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Identifying Determinants of Vaccination Status of Under Five Children in South Omo Zone, SNNPR, Ethiopia

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Abstract: Vaccination is the administration of antigenic material (a vaccine) to stimulate an individual's immune system to develop adaptive immunity to a pathogen. The aim of this study was to analyze the determinant factor of vaccination status of under five children in South Omo zone, SNNPR, Ethiopia using binary logistic regression model. Thus from 174 children under investigation 47(27%) of children are not fully vaccinated and 127(73%) are fully vaccinated. Woreda, household sex, religion, mother education level, child sex and child order are the most factors that affect the vaccination status of children. Full vaccination status of children is more likely for children from educated mothers as compared to those from illiterate mothers. The odd of female children to be full vaccinated was increased by 51%. First (OR: 0.401, 95% CI: 0.091, 1.763) and third order (OR: 0.219, 95% CI: 0.051, 0.931) children are associated with full vaccination status of children negatively. Second (OR: 1.128, 95% CI: 0.281, 4.526) and fourth birth order (OR: 1.034, 95% CI: 0.233, 4.58) children are more likely to be vaccinated than first and third order children. Children from female household are highly related to be fully vaccinated than children from male household. Children from orthodox (OR: 1.88, 95% CI: 1.177, 3.002) family are more vaccinated than the Muslim, catholic and Protestant.

Keywords: Vaccination Status, Under-Five, Children, Determinants

1. Introduction

Vaccination is the administration of antigenic material (a vaccine) to stimulate an individual's immune system to develop adaptive immunity to a pathogen. Vaccines can prevent or ameliorate infectious disease. When a sufficiently large percentage of a population has been vaccinated, herd immunity results. Vaccination is the most effective method of preventing infectious diseases; widespread immunity due to vaccination is largely responsible for the worldwide eradication of smallpox and the elimination of diseases such as polio, measles, and tetanus from much of the world [1].

According to the guidelines developed by the World Health Organization, children are considered to have received all basic vaccinations when they have received a vaccination against tuberculosis (also known as BCG), three doses each of the DPT-HepB-Hib (also called pentavalent), polio vaccines, and a vaccination against measles. The BCG vaccine is usually given at birth or at first clinical contact, while the DPT-HepB-Hib and polio vaccines are given at approximately age 6, 10, and 14 weeks. Measles vaccinations should be given at or soon after age 9 months.

Immunization prevents illness, disability and death from vaccine-preventable diseases including cervical cancer, diphtheria, hepatitis B, measles, mumps, pertussis (whooping cough), pneumonia, polio, rotavirus diarrhoea, rubella and tetanus. Global vaccination coverage remains at 85%, with no significant changes during the past few years. Uptake of new and underused vaccines is increasing. An additional 1.5 million deaths could be avoided, however if global immunization coverage improves. An estimated 19.9 million children under the age of one did not receive DTP3 vaccine [2].

During 2017, about 85% of infants worldwide (116.2 million infants) received 3 doses of diphtheria-tetanus-pertussis (DTP3) vaccine, protecting them against infectious diseases that can cause serious illness and disability or be fatal. By 2017, 123 countries had reached at least 90% coverage of DTP3 vaccine [2].

Neonatal tetanus is a major cause of early infant mortality in many developing countries, often due to failure to observe hygienic procedures during delivery. In Ethiopia, only 48% of births are protected against neonatal tetanus [3].

Children ages 12-23 months are the youngest cohort to have reached the age by which a child should be fully immunized [4]. Data show that 39 percent of children ages 12-23 months have received all basic vaccinations. Sixteen percent of children in this age group have not received any vaccinations. Sixty-nine percent of children have received the BCG, 73 percent the first dose of pentavalent, 81 percent the first dose of polio, 67 percent the first dose of the pneumococcal vaccine, and 64 percent the first dose of rotavirus vaccine. Fifty-four percent of children have received a measles vaccination. Coverage rates decline for subsequent doses, with 53 percent of children receiving the recommended three doses of the pentavalent, 56 percent the three doses of polio, 49 percent the three doses of the pneumococcal vaccine, and 56 percent the two doses of the rotavirus vaccine [4].

