

# Determining Factors of Full Immunization of Children among 12-23 Months Old in Rural Ethiopia

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**Abstract** Immunization is a confirmed instrument for controlling and eliminating life-threatening infectious diseases. It is one of the most cost-effective health investments, with recognized strategies that make it accessible to even the most hard-to-reach and exposed populations. Globally, immunization coverage has increased during the past decade, but in developing countries including Ethiopia, the coverage is still very low. The general objective of this study was to assess and identify factors associated with full immunization among children aged 12-23 months in rural Ethiopia. The study used the 2016 Ethiopian Demographic and Health Survey children's data. A study was conducted on total of 5,063 children aged between 12- 23 months born to 5,063 women aged 15-49 years. The result revealed that only about 34.9% of the children in rural Ethiopia received full immunization. Binary logistic regression model was used to identify the critical determinants of full child immunization status and the result confirmed that region, mother's education, antenatal care, religion, household wealth, delivery place as well as mother's age significantly influenced full immunization of children. In conclusion, Full child immunization coverage is low but it is increasing in rural Ethiopia. The children in households with low income, and those born to mothers without formal education were less likely to be fully immunized. These groups need to be further targeted for a more comprehensive immunization for children.

**Keywords:** binary logistic model, children, determinants, full immunization, rural Ethiopia

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## 1. Introduction

Immunization is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine. Vaccines stimulate the body's own immune system to protect the person against subsequent infection or disease. Immunization is a confirmed instrument for controlling and eliminating life-threatening infectious diseases and is estimated to avert between 2 and 3 million deaths each year globally. It is one of the most cost-effective health investments, with proven strategies that make it accessible to even the most hard-to-reach and vulnerable populations. It has clearly defined target groups; it can be delivered effectively through outreach activities; since it does not require any major lifestyle change [1].

Universal immunization of children is crucial to reducing infant and child mortality. These diseases immunization are against six common vaccine-preventable diseases include tuberculosis, diphtheria, whooping cough (pertussis), tetanus, polio, and measles. Other childhood vaccines are also given in Ethiopia. The government of Ethiopia introduced the pneumococcal conjugate vaccine (PCV 13) and monovalent human rotavirus vaccine (RV1) into the national's infant immunization program in November 2011 and October 2012, respectively. The

pneumococcal vaccine protects against *Streptococcus pneumoniae* bacteria, which cause severe pneumonia, meningitis and other illnesses. Rotavirus is a virus that causes gastroenteritis; an inflammation of the stomach and intestines [2].

There exists slight difference in the vaccination coverage rates between male and female children. The coverage of vaccination is highly influenced by geographical location. Empirical studies revealed that full vaccination coverage is much higher in urban than rural areas which accounts for 65 percent in urban and 35 percent in rural, respectively in Ethiopia. Full vaccination coverage is highest in Addis Ababa (89 percent) and lowest in Afar region (15 percent). Vaccination coverage increases as mother's education increases. In Ethiopia, about 3 in 10 of children whose mothers have no education are fully vaccinated compared with more than 7 in 10 of children whose mothers have more than a secondary education [2].

The Ethiopian immunization implementation guideline has been revised in 2015. Children of less than one year of age and women of reproductive age group (15-49 years) are the targets for the currently available Extended Program on Immunization in Ethiopia (BCG, Measles, DPT-HepB-Hib or penta-valent, Rotavirus, Pneumococcus vaccine (PCV), OPV and TT). Moreover, it is directed in the implementation guideline to introduce Inactivated Polio Virus (IPV), measles-rubella, meningitis and yellow fever vaccines for less than one year children and Human

Papilloma Virus (HPV) and Td vaccines between 2015 and 2019. The country's immunization schedule for the above listed vaccines strictly follows the World Health Organization recommendations for developing countries [3].

The Ethiopian Health Policy stresses prevention and control of major communicable diseases (TGE, 1993). Reinforcement of the Extended Program on Immunization is, therefore, one of the essential activities in the current Health Sector Development Program (HSDP) to reduce child mortality. The EPI policy calls for BCG vaccine at birth, three doses of DPT-HepBHib vaccine at approximately 4, 8, and 12 weeks of age, four doses of oral Polio vaccine at 0-2, 4, 8, and 12 weeks of age, and measles vaccine at or soon after reaching 9 months of age. A child is said to be fully vaccinated if all eight vaccinations mentioned above have been received. Although the EPI was initiated in 1980 with the goal of universal coverage by 1990 achievements are still far below the international standard [4]. According to Ethiopian Demographic and Health Survey (2011), only 24 percent of children ages 12-23 months were fully vaccinated whereas as the coverage of measles vaccination was 56 percent. In Ethiopia, living in rural area and distance to health clinic, mothers with limited education, and socioeconomic capital are linked to low vaccine uptake and placing children at risk for vaccine preventable diseases [5].

