 (1.42)	0.068 (9.19)***	0.008 (0.81)
Socio-economic characteristics									
Level of education	Primary					0.085 (10.06)***	0.055 (5.57)***	0.083 (9.93)***	0.055 (5.59)***
	Secondary					0.109 (11.43)***	0.058 (4.89)***	0.102 (10.74)***	0.058 (4.85)***
	Higher education					0.165 (9.18)***	0.042 (1.50)	0.156 (8.68)***	0.046 (1.61)
Electricity	Access					0.043 (4.16)***	-0.011 (-0.79)	0.013 (1.22)	-0.021 (-1.40)
Drinking water	Access					0.049 (4.44)***	-0.030 (-2.07)	0.029 (2.65)***	-0.028 (-1,86) *

continued next page

Table 6 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Community characteristics									
Place of residence	Rural							-0.092 (-4.17)***	-0.131 (-6.68)***
Place of residence per period	Rural_1998							0.022 (0.78)	0.105 (3.28)***
	Rural_2004							0.036 (1.50)	0.137 (6.07)***
	Rural_2011							0.059 (2.60)***	0.148 (6.90)***
Household size	Household size							-0.064 (-4.87)***	0.003 (0.20)
Analysis period	1998	0.133 (9.89)***	-0.148 (-9.54)***	0.137 (10.42)***	-0.154 (-9.91)***	0.130 (9.97)***	-0.162 (-10.37)***	0.128 (7.72)***	-0.206 (-9.14)***
	2004	0.122 (11.57)***	-0.063 (-5.91)***	0.103 (9.98)***	-0.077 (-7.05)***	0.107 (10.39)***	-0.084 (-7.68)***	0.098 (7.88)***	-0.148 (-9.91)***
	2011	0.198 (19.97)***	-0.048 (-4.77)***	0.172 (17.65)***	-0.061 (-6.01)***	0.173 (17.77)***	-0.069 (-6.75)***	0.152 (13.01)***	-0.143 (-10.15)***

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4. Note: Values in parentheses are student's statistics *** (**) (*) represent the significance thresholds at 1%, 5%, and 10%, respectively.

Robustness of the analysis

Stability in vaccine behaviour may be increased when vaccines are close and during the first months of the child's life. In addition, it is recommended by the World Bank to study the correct immunization of the under two years age group (Bolton et al, 1998; WHO, 2007). Thus, the analysis of the robustness of the effect of birth order on the demand for immunization will be done taking into account these considerations.

Taking into account the time lag in the immunization of children

Among the seven EPI vaccines, and according to the immunization schedule, five are taken after 14 weeks and the other two at nine months, i.e. ive months later (Table 2). This distance between the two groups is likely to create disparities in the immunization of children. Parents might forget or abandon the last vaccines because of their occupations. Until about four months after the birth of the child, the mother still benefits from the follow-up of the society (parents, family, friends, etc) or she is on maternity leave for those who work. This follow-up would allow her to give the child more time and increase chances of being fully immunized. Table 7 shows that, of vaccines taken in the first four months, 45.9% of children are not fully immunized. This proportion increases to 52% when the remaining vaccines are added to the immunization schedule (up to nine months). The increase, which is 6.1%, comes from 3% of children who took all the first vaccines on time and 3.1% from those who had taken at least one vaccine late.

Table 7: Comparison of the immunization status for vaccines taken between 0-4 months and 0-9 months

Immunization status	Immunization period covered (%)	
	First 4 months	Until 9 months
Incomplete immunization	0.459 (0.004)	0.520 (0.004)
Timely full immunization	0.196 (0.003)	0.165 (0.003)
At least one vaccine taken late	0.345 (0.003)	0.315 (0.003)

Source: From DHS 1, 2, 3 and 4. Values in parentheses are standard deviations

Despite increased attendance of health facilities due to increased vulnerability of children between six and 11 months[8] (INS, 2012), the immunization status of children in terms of VAR intake did not improve. Tables 8 and A3 for the 0-4 month vaccines give us a stable relationship between birth order and the immunization of children. The increase in impact for vaccines of the first four months compared to all vaccines is due to the prevalence of measles, which is one of the diseases whose vaccine is the most widely used in routine immunization campaigns. This dependence of the anti-measles vaccine on routine immunization campaigns means that it will no longer be

affected by the dilution of resources caused by the number of children, since the agents go to the children. In addition, parents are a little more receptive to the authorities' efforts to stimulate the immunization of children with the first vaccines. Compared to 1991, the 1998, 2004 and 2011 periods increase the probability of receiving the first vaccines by 14.8%, 11.2% and 17.4%, respectively, whereas taking into account the nine-month vaccines, these effects were 12.8%, 9.8% and 15.2%.

Analysis on children under 2

Considering the population on which national and international institutions (WHO, World Bank, UNICEF) study timely immunization, i.e. children of 10-23 months, we note that birth order has the same effect on the immunization of children (Table 9 and A4). This population has the peculiarity of not being affected by the dilution of resources due to the occurrence of a younger sibling, but rather due to the total number of siblings. The difference with the under-5 population is in the intensity of the impact, which is higher in the population of 10-23 months. At the age of two, the complementary vaccination strategies of the EPI still give the mother the possibility to make up for the absence of child immunization until the age of ive. It should be noted that immunization campaigns are also carried out in schools.The proliferation of kindergartens and the desire to empower women through work means that by the age of three, most children are already in school and can be immunized during campaigns. This explains the importance of the dilution phenomenon on children under the age of two compared with those under the age of five.

This effect of EPI strategies is reflected in the analysis period, which is significant in all four models when we are in the population of children under five and in children under two. In fact, compared to 1991, the 1998, 2004 and 2011 periods favoured the full immunization of children under five. In model 4, where the demo-biological, socio-cultural, socio-economic and community characteristics were controlled, the actions carried out in rural areas had a rather similar effect on the two populations (less than the age of two and less than the age of five).