There is little difference in the vaccination coverage rates between male and female children. However, full vaccination coverage is much higher in urban than rural areas (65 percent versus 35 percent). Full vaccination coverage is highest in Addis Ababa (89 percent) and lowest in Afar (15 percent). Vaccination coverage increases with mother's education. About 3 in 10 (31 percent) of children whose mothers have no education are fully vaccinated compared with more than 7 in 10 (72 percent) of children whose mothers have more than a secondary education. Similar patterns are observed by household wealth [4].

Routine immunization coverage remains particularly low in Africa; indeed, it has stagnated over the last three years, against a backdrop of weak and under-resourced health systems. As a result, one in five African children still do not receive lifesaving vaccination. In 2014, an estimated 42% of all global deaths from measles were in Africa [5].

Vaccination has been shown to be one of the most effective public health interventions in the world, through which a number of serious childhood diseases have been successfully eradicated. Vaccination of children in Ethiopia prevents different kind of child illness and deaths but the coverage is still low and many children do not receive even one dose of BCG.

This study was tried to address the following research questions.

How was the vaccination status of under five children in South Omo zone, SNNPR, Ethiopia?

What are demographic and socio economic factors affecting immunization status among children aged 0-59 months.

2. Method

The study will be conducted in South Omo Zone, SNNPR, Ethiopia. Using simple random sampling Debub Ari, Bena Tsemay and Jinka woredas are selected in the study area. To see the vaccination status of under five children, 174 children were selected from three places using survey method.

2.1. Variables of the Study

Dependent variable is a variable whose values are influenced by the value of other variables [6]. Dependent value as a variable that is potentially influenced by the independent variable, because it is influenced by, and thus to some extent depends on the independent variables [7].

Table 1. *Distribution of Categorical Variables.*

Variable Type	Variables	Category
Dependent Variable	Vaccination Status	0 = the child has no/incomplete Vaccination 1= the child had full vaccination
Explanatory Variables	Woreda	1 = Debub Ari 2= Bena tsemay 3 = Jinka
	Residence	1 = Rural 2 = Urban
	Household Sex	1 = Female 2 = Male
	Religion	1 = Orthodox 2 = Muslim 3 = Catholic 4 = Protestant 5 = Other
	Mother Education Level	1 = Illiterate 2 = Read and Write 3 = Primary 4 = secondary and Above
	Child Sex	1= Female 2 =Male
	Child Order	1 =First 2 =Second 3 =Third 4 =Fourth 5 = Fifth and Above
	Mother Marital Status	1= Single 2= Married 3= Divorced 4 =Widowed

Since we have binary responses, binary Logistic Regression was used for data analysis.

2.2. Logistic Regression

Let Y denote a dichotomous outcome variable, which may assume values "1" if full vaccination and stunted and "0" No/incomplete vaccination. Let the vector $X' = (x_1, x_2,..., x_k)$ denote a set of k predictor variables. The general data layout can be represented as follows:

$$X = \begin{pmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1k} \\ 1 & x_{21} & x_{22} & \cdots & x_{2k} \\ . & . & . & \cdots & . \\ . & . & . & \cdots & . \\ . & . & . & \cdots & . \\ 1 & x_{n1} & x_{n2} & \cdots & x_{nk} \end{pmatrix}_{nx(k+1)} \quad \text{and} \quad Y = \begin{pmatrix} y_1 \\ y_2 \\ . \\ . \\ . \\ y_n \end{pmatrix}_{nx1}$$

Where, X is called the design or regression matrix. And without the loading column of 1's, this design matrix is said to be predictor data matrix. Then the logistic model which relates the probability of the event occurring to the predictor variables x is given by:

$\pi(xi)$ is the probability that i[th] children is health status used given that k predictor variables. β is a vector of unknown coefficients

(i.e $\boldsymbol{\beta} = (\beta_0, \beta_1, \beta_2, \ldots, \beta_k)'$

$$P(Y=1/X=xi) = \frac{\exp(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik})}{1+\exp(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik})} = \frac{e^{\mathbf{X}'\boldsymbol{\beta}}}{1+e^{\mathbf{X}'\boldsymbol{\beta}}} = \pi(xi)$$

and thus

$$P(Y=0/X=xi) = 1-\pi(xi)$$

After performing the logit transformation on $\pi(x_i)$ in equation [1] we obtain the following logistic model:

$$\log it(\pi(xi)) = \log\left[\frac{\pi(xi)}{1-\pi(xi)}\right] = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip} \text{ ,i=1,2 ? , n}$$

where log denotes the natural logarithm. This class of generalized linear models allows $\pi(x_i)$ to be related to the linear component $\beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip}$ by the use of a logistic link function.