Still related system-wide barriers are linked to incomplete vaccination or no vaccination of children. As a result, childhood immunization and associated factors should be targeted through relevant research which is a high motive of this current investigation. Some reports and publications have identified determinants of child full immunization, but most of them did not consider factors associated with it in the rural areas at the household level analysis. Hence, this study is carried out to assess and analyze determinants of child full immunization in rural Ethiopia using EDHS 2016 data. Since EDHS 2016 data is the most recently released data and no study was conducted using it, in the specified area, this study was conducted to identify the current gaps and supplement the past studies. Thus, it can be used as a reference for health care providers, health care educators, policy makers, and future researchers in this and/or related fields.

## 2. Methods and Materials

### 2.1. The Study Area

Ethiopia is officially known as the Federal Democratic Republic of Ethiopia (FDRE) and the second most populous country in sub-Saharan Africa with over 90 million population. Administratively, Ethiopia is divided into nine geographical regions (Tigray, Afar, Amhara, Oromiya, Somali, Benshangul-Gumuz, SNNPR, Gambela and Harar) and two administrative cities (Addis Ababa and Dire-Dawa). The sample for the EDHS 2016 was designed to provide estimates of key indicators for the country as a whole, for urban and rural areas separately. Ethiopia is a land-locked country located in East Africa, and is bordered by Eritrea, Djibouti, Somalia, Kenya and

Sudan with area covers approximately 1,221,900 square kilometers. About 84 percent of the total population in the country was found in rural areas, while the remaining 16 percent live in urban areas [6].

### 2.2. Data Description

The sampling frame used for this current study was Ethiopian Demographic and Health Survey (2016) which is the fourth survey in the country. This survey was implemented by the Central Statistical Agency (CSA) on the request of the Ministry of Health. Data collection took place from January 18, 2016, to June 27, 2016. Additionally, the EDHS (2016) included a health facility component that recorded data on children's vaccinations, which were then combined with the household data on children's vaccinations. Information on vaccination coverage was obtained in three ways in the EDHS (2016). These are from written vaccination records, including the Infant Immunization Card and other health cards, from mothers' verbal reports, and from health facility records. In the EDHS (2016), for each child born in the 3 years before the survey, mothers were asked to show the Infant Immunization Card or health card used to record the child's immunizations.

If the Infant Immunization Card or other health card was available, the interviewer copied the dates of each vaccination received in the respective section of the Woman's questionnaire. In case a vaccination was not recorded in the Infant Immunization Card or on the health card, the mother was asked to recall whether that particular vaccination had been given. If the mother was not able to present the Infant Immunization Card or card for a child, she was asked to recall whether the child had received BCG, polio, DPT-HepB-Hib, measles, pneumococcal, and rotavirus vaccine. If she indicated that the child had received the polio, DPT-HepB-Hib, pneumococcal, or rotavirus vaccine, she was asked the number of doses that the child received. In addition, if the mother was not able to present the Infant Immunization Card, and the child had visited a health facility, a separate team visited the health facility to collect complementary vaccination records. The purpose of obtaining information at the health facility was to complement the information collected on vaccination based on mother's recall.

### 2.3. Variables of the Study

**Dependent variable:** The dependent variable for this study is child full immunization and coded as **1** if a child was fully vaccinated and **0** otherwise. A child is said to be fully vaccinated if received all the basic vaccines before the age of two (a dose of Bacille Calmette-Guerin (BCG) vaccine four doses of oral polio, three doses of DPT, and one dose of measles vaccine).

**Independent variables:** Based on the reviewed literatures and prevailing situation, the explanatory variables selected for this study were:  $X_1$  = Sex of child (0 = female, 1 = male),  $X_2$  = Education of mother (0 = no education, 1 = primary, 2 = secondary, 3 = higher),  $X_3$  = Wealth Index (1 = poor, 2 = middle, 3 = rich),  $X_4$  = Region (1 = Tigray, 2 = Afar, 3 = Amhara, 4 = Oromiya,

5 = Somali, 6 = Benishangul, 7 = SNNPR, 8 = Gambela, 9 = Harari, 10 = Dire-Dawa),  $X_5$  =Religion (1 = Orthodox, 2 = Catholic, 3 = Protestant, 4 = Muslim, 5 = Traditional, 6 = Other),  $X_6$  =Marital status (0 = never in union, 1 = married, 2 = living with partner, 3 = widowed, 4 = divorced, 5 = no longer living together/separated),  $X_7$  =Age of mother (year),  $X_8$  =Occupation (0 = armed force occupation, 1 = managers and legislators, 2 = professionals, 3 = associate professionals, 4=clerks and support workers, 5 = personal care and service workers, 6 = market oriented workers, 7 = technical and vocational workers, 8 = drivers, assemblers and operators, 9 = cleaners, helpers and laborers),  $X_9$  =Place of delivery (1 = home, 2 = government health worker, 3 = private health center, 4 = other),  $X_{10}$  =Antenatal care (0 = no, 1 = yes).