Table 8: Results of estimates for children under the age of 5 and vaccines administered up to 4 months[9] (marginal effects)

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Demo-biological characteristics									
Child's birth order	Order 3	0.001 (0.09)	-0.006 (-0.61)	-0.029 (-3.43)***	-0.018 (-1.60)	-0.020 (-2,30) **	-0.019 (-1,71) *	-0.017 (-2,05) **	-0.020 (-1,84) *
	Order 4	-0.033 (-3.62)***	0.004 (0.37)	-0.072 (-7.28)***	-0.017 (-1.38)	-0.055 (-5.47)***	-0.019 (-1.45)	-0.050 (-5.00)***	-0.021 (-1,68) *
	Order 5	-0.041 (-3.97)***	0.011 (0.89)	-0.087 (-7.66)***	-0.021 (-1.44)	-0.064 (-5.59)***	-0.022 (-1.49)	-0.058 (-5.08)***	-0.026 (-1,79) *
	Order 6	-0.049 (-4.20)***	-0.002 (-0.16)	-0.097 (-7.44)***	-0.044 (-2.66)***	-0.069 (-5.22)***	-0.044 (-2.64)***	-0.063 (-4.76)***	-0.048 (-2.90)***
	Order 7	-0.098 (-10.37)***	0.003 (0.25)	-0.140 (-10.86)***	-0.040 (-2,53) **	-0.099 (-7.50)***	-0.038 (-2,31) **	-0.091 (-6.87)***	-0.042 (-2.60)***
Gender of the child	Male	-0.007 (-1.16)	0.006 (0.81)	-0.008 (-1.51)	0.005 (0.72)	-0.009 (-1,68) *	0.005 (0.69)	-0.009 (-1.64)	0.004 (0.65)
Health at birth	Poor health	0.049 (4.66)***	0.027 (2,02) **	0.032 (3.20)***	0.019 (1.40)	0.021 (2,07) **	0.015 (1.14)	0.018 (1,85) *	0.014 (1.03)
Multiplicity of births	Twin	0.072 (5.18)***	0.048 (2.70)***	0.059 (4.40)***	0.044 (2,46) **	0.049 (3.71)***	0.040 (2,23) *	0.048 (3.67)***	0.039 (2,20) **
Socio-cultural characteristics									
Care of the child	Another person			-0.226 (-17.06)***	0.006 (0.48)	-0.224 (-17.14)***	0.006 (0.51)	-0.225 (-17.23)***	0.007 (0.55)
Mother's age	20 -24			0.041 (3.37)***	-0.002 (-0.13)	0.035 (2.92)***	-0.001 (-0.04)	0.034 (2.82)***	-0.001 (-0.04)
	25 -29			0.092 (7.34)***	0.013 (0.86)	0.080 (6.37)***	0.016 (1.04)	0.075 (5.97)***	0.017 (1.11)
	30 -34			0.115 (8.24)***	0.050 (2.87)***	0.094 (6.76)***	0.052 (2.99)***	0.087 (6.26)***	0.055 (3.14)***
	35 -39			0.140 (8.97)***	0.047 (2,41) *	0.114 (7.24)***	0.050 (2,55) **	0.105 (6.65)***	0.054 (2.74)***
	40 -44			0.127 (6.84)***	0.080 (3.50)***	0.106 (5.66)***	0.086 (3.73)***	0.099 (5.28)***	0.090 (3.92)***
	45 -49			0.123 (4.42)***	0.004 (0.11)	0.098 (3.53)***	0.014 (0.43)	0.092 (3.31)***	0.022 (0.66)
Religion	Reformist			-0.070 (-10.02)***	-0.059 (-7.08)***	-0.033 (-4.39)***	-0.040 (-4.44)***	-0.036 (-4.73)***	-0.038 (-4.17)***
	No religion			-0.038 (-3.25)***	-0.009 (-0.62)	-0.017 (-1.41)	0.005 (0.34)	-0.014 (-1.18)	0.001 (0.03)

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Table 8 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Socio-cultural characteristics									
Marital status	In a relationship			-0.008 (-1.01)	0.008 (0.73)	0.001 (0.15)	0.012 (1.15)	0.001 (0.08)	0.013 (1.26)
Media exposure	Limited exposure			0.088 (11.89)***	-0.006 (-0.71)	0.054 (6.98)***	-0.015 (-1.64)	0.049 (6.37)***	-0.019 (-1,98) **
	High exposure			0.144 (21.37)***	0.018 (2,13) **	0.085 (11.08)***	0.007 (0.70)	0.074 (9.46)***	0.001 (0.04)
Socio-economic characteristics									
Level of education	Primary					0.088 (10.18)***	0.052 (5.19)***	0.088 (10.11)***	0.052 (5.21)***
	Secondary					0.120 (12.09)***	0.048 (3.97)***	0.114 (11.44)***	0.048 (3.92)***
	Higher education					0.173 (8.78)***	0.034 (1.15)	0.163 (8.27)***	0.037 (1.26)
Electricity	Access					0.054 (4.94)***	-0.020 (-1.36)	0.022 (1,92) *	-0.031 (-2,01) **
Drinking water	Access					0.035 (2.98)***	-0.020 (-1.33)	0.015 (1.30)	-0.016 (-1.07)

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Table 8 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Community characteristics									
Place of residence	Rural							-0.090 (-4.09)***	-0.139 (-6.90)***
Place of residence per period	Rural_1998							0.029 (0.98)	0.105 (3.21)***
	Rural_2004							0.032 (1.36)	0.144 (6.21)***
	Rural_2011							0.050 (2,18) **	0.154 (6.97)***
Household size	Household size							-0.057 (-4.08)***	0.018 (0.99)
Analysis period	1998	0.160 (11.42)***	-0.147 (-9.29)***	0.163 (11.93)***	-0.157 (-9.90)***	0.154 (11.35)***	-0.163 (-10.28)***	0.148 (8.33)***	-0.207 (-8.97)***
	2004	0.139 (12.70)***	-0.045 (-4.11)***	0.117 (10.94)***	-0.058 (-5.20)***	0.120 (11.25)***	-0.065 (-5.80)***	0.112 (8.44)***	-0.132 (-8.55)***
	2011	0.220 (21.51)***	-0.052 (-5.01)***	0.192 (18.97)***	-0.064 (-6.06)***	0.191 (18.95)***	-0.071 (-6.71)***	0.174 (13.97)***	-0.146 (-10.04)***

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4. Note: Values in parentheses are student's statistics *** (**) (*) represent the significance thresholds at 1%, 5%, and 10%, respectively.