Where: β_0 is the constant of the equation and, $\beta_1, \beta_2, \ldots, \beta_p$ are the coefficients of the predictor variables. The above equation is known as the logistic function.

2.2.1. Assumptions of Logistic Regression

There are different assumptions of logistic regression. The following assumptions of logistic regression are considered [8].

Linearity in the logit.

Normally distributed error terms are not assumed.

Meaningful coding. Logistic coefficients will be difficult to interpret if not coded meaningfully. The convention for binomial logistic regression is to code the dependent class of greatest interest as 1 and the other class as 0.

Logistic regression requires the dependent variable to be binary or dichotomous.

The categories (groups) must be mutually exclusive and exhaustive; a case can only be in one group and every case must be a member of one of the groups.

Logistic regression uses Maximum Likelihood Estimation (MLE) and requires a larger sample size than would be required for OLS regression.

2.2.2. Odds Ratio

The odds ratio is the ratio between two odds. The odds of some event happening is defined as the ratio of the probability of occurrence to the probability of nonoccurrence.

The odds ratio is a value which shows the strength of association between a predictor and the response of interest (log odds of the dependent variable) in the model. It can vary from 0 to infinity. If the odds ratio is one, there is no association. So, the parameter estimates of a logistic regression can be interpreted easily in terms of odds ratios

Akaike Information Criterion (AIC) and Baye's Information Criterion (BIC) are used for model selection and maximum likelihood method was used for parameter estimation [9]. CoxandSnell and Nagelkerke methods are used to estimate the coefficient of determination. And to test the goodness of fit for logistic regression models Hosmer Lemeshow test are used. The Wald test is one of a number of ways of testing whether the parameters associated with a group of explanatory variables are zero. If $\widehat{\beta\imath}$ for a particular explanatory variable or group of explanatory variables different from zero, the Wald test is significant [10 and 11].

3. Statistical Data Analysis and Result

The aim of this study was to study the determinants of vaccination status of Under Five Children in South Omo Zone. Debub Ari, Bena Tsemay and Jinka woredas are selected and 174 children vaccination status and its determinants were analyzed using SPSS 20 software.

Table 2. *Frequency Distribution of Vaccination Status.*

Variable	Category	Frequency	Percentage
Vaccination	Incomplete Vaccination	47	27%
Status	Complete Vaccinated	127	73%

Table 2 shows that from 174 children 47(27%) of children are not fully vaccinated and 127(73%) are fully vaccinated.

In our study child woreda, child residence, household sex, family religion, mother education level, mother marital status, child sex and child order are used as an explanatory variable for the determinants of vaccination status of children in South Omo zone.

Table 3. *Cross Tabulation of Frequency Distribution for Explanatory Variables.*

Variables	Category	Frequency	Vaccination Status	
			Incomplete Vaccination	Complete Vaccinated
Woreda	1 = Debub Ari	50	2(1.15%)	48(27.59%)
	2= Bena tsemay	99	41(23.56%)	58(33.33%)
	3 = Jinka	25	4(2.3%)	21(12.07%)
Residence	1 = Rural	149	43(24.71%)	106(60.92%)
	2 = Urban	25	4(2.3%)	21(12.07%)
Household Sex	1 = Female	32	4(2.3%)	28(16.09%)
	2 = Male	142	43(24.71%)	99(56.9%)
Religion	1 = Orthodox	24	1(0.57%)	23(13.22%)
	2 = Muslim	8	0	8(4.6%)
	3 = Catholic	29	3(1.72%)	26(14.94%)
	4 = Protestant	52	6(3.45%)	46(26.44%)
	5 = Other	61	37(21.46%)	24(13.79%)
Mother Education Level	1 = Illiterate	121	40(22.99%)	81(46.55%)
	2 = Read and Write	45	7(4.02%)	38(21.84%)
	3 = Primary	6	0	6(3.45%)
	4 = secondary and Above	2	0	2(1.15%)
Child Sex	1= Female	74	14(8.05%)	60(34.48%)
	2 =Male	100	33(18.97%)	67(38.51%)
Child Order	1 =First	39	10(5.75%)	29(16.67%)
	2 =Second	34	8(4.60%)	26(14.94%)
	3 =Third	31	16(9.2%)	15(8.62%)
	4 =Fourth	30	6(3.45%)	24(13.79%)
	5 = Fifth and Above	40	7(4.02%)	33(18.97%)
Mother Marital Status	1= Single	11	4(2.3%)	7(4.02%)
	2= Married	154	41(23.56%)	113(64.94%)
	3= Divorced	2	0	2(1.15%)
	4 =Widowed	7	2(1.15%)	5(2.87%)