## 2.4. Method of Data Analysis

### 2.4.1. Logistic Regression Analysis

The binary logistic regression procedure empowers one to select the predictive model for dichotomous dependent variables. It describes the relationship between a dichotomous response variable and a set of explanatory variables. The explanatory variables may be continuous or discrete [7]. Binary response models are of major importance in the social sciences as well as in demography since many social phenomena are discrete or qualitative rather than continuous or quantitative in nature. In such studies, the logistic regression model has become the statistical model of choice [8].

For this study, the binary logistic regression model was used to investigate effect of predictors on the probability of the response variable, child full Immunization, ( $Y_i$ ) in Ethiopia which is coded as 1 if a child experienced full vaccination and 0 other wise. Where: -  $i = 1,2,...,n$ , and  $n$  is the number of sampled child. Let us denote the proportion of success (experience full vaccination).

$$p(Y_i = 1) = \pi_i, p(Y_i = 0) = 1 - \pi_i \tag{1}$$

and  $Y_i \sim$  Bernoulli ( $\pi_i$ ).

The logistic regression model is defined as follows. Let  $X_{n \times (k+1)}$  denote the single level binary logistic regression data matrix of  $k$  predictor variables of the child vaccination and  $\beta_{(k+1) \times 1}$  be a vector of coefficients and given as:

$$X = \begin{bmatrix} 1 & x_{11} & x_{12} & \dots & x_{1k} \\ 1 & x_{21} & x_{22} & \dots & x_{2k} \\ \vdots & \dots & \dots & \dots & \vdots \\ 1 & x_{n1} & x_{n2} & \dots & x_{nk} \end{bmatrix}, \beta = \begin{bmatrix} \beta_o \\ \beta_1 \\ \vdots \\ \beta_k \end{bmatrix}$$

$X$  -is the design matrix.

$\beta$  - is the vector of unknown coefficients of the covariates and intercept. Then, the logistic regression function is given as:

$$\pi_i = \frac{\exp(\beta_o + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ik})}{1 + \exp(\beta_o + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ik})} = \frac{\exp(X_i' \beta)}{1 + \exp(X_i' \beta)} \tag{2}$$

Where: -  $\pi_i$  ( $i = 1,2, \dots, n$ ) is the  $i^{\text{th}}$  probability of experiencing child vaccination given the vector of predictors ( $X$ ). By algebraic manipulation, the logistic regression equation can be written in terms of an odds ratio:

$$\pi = \frac{P(y = 1 / X_i)}{1 - p(y = 1 / X_i)} = \exp(\beta_o + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k) = \exp(X_i' \beta) \tag{3}$$

$$\log\left(\frac{P(y = 1 / X_i)}{1 - p(y = 1 / X_i)}\right) = \log\left(\frac{\pi_i}{1 - \pi_i}\right) = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k = X_i' \beta \tag{4}$$

Where: -  $i = 1, 2, \dots, k$ .

The coefficient is interpreted as the change in the log-odds of experiencing vaccination per unit change of the corresponding continuous covariate. In case of categorical predictor variable, it is interpreted as the log-odds of experiencing vaccination given a category compared to the reference category [9].

## 3. Results and Discussion

### 3.1. Results

#### 3.1.1. Descriptive Results

The study was conducted on 5,063 mothers of children aged between 12-23 months old of which 50.9 % were male children and the rest 49.1% were female children. The education status of the mothers was considered as an important factor for the investigation of child full immunization. Accordingly, the result shows that of the total surveyed mothers, 26.5% were without education, 40.4% had primary education while the remaining 33.1% had secondary and higher education. Most of the mothers were currently married (94.6%), while the remaining 5.4% were either never married or formerly married. The analysis of the wealth category of those mothers indicates that 71.1%, 14.6% and 14.3% of them were poor, at the middle class and rich, respectively. Out of the total surveyed children, 42.8% of them were belong to mothers those attended antenatal care