Table 9: Results of multinomial probit estimates of the immunization of children under the age of 2 (marginal effects)

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Demo-biological characteristics									
Child's birth order	Order 3	0.014 (1.03)	-0.013 (-0.83)	-0.032 (-2,23) **	-0.029 (-1,66) *	-0.020 (-1.37)	-0.030 (-1,74) *	-0.017 (-1.16)	-0.032 (-1,86) *
	Order 4	-0.034 (-2,14) **	-0.013 (-0.72)	-0.091 (-5.30)***	-0.038 (-1,87) *	-0.068 (-3.94)***	-0.043 (-2,12) **	-0.060 (-3.51)***	-0.047 (-2,34) **
	Order 5	-0.063 (-3.55)***	-0.028 (-1.46)	-0.133 (-6.65)***	-0.065 (-2.85)***	-0.099 (-4.93)***	-0.072 (-3.07)***	-0.088 (-4.37)***	-0.077 (-3.29)***
	Order 6	-0.069 (-3.40)***	-0.025 (-1.15)	-0.148 (-6.49)***	-0.073 (-2.80)***	-0.108 (-4.69)***	-0.079 (-3.00)***	-0.097 (-4.20)***	-0.086 (-3.23)***
	Order 7	-0.101 (-6.14)***	-0.028 (-1,65) *	-0.176 (-7.77)***	-0.080 (-3.10)***	-0.120 (-5.17)***	-0.085 (-3.21)***	-0.107 (-4.61)***	-0.091 (-3.42)***
Gender of the child	Male	0.002 (0.22)	0.0004 (0.04)	0.003 (0.27)	0.001 (0.08)	0.0003 (0.04)	0.001 (0.13)	-0.001 (-0.02)	0.001 (0.10)
Health at birth	Poor health	0.053 (2.88)***	0.033 (1.54)	0.041 (2,31) **	0.027 (1.26)	0.026 (1.48)	0.026 (1.25)	0.022 (1.27)	0.026 (1.24)
Multiplicity of births	Twin	0.041 (1.61)	0.055 (1,94) *	0.034 (1.40)	0.048 (1,72) *	0.019 (0.77)	0.046 (1.64)	0.021 (0.88)	0.047 (1,69) *
Socio-cultural characteristics									
Care of the child	Another person			-0.260 (-7.16)***	-0.048 (-1.58)	-0.262 (-7.37)***	-0.049 (-1.62)	-0.265 (-7.54)***	-0.052 (-1,73) *
Mother's age	20 -24			0.095 (5.39)***	-0.008 (-0.43)	0.085 (4.88)***	-0.005 (-0.27)	0.082 (4.72)***	-0.004 (-0.20)
	25 -29			0.150 (7.81)***	0.015 (0.71)	0.130 (6.77)***	0.022 (1.04)	0.120 (6.25)***	0.026 (1.22)
	30 -34			0.195 (8.85)***	0.040 (1.62)	0.165 (7.42)***	0.049 (1,94) *	0.152 (6.85)***	0.054 (2,12) **
	35 -39			0.239 (9.19)***	0.049 (1,66) *	0.197 (7.51)***	0.060 (2,00) **	0.179 (6.85)***	0.065 (2,17) **
	40 -44			0.202 (6.00)***	0.091 (2,48) **	0.170 (5.05)***	0.104 (2.81)***	0.155 (4.62)***	0.107 (2.89)***
	45 -49			0.196 (3.11)***	-0.122 (-1.60)	0.162 (2,54) **	-0.099 (-1.28)	0.140 (2,20) **	-0.081 (-1.06)
Religion	Reformist			-0.062 (-5.08)***	-0.062 (-4.59)***	-0.020 (-1.57)	-0.049 (-3.38)***	-0.028 (-2,11) **	-0.046 (-3.18)***
	No religion			-0.032 (-1.59)	-0.012 (-0.53)	-0.006 (-0.27)	-0.001 (-0.04)	-0.002 (-0.09)	-0.005 (-0.24)
Marital status	In a relationship			-0.017 (-1.19)	0.015 (0.92)	-0.005 (-0.37)	0.020 (1.24)	-0.007 (-0.53)	0.020 (1.23)
Media exposure	Limited exposure			0.082 (6.38)***	-0.012 (-0.84)	0.042 (3.13)***	-0.016 (-1.09)	0.036 (2.69)***	-0.018 (-1.25)
	High exposure			0.158 (13.60)***	-0.001 (-0.10)	0.089 (6.82)***	-0.003 (-0.20)	0.072 (5.43)***	-0.006 (-0.40)