Table 3 shows that the cross tabulation of vaccination status and explanatory variables. From 174 children under study; 2(1.15%), 41(23.56%) and 4(2.3%) of children are incomplete vaccination in Debub Ari, Bena Tsemay and Jinka, respectively. As compared to the other places children who lives in Bena Tsemay are more likely to be not/incomplete vaccination.

Incomplete vaccination for rural and urban area are 43(24.71%) and 4(2.3%), respectively. This shows that incomplete vaccination was high in rural and complete vaccination was high in urban area children. Incomplete vaccination was high in male household than female. The above descriptive table shows that 24.71% of incomplete vaccination was from families with male household and 2.3% are from female household.

From table 3 from 121 illiterate mothers, 40(22.99%) of children are incomplete vaccination and 81(46.55%) of children are complete vaccination. From 74 female children under study, 14(8.05%) and 60(34.48%) are incomplete and complete vaccination, respectively. Likewise, from 100 male children 33(18.98%) and 67(38.51%) are incomplete and complete vaccination, respectively. From 154 married women under study 41(23.56%) and 113(64.94%) of children are incomplete and complete vaccination, respectively.

To study the determinants of vaccination status of under five children in South Omo zone eight explanatory variable are used in this study. To examine the association between response and explanatory variables chi-square statistics are used.

Table 4. *The chi-square statistic and p- value for each explanatory variable.*

Variables	Chi-square	P - values
Woreda	25.383	0.000*
Residence	1.796	0.180
Household Sex	4.188	0.041*
Religion	54.737	0.000*
Mother Education Level	3.924	0.000*
Child Sex	4.277	0.039*
Child Order	12.346	0.015*
Mother Marital Status	1.249	0.741

Table 4 shows that woreda, household sex, religion, mother education level, child sex and child order are statistically significant at 5% level of significant. But residence and mother marital status was not significant since their P- value are greater than 5% level of significant. Here we considered two models: Model I contain all the eight explanatory variables while Model II excludes residence and mother marital status from the analysis. The results of goodness of fit tests for each model are shown in Table 5.

Table 5. *Hosmere and Lemeshow Test.*

Model	Test	Chi-square	df	Sig
Model I	Hosmerand lemeshow	9.114	8	0.333
Model II	Hosmer and lemeshow	4.194	8	0.839

An insignificant chi-square indicates a good fit to the data and, therefore, the overall model good fit. The p-value is 0.333 (>0.05) for model I and 0.839 (>0.05) for model II which indicates that both models are insignificant. Therefore, both of our logistic regression models are good fit. But to choose the best fit model among these two, we can use the Akaike information criterion (AIC) and Bayesian information criterion (BIC).

Table 6. *Model Selection Criterion.*

Model	-2Loglikelihood	Selection Criterion	
		AIC	BIC
Model I	120.195	176.195	182.930
Model II	129.632	165.632	169.962

From Table 6 we observe that the AIC values for Model I and II are 176.195 and 182.93, respectively. While the BIC values are 165.632 and 169.962, respectively. Since Model II has smaller values of both AIC and BIC, we conclude that Model II was a better fit to the data. The result of binary logistic regression model for Model II is shown in Table 7 below.

Table 7. *Binary logistic regression model for determinants of vaccination status of children.*

Variables	B	S.E	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Woreda			2.989	2	.030			
Debub Ari(1)	.254	1.267	3.981	1	.008	1.289	0.374	4.442
Bena Tsemay(2)	.570	1.125	2.215	1	.001	1.768	.588	8.364
Female(1)	.864	.764	1.278	1	.000	2.372	.531	10.601
Religion			1.832	4	.019			
Orthodox(1)	.631	.239	6.979	1	.008	1.880	1.177	3.002
Muslim(2)	-2.181	.175	154.818	1	.000	.113	.080	.159
Catholic(3)	-.079	.202	.151	1	.697	.924	.622	1.373
Protestant(4)	-.981	.176	30.960	1	.000	.375	.265	.530
Mother Education Level			.315	3	.000			
Illeterate(1)	-.344	.695	.011	1	.005	.708	.276	4.208
Read and Write(2)	-.066	.691	.009	1	.000	.937	.241	3.632
Primary(3)	.381	.746	.059	1	.001	1.463	.278	5.168
Female(1)	.412	.491	.703	1	.002	1.510	.576	3.956
Child order			7.902	4	.005			
First(1)	-.913	.755	1.462	1	.000	.401	.091	1.763
Second(2)	.120	.709	.029	1	.001	1.128	.281	4.526
Third(3)	-1.519	.739	4.230	1	.040	.219	.051	.931
Fourth(4)	.033	.759	.002	1	.000	1.034	.233	4.580
Constant	1.488	2.642	.317	1	.001	4.429		

4. Discussion

From binary logistic regression model of table 7, taking Jinka as a reference categoty, we observe that the odds of being fully vaccinated was increased by 1.289 and 1.768 for Debub Ari and Bena Tsemay, respectively controlling other variable in the model. As compared to male household the odds of female household being fully vaccinated are increased by a factor of 2.372.

In this study religion was one explanatory variable. The odds of Orthodox family children to be fully vaccinated were increased by 88%. The highest proportion of vaccination is performed among orthodox religion. It could be that religion has an immense social, economic and political significance in most societies, and thus plays an important role in sanctioning or promoting acceptance of or creating resistance to vaccination [9]. But the odds of children for Muslim, Catholic and Protestant are decreased by a factor of 0.113, 0.924 and 0.375, respectively controlling the other variable. Muslim religion (OR=4.3), increased the risk of non-immunization significantly [12].

When we saw mother education level, taking secondary and above as a reference category, the odds of children from illiterate mother and mother can read and write to be fully vaccinated are decreased by a factor of 0.708 and 0.937. But the odds of children being fully vaccinated from primary educated mother are increased by 46.3% controlling the other variable in the model. Mothers with secondary and higher level of education are 63.6% more likely to vaccinate their child as compared to those with no education [15]. The odds of complete immunization status among children from parents with secondary education were slightly higher than those with no education [13]. Educated mothers were more likely to have their children immunized than mothers who had no education. Mothers with secondary and higher education had a 2.4 times higher chance for full immunization [14].

Taking male household children the odds of female household children being fully vaccinated was increased by 51%. When we see child order, taking fifth and above order as a reference category, the odds of first and third child children to be fully vaccinated are decreased by a factor of 0.401 and 0.219, respectively. First order children are 53.9% more likely to be vaccinated and the odds of children being vaccinated have increased by a factor of 1.304 for third order children [9]. But the odds of second and fourth children being fully vaccinated are increased by 12.8% and 3.4%&, respectively controlling the other variable in the model was in line with [15].

5. Conclusion

The Ethiopian immunization policy for children of under-one year of age was the targets for the EPI vaccines (e.g. BCG, Measles, DPT-HepB-Hib or penta-valent vaccine). This study was studied to analyze the determinant factors that affect vaccination status of under-five year age children in South Omo zone, SNNPR, Ethiopia.

The study revealed that woreda, household sex, religion, mother education level, child sex and child order have significant effect on the vaccination status of children. In particular the study revealed that full vaccination status of children was more likely for children from educated mothers as compared to those from illiterate mothers. Considering birth order, high birth order was negatively associated with vaccination status of children. Children from female household are highly related to be fully vaccinated than children from male household. Children from orthodox family are more vaccinated than the Muslim, catholic and Protestant. Second and fourth birth order children are more likely to be vaccinated than first and third order children.

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