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Table 9 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Socio-economic characteristics									
Level of education	Primary					0.100 (6.46)***	0.038 (2,38) **	0.099 (6.41)***	0.038 (2,36) **
	Secondary					0.136 (7.79)***	0.039 (2,02) **	0.127 (7.26)***	0.039 (2,03) **
	Higher education					0.216 (6.38)***	-0.014 (-0.30)	0.201 (5.97)***	-0.009 (-0.20)
Electricity	Access					0.066 (3.52)***	-0.022 (-0.96)	0.022 (1.12)	-0.021 (-0.86)
Drinking water	Access					0.068 (3.39)***	-0.047 (-1,98) **	0.042 (2,06) **	-0.042 (-1,74) *
Community characteristics									
Place of residence	Rural							-0.079 (-2,28) **	-0.115 (-3.68)***
Place of residence per period	Rural_1998							0.006 (0.14)	0.081 (1,85) *
	Rural_2004							-0.013 (-0.33)	0.136 (3.74)***
	Rural_2011							0.011 (0.29)	0.146 (4.19)***
Household size	Household size							-0.024 (-0.96)	0.014 (0.48)
Analysis period	1998	0.071 (3.30)***	-0.118 (-5.57)***	0.078 (3.74)***	-0.128 (-6.01)***	0.073 (3.53)***	-0.133 (-6.24)***	0.075 (2.86)***	-0.160 (-5.32)***
	2004	0.122 (6.65)***	-0.066 (-3.77)***	0.099 (5.53)***	-0.075 (-4.20)	0.107 (5.99)***	-0.082 (-4.58)***	0.119 (5.40)***	-0.141 (-5.77)***
	2011	0.182 (10.48)***	-0.060 (-3.60)***	0.149 (8.78)***	-0.067 (-3.97)***	0.151 (8.95)***	-0.074 (-4.38)***	0.154 (7.38)***	-0.141 (-6.13)***

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4. Note: Values in parentheses are student's statistics *** (**) (*) represent the significance thresholds at 1%, 5%, and 10%, respectively.

6. Discussion

In relation to the limits found on the various theoretical explanations of the effect of birth order, the dilution theory (Blake, 1981) is the transmission mechanism that has been approved by most studies. A reduction in the younger siblings' state of health due to deterioration of resources would also be due to reduction of health inputs such as vaccines administered to them. The hypothesis of a possible discrimination in favour of the youngest highlighted by Hotz and Pantano (2015) is not verified for the immunization of children under five. Because the negative impact of the rank increases with each birth, it shows equal treatment of children despite the fact that cadets would need more attention from parents.

Although cultural considerations increase the negative effect of birth order on childhood immunization, they are, however, mitigated by socio-economic factors. Everything happens as though improvement of the standard of living of individuals through education makes it possible to better understand the importance of immunization and thus reduce the extent of cultural prejudices. In addition, the increased care given to the child during the first months of life can be seen in the intake of the first three vaccines on which the effect of birth order is higher. In the case where the mother works, during this period, she benefits from maternity leave and for some people, from the assistance of relatives. These contributions do not eliminate the effect of birth order but increase its impact in that it allows immunization to depend mainly on the behaviour of the mother.

Given the government's complementary immunization policies and routine immunization campaigns, the effects of birth order on immunization can be mitigated when we consider the cohort of children aged 10 to 59 months. On the other hand, considering the age group on which the national and international institutions recommend the study of correct immunization, it turns out that the dilution phenomenon is much more increased. After two years, the immunization of children no longer depends on the specificities of the mother or the household. The proliferation of kindergartens and the desire to empower women through work means that by the age of three, most children are already in school and can be immunized during campaigns.

7. Conclusion and recommendations

The objective of this study was to measure the effect of birth order on immunization of children under the age of five. Based on the data analysis of a large nationally representative sample of Cameroonian children, this study resulted in a negative effect of birth order on the immunization of children. This effect increases as the child's birth order increases. In addition, when we focus on vaccines administered during the first four (4) months of the child's life, the effect of birth order is higher because of the greater dependence of immunization on maternal availability. Similarly, by ignoring complementary immunization policies, the analysis of children under the age of two has a higher impact than on those aged 10-59 months.

Other key findings from this study show that childhood immunization in Cameroon is consistent with observed trends in socio-cultural, socio-economic and environmental characteristics. The probability of being fully immunized increases when the child is born in poor health and when he is a twin. There is no gender difference in the immunization of children. The mother is the one who is most willing to immunize the child and this is more significant when she is educated.

In a number of ways, this study contributes to the literature. For the first time, it evaluates the effect of birth order on immunization, which is a health input. This analysis contributes to the empirical validation of the dilution theory in that it allows to perceive that the negative effect of birth order on the morbidity and mortality of the individuals is due to losses in terms of childcare following the reduction of resources for children. This was made possible by the database used which contains information on EPI immunizations for all children under five in the household. Then, the same analyses were carried out taking into account the homogeneity as regards the period of vaccine intake. Finally, it therefore provides an excellent basis for making various recommendations for economic policies on immunization for these countries.

Therefore, in terms of policy implications, it is important to distinguish the effect due to different factors from that due to birth order. The negative effect of birth order which increases with birth order presupposes a certain fatigue of parents and limited resources allocated to each child as births increase, which highlights the need for birth control through spacing. The modal birth interval is currently 24 months, and therefore its increase to 48 months could reduce the burden on the mother since the youngest child would already be able to self-manage for certain tasks. To this end, the

state should encourage women to space births by promoting modern contraceptive methods. The increase in the negative impact of birth order due to cultural factors requires increased awareness on the importance of immunization. This sensitization should be done not only through the media, but also in public spaces to reach out to population segments with no media exposure. In addition, health authorities should expand routine immunization campaigns on all vaccines (excluding BCG) against two currently (measles, polio).

Notes

1. Many diseases such as polio that prevail in adulthood have their origins in early childhood (Hertzman and Power, 2004).

2. According to WHO estimates, immunization prevents nearly 750,000 children from suffering serious physical, mental and neurological disabilities, and more than three million deaths each year (PEV, 2009).

3. Care may be a short-term investment since the individual may recidivate after treatment, while vaccination is longer term.

4. The average number of children per woman in the world is three. In OECD countries and in the USA, this figure drops to two and in Sub-Saharan Africa, it is five.

5. The correlation between birth order and health regardless of family size may falsely attribute differences to birth order.

6. BCG, DTC-HepB-Hib, VPO and VAR.

7. According to WHO, children born with less than 2,500 grams are considered to be in poor health.

8. Childhood diseases such as Acute Respiratory Infections (ARI), fever and diarrhoea are more common in children between six and 11 months and parents seek advice or treatment in health facilities.

9. BCG, VPO, DTC-HepB-Hib.

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Annex

Table A1: Immunization rate by period and place of residence

Doses	Urban (%)					Rural (%)				
	1991	1998	2004	2011	Total	1991	1998	2004	2011	Total
BCG	85.45	87.69	90.97	93.78	89.05	62.95	65.05	78.17	82.67	77.26
DTC1	79.29	80.84	86.66	89.33	86.04	56.49	59.83	73.09	78.32	72.32
DTC2	69.46	70.10	79.13	83.29	78.50	42.30	48.08	64.46	69.63	62.75
DTC3	57.53	57.26	68.71	73.92	68.08	29.33	36.26	52.07	58.58	50.97
DTC	56.45	56.51	68.37	73.46	67.50	28.78	35.79	51.48	58.06	50.39
POLIO1	80.25	84.91	90.90	91.50	88.76	58.90	71.35	86.87	86.71	82.07
POLIO2	72.03	72.03	83.66	84.23	80.87	46.10	55.51	77.98	78.08	72.23
POLIO3	58.84	51.14	64.12	67.88	63.75	31.33	33.93	57.88	62.67	54.67
POLIO	57.64	50.30	63.63	67.43	63.12	30.46	33.33	57.19	61.98	54.06
VAR	61.24	51.94	64.63	69.65	65.18	41.50	36.93	52.56	59.97	53.24
Total	46.18	35.80	44.95	52.72	47.83	22.43	23.11	33.87	41.83	35.24

Source: From DHS 1, 2, 3 and 4

Table A2: Results of multinomial probit estimates of the immunization of children under the age of 5 (coefficients)

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Demo-biological characteristics									
Child's birth order	Order 3	-0.012 (-0.27)	-0.036 (-0.89)	-0.249 (-4.91)***	-0.180 (-4.04)***	-0.193 (-3.75)***	-0.167 (-3.70)***	-0.183 (-3.53)***	-0.170 (-3.76)***
	Order 4	-0.198 (-3.93)***	-0.073 (-1,66) *	-0.534 (-9.03)***	-0.297 (-5.84)***	-0.429 (-7.11)***	-0.267 (-5.20)***	-0.406 (-6.69)***	-0.272 (-5.26)***
	Order 5	-0.253 (-4.47)***	-0.073 (-1.50)	-0.669 (-9.80)***	-0.367 (-6.31)***	-0.531 (-7.59)***	-0.325 (-5.51)***	-0.503 (-7.14)***	-0.334 (-5.64)***
	Order 6	-0.398 (-6.09)***	-0.133 (-2,45) *	-0.857 (-10.81)***	-0.488 (-7.39)***	-0.687 (-8.46)***	-0.434 (-6.46)***	-0.657 (-8.05)***	-0.442 (-6.55)***
	Order 7	-0.565 (-10.91)***	-0.234 (-5.55)***	-1.016 (-13.17)***	-0.618 (-9.65)***	-0.758 (-9.49)***	-0.526 (-8.01)***	-0.717 (-8.91)***	-0.532 (-8.05)***
Gender of the child	Male	-0.024 (-0.76)	0.012 (0.45)	-0.037 (-1.15)	0.006 (0.21)	-0.044 (-1.33)	0.003 (0.11)	-0.044 (-1.34)	0.002 (0.07)
Health at birth	Poor health	0.295 (5.03)***	0.208 (3.88)***	0.203 (3.33)***	0.147 (2.71)***	0.125 (2,03) **	0.110 (2,03) *	0.111 (1,81) *	0.102 (1,87) *
Multiplicity of births	Twin	0.422 (5.36)***	0.313 (4.41)***	0.371 (4.55)***	0.279 (3.88)***	0.311 (3.79)***	0.245 (3.40)***	0.310 (3.77)***	0.244 (3.38)***
Socio-cultural characteristics									
Care of the child	Another person			-1.298 (-16.81)***	-0.362 (-7.57)***	-1.306 (-16.84)***	-0.366 (-7.62)***	-1.317 (-16.92)***	-0.369 (-7.65)***
Mother's age	20 -24			0.347 (4.78)***	0.136 (2,35) **	0.318 (4.33)***	0.131 (2,26) **	0.311 (4.22)***	0.129 (2,22) **
	25 -29			0.732 (9.68)***	0.363 (5.89)***	0.670 (8.73)***	0.354 (5.69)***	0.640 (8.30)***	0.349 (5.59)***
	30 -34			0.943 (11.24)***	0.551 (7.95)***	0.830 (9.71)***	0.525 (7.50)***	0.793 (9.22)***	0.525 (7.47)***
	35 -39			1.164 (12.37)***	0.692 (8.82)***	1.015 (10.57)***	0.658 (8.29)***	0.966 (10.00)***	0.658 (8.25)***
	40 -44			1.055 (9.39)***	0.765 (8.35)***	0.939 (8.21)***	0.751 (8.12)***	0.905 (7.86)***	0.757 (8.16)***
	45 -49			1.020 (6.28)***	0.538 (4.06)***	0.878 (5.28)***	0.538 (4.02)***	0.855 (5.13)***	0.558 (4.17)***
Religion	Reformist			-0.569 (-13.61)***	-0.396 (-11.83)***	-0.308 (-6.78)***	-0.239 (-6.58)***	-0.319 (-6.95)***	-0.234 (-6.38)***
	No religion			-0.218 (-3.14)***	-0.097 (-1,70) *	-0.062 (-0.87)	0.004 (0.07)	-0.051 (-0.71)	-0.007 (-0.12)

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Table A2 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Socio-cultural characteristics									
Marital status	In a relationship			-0.011 (-0.22)	0.041 (0.95)	0.054 (1.08)	0.081 (1,87) *	0.051 (1.02)	0.084 (1,95) *
Media exposure	Limited exposure			0.528 (11.89)***	0.136 (3.82)***	0.299 (6.40)***	0.026 (0.69)	0.268 (5.67)***	0.006 (0.16)
	High exposure			0.940 (22.77)***	0.382 (11.27)***	0.562 (11.98)***	0.215 (5.50)***	0.482 (10.07)***	0.171 (4.29)***
Socio-economic characteristics									
Level of education	Primary					0.687 (13.01)***	0.409 (10.31)***	0.684 (12.89)***	0.409 (10.31)***
	Secondary					0.859 (14.14)***	0.472 (9.68)***	0.820 (13.41)***	0.460 (9.40)***
	Higher education					1.215 (9.77)***	0.514 (4.25)***	1.167 (9.33)***	0.515 (4.23)***
Electricity	Access (Cluster)					0.270 (4.04)***	0.037 (0.63)	0.049 (0.69)	-0.066 (-1.05)
Drinking water	Access (Cluster)					0.271 (3.82)***	-0.037 (-0.60)	0.147 (2,03) **	-0.063 (-1.01)
Community characteristics									
Place of residence	Rural							-0.897 (-6.57)***	-0.763 (-10.14)***
Place of residence per period	Rural_1998							0.366 (2,04) **	0.508 (3.98)***
	Rural_2004							0.522 (3.54)***	0.677 (7.65)***
	Rural_2011							0.707 (4.97)***	0.773 (9.20)***
Household size	Household size							-0.435 (-5.09)***	-0.114 (-1.58)

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Table A2 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Community characteristics									
Analysis period	1998	0.556 (7.21)***	-0.391 (-6.36)***	0.617 (7.56)***	-0.403 (-6.42)***	0.567 (6.88)***	-0.448 (-7.10)***	0.469 (4.32)***	-0.651 (-6.90)***
	2004	0.636 (10.60)***	-0.053 (-1.26)	0.541 (8.48)***	-0.132 (-3.03)***	0.565 (8.71)***	-0.153 (-3.50)***	0.380 (4.67)***	-0.455 (-7.27)***
	2011	1.132 (19.83)***	0.147 (3.69)***	1.036 (17.00)***	0.070 (1,71) *	1.046 (16.85)***	0.041 (0.98)	0.763 (9.90)***	-0.321 (-5.43)***
Constancy	Constant	-1.584 (-27.10)***	-0.406 (-9.83)***	-2.285 (-23.35)***	-0.623 (-8.46)***	-3.076 (-27.24)***	-0.912 (-10.79)***	-1.555 (-6.87)***	-0.237 (-1.26)
Characteristics of the estimate	Log likelihood	-18495.021	-17646.869	-17455.551	-17350.976				
	Observation number	18.935	18.935	18.935	18.935				
	Wald chi2	823,83 ***	2221,84 ***	2511,85 ***	2658,36 ***				

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4. Note: Values in parentheses are student's statistics *** (**) (*) represent the significance thresholds at 1%, 5%, and 10%, respectively.

Table A3: Results of estimates for children under the age of 5 and vaccines administered up to 4 months (coefficients)

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Demo-biological characteristics									
Child's birth order	Order 3	-0.008 (-0.18)	-0.025 (-0.62)	-0.220 (-4.43)***	-0.139 (-3.11)***	-0.166 (-3.28)***	-0.125 (-2.78)***	-0.156 (-3.08)***	-0.128 (-2.83)***
	Order 4	-0.183 (-3.72)***	-0.047 (-1.06)	-0.488 (-8.45)***	-0.228 (-4.49)***	-0.388 (-6.58)***	-0.198 (-3.86)***	-0.366 (-6.19)***	-0.202 (-3.92)***
	Order 5	-0.212 (-3.87)***	-0.032 (-0.67)	-0.590 (-8.90)***	-0.275 (-4.73)***	-0.457 (-6.73)***	-0.234 (-3.96)***	-0.432 (-6.33)***	-0.242 (-4.09)***
	Order 6	-0.284 (-4.59)***	-0.103 (-1,90) *	-0.700 (-9.25)***	-0.396 (-5.99)***	-0.534 (-6.88)***	-0.341 (-5.08)***	-0.508 (-6.52)***	-0.349 (-5.18)***
	Order 7	-0.556 (-11.14)***	-0.177 (-4.25)***	-0.962 (-12.86)***	-0.471 (-7.39)***	-0.712 (-9.21)***	-0.378 (-5.79)***	-0.674 (-8.66)***	-0.384 (-5.84)***
Gender of the child	Male	-0.027 (-0.89)	0.011 (0.40)	-0.041 (-1.30)	0.004 (0.14)	-0.048 (-1.50)	0.001 (0.03)	-0.047 (-1.48)	0.001 (0.00)
Health at birth	Poor health	0.333 (5.76)***	0.209 (3.86)***	0.241 (4.04)***	0.150 (2.73)***	0.165 (2.74)***	0.112 (2,03) *	0.148 (2,45) **	0.101 (1,82) *
Multiplicity of births	Twin	0.507 (6.56)***	0.342 (4.75)	0.460 (5.73)***	0.314 (4.28)***	0.398 (4.94)***	0.278 (3.79)	0.395 (4.89)***	0.276 (3.75)***
Socio-cultural characteristics									
Care of the child	Another person			-1.397 (-19.06)***	-0.451 (-9.51)***	-1.413 (-19.17)***	-0.455 (-9.57)***	-1.425 (-19.26)***	-0.458 (-9.60)***
Mother's age	20 -24			0.251 (3.67)***	-0.451 (-9.51)	0.222 (3.21)***	0.073 (1.27)	0.216 (3.11)***	0.071 (1.24)
	25 -29			0.605 (8.40)***	0.253 (4.13)***	0.545 (7.46)***	0.243 (3.94)***	0.518 (7.06)***	0.238 (3.85)***
	30 -34			0.822 (10.22)***	0.457 (6.63)***	0.714 (8.73)***	0.431 (6.18)***	0.680 (8.27)***	0.430 (6.15)***
	35 -39			0.976 (10.79)***	0.500 (6.40)***	0.834 (9.04)***	0.465 (5.87)***	0.788 (8.50)***	0.465 (5.85)***
	40 -44			0.966 (8.99)***	0.617 (6.75)***	0.859 (7.85)***	0.602 (6.54)***	0.828 (7.53)***	0.610 (6.60)***
	45 -49			0.775 (4.94)***	0.276 (2,10) **	0.655 (4.10)***	0.274 (2,07) **	0.636 (3.97)***	0.296 (2,23) **
Religion	Reformist			-0.565 (-14.17)***	-0.406 (-12.29)***	-0.298 (-6.87)***	-0.248 (-6.89)***	-0.313 (-7.14)***	-0.245 (-6.77)***
	No religion			-0.259 (-3.85)***	-0.120 (-2,11) **	-0.096 (-1.39)	-0.015 (-0.25)	-0.089 (-1.28)	-0.028 (-0.49)

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Table A3 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Socio-cultural characteristics									
Marital status	In a relationship			-0.036 (-0.75)	0.016 (0.37)	0.035 (0.71)	0.057 (1.31)	0.033 (0.69)	0.060 (1.40)
Media exposure	Limited exposure			0.539 (12.73)***	0.160 (4.53)***	0.310 (6.95)***	0.049 (1.33)	0.277 (6.14)***	0.026 (0.70)
	High exposure			0.939 (23.62)***	0.382 (11.28)***	0.557 (12.30)***	0.213 (5.46)***	0.474 (10.27)***	0.162 (4.08)***
Socio-economic characteristics									
Level of education	Primary					0.676 (13.61)***	0.417 (10.68)***	0.675 (13.55)***	0.419 (10.70)***
	Secondary					0.868 (15.01)***	0.469 (9.68)***	0.832 (14.30)***	0.457 (9.38)***
	Higher education					1.176 (9.38)***	0.520 (4.21)***	1.126 (8.94)***	0.517 (4.16)***
Electricity	Access (Cluster)					0.303 (4.64)***	0.031 (0.54)	0.077 (1.10)	-0.086 (-1.38)
Drinking water	Access (Cluster)					0.179 (2.59)***	-0.012 (-0.20)	0.064 (0.90)	-0.038 (-0.61)
Community characteristics									
Place of residence	Rural							-0.878 (-7.14)***	-0.805 (-10.77)***
Place of residence per period	Rural_1998							0.412 (2,49) **	0.522 (4.13)***
	Rural_2004							0.521 (3.88)***	0.702 (7.98)***
	Rural_2011							0.655 (5.07)***	0.784 (9.36)***
Household size	Household size							-0.328 (-3.96)***	-0.046 (-0.65)

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Table A3 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Community characteristics									
Analysis period	1998	0.633 (8.68)***	-0.311 (-5.13)***	0.687 (8.92)***	-0.335 (-5.42)***	0.630 (8.09)***	-0.379 (-6.09)***	0.497 (4.72)***	-0.588 (-6.27)***
	2004	0.707 (12.48)***	0.075 (1,80) *	0.611 (10.15)***	-0.003 (-0.07)	0.627 (10.25)***	-0.024 (-0.56)	0.430 (5.47)***	-0.337 (-5.36)***
	2011	1.162 (21.54)***	0.205 (5.15)***	1.064 (18.50)***	0.130 (3.16)***	1.066 (18.20)***	0.102 (2,45) **	0.796 (10.68)***	-0.263 (-4.40)***
Constancy	Constant	-1.406 (-25.43)***	-0.312 (-7.57)***	-1.961 (-21.22)***	-0.424 (-5.80)***	-2.705 (-25.39)***	-0.725 (-8.65)***	-1.403 (-6.42)***	-0.160 (-0.85)
Characteristics of the estimate	Log likelihood	-19291.247	-18403.279	-18204.985	-18099.693				
	Observation number	18935	18935	18935	18935				
	Wald chi2	869,46 ***	2325,79 ***	2633,04 ***	2786,77 ***				

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4. Note: Values in parentheses are student's statistics *** (**) (*) represent the significance thresholds at 1%, 5% and 10%, respectively.

Table A4: Results of multinomial probit estimates of the immunization of children under the age of 2 (coefficients)

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Demo-biological characteristics									
Child's birth order	Order 3	0.055 (0.75)	-0.036 (-0.51)	-0.248 (-3.00)***	-0.199 (-2,53) **	-0.180 (-2,14) **	-0.184 (-2,31) **	-0.166 (-1,96) **	-0.188 (-2,36) **
	Order 4	-0.206 (-2,51) **	-0.118 (-1.52)	-0.613 (-6.28)***	-0.353 (-3.90)***	-0.496 (-4.97)***	-0.337 (-3.67)***	-0.463 (-4.61)***	-0.345 (-3.74)***
	Order 5	-0.394 (-4.27)***	-0.241 (-2.83)***	-0.913 (-8.08)***	-0.565 (-5.45)***	-0.743 (-6.40)***	-0.337 (-3.67)***	-0.691 (-5.90)***	-0.542 (-5.10)***
	Order 6	-0.420 (-4.01)***	-0.237 (-2,49) **	-1.016 (-7.90)***	-0.630 (-5.36)***	-0.810 (-6.12)***	-0.589 (-4.93)***	-0.760 (-5.70)***	-0.600 (-4.98)***
	Order 7	-0.598 (-7.08)***	-0.307 (-4.09)***	-1.198 (-9.32)***	-0.717 (-6.15)***	-0.892 (-6.70)***	-0.639 (-5.33)***	-0.831 (-6.19)***	-0.645 (-5.35)***
Gender of the child	Male	0.013 (0.25)	0.006 (0.12)	0.017 (0.32)	0.009 (0.19)	0.005 (0.10)	0.007 (0.15)	0.001 (0.02)	0.005 (0.10)
Health at birth	Poor health	0.347 (3.54)***	0.245 (2.57)***	0.293 (2.89)***	0.205 (2,12) **	0.208 (2,04) **	0.176 (1,82) *	0.186 (1,82) *	0.169 (1,74) *
Multiplicity of births	Twin	0.318 (2,37) **	0.324 (2.57)***	0.295 (2,12) **	0.294 (2,31) **	0.202 (1.44)	0.255 (2,00) **	0.223 (1.58)	0.268 (2,09) **
Socio-cultural characteristics									
Care of the child	Another person			-1.633 (-8.39)***	-0.726 (-5.75)***	-1.688 (-8.63)***	-0.745 (-5.88)***	-1.727 (-8.83)***	-0.770 (-6.05)***
Mother's age	20 -24			0.548 (5.60)***	0.143 (1,72) *	0.508 (5.12)***	0.142 (1,69) *	0.495 (4.98)***	0.143 (1,69) *
	25 -29			0.921 (8.48)***	0.360 (3.75)***	0.835 (7.54)***	0.361 (3.72)***	0.788 (7.06)***	0.362 (3.71)***
	30 -34			1.233 (9.83)***	0.565 (5.02)***	1.095 (8.51)***	0.554 (4.85)***	1.035 (7.98)***	0.555 (4.82)***
	35 -39			1.510 (10.20)***	0.691 (5.14)***	1.311 (8.63)***	0.671 (4.91)***	1.227 (8.01)***	0.665 (4.84)***
	40 -44			1.371 (7.26)***	0.820 (4.96)***	1.234 (6.40)***	0.827 (4.96)***	1.159 (5.98)***	0.817 (4.88)***
	45 -49			0.926 (2.75)***	-0.203 (-0.62)	0.789 (2,27) **	-0.156 (-0,47) *	0.701 (1,99) **	-0.113 (-0.34)
Religion	Reformist			-0.488 (-7.19)***	-0.413 (-6.90)***	-0.220 (-2.99)***	-0.274 (-4.24)***	-0.260 (-3.49)***	-0.277 (-4.25)***
	No religion			-0.216 (-1,90) *	-0.119 (-1.19)	-0.036 (-0.31)	-0.015 (-0.15)	-0.022 (-0.18)	-0.029 (-0.29)

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Table A4 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Socio-cultural characteristics									
Marital status	In a relationship			-0.069 (-0.89)	0.039 (0.54)	0.008 (0.11)	0.086 (1.17)	-0.005 (-0.06)	0.082 (1.11)
Media exposure	Limited exposure			0.465 (6.50)***	0.102 (1.64)	0.222 (2.94)***	0.005 (0.07)	0.184 (2,41) **	-0.018 (-0.27)
	High exposure			0.934 (13.99)***	0.297 (4.97)***	0.537 (7.10)***	0.160 (2,34) **	0.431 (5.58)***	0.113 (1.62)
Socio-economic characteristics									
Level of education	Primary					0.684 (7.87)***	0.379 (5.35)***	0.682 (7.80)***	0.376 (5.30)***
	Secondary					0.902 (9.07)***	0.450 (5.25)***	0.853 (8.52)***	0.436 (5.05)***
	Higher education					1.284 (6.21)***	0.353 (1.61)	1.215 (5.85)***	0.350 (1.59)
Electricity	Access (Cluster)					0.359 (3.30)***	0.025 (0.24)	0.096 (0.83)	-0.055 (-0.50)
Drinking water	Access (Cluster)					0.322 (2.77)***	-0.090 (-0.84)	0.176 (1.47)	-0.118 (-1.08)
Community characteristics									
Place of residence	Rural							-0.713 (-3.65)***	-0.708 (-5.19)***
Place of residence per period	Rural_1998							0.196 (0.79)	0.399 (2,08) **
	Rural_2004							0.191 (0.89)	0.630 (3.91)***
	Rural_2011							0.351 (1,69) *	0.719 (4.69)***
Household size	Household size							-0.117 (-0.82)	0.020 (0.15)

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Table A4 Continued

Variables	Categories	Model 1		Model 2		Model 3		Model 4	
		Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late	Timely full immunization	At least one vaccine taken late
Community characteristics									
Analysis period	1998	0.180 (1,65) *	-0.421 (-4.59)***	0.219 (1,89) *	-0.458 (-4.87)***	0.185 (1.58)	-0.492 (-5.20)***	0.147 (0.96)	-0.621 (-4.51)***
	2004	0.548 (5.83)***	-0.093 (-1.22)	0.445 (4.48)***	-0.164 (-2,08) **	0.488 (4.83)***	-0.181 (-2,28) **	0.453 (3.49)***	-0.442 (-3.92)***
	2011	0.882 (9.87)***	0.042 (0.57)	0.757 (7.97)***	-0.029 (-0.39)	0.774 (8.00)***	-0.058 (-0.76)	0.664 (5.38)***	-0.375 (-3.51)***
Constancy	Constant	-1.268 (-13.86)***	-0.459 (-6.18)***	-2.042 (-14.60)***	-0.591 (-5.16)***	-2.936 (-17.41)***	-0.856 (-6.24)***	-2.072 (-5.65)***	-0.497 (-1.51)
Characteristics of the estimate	Log likelihood	-6414.505	-6092.871	-6009.475	-5968.836				
	Observation number	6529	6529	6529	6529				
	Wald chi2	287,60 ***	832,83 ***	961,06 ***	1029,78 ***				

Source: Established by the author from Demographic and Health Surveys (DHS) 1, 2, 3 and 4. Note: Values in parentheses are student's statistics *** (**) (*) represent the significance thresholds at 1%, 5% and 10%, respectively.

Mission

To strengthen local capacity for conducting independent, rigorous inquiry into the problems facing the management of economies in sub-Saharan Africa.

The mission rests on two basic premises: that development is more likely to occur where there is sustained sound management of the economy, and that such management is more likely to happen where there is an active, well-informed group of locally based professional economists to conduct policy-relevant research.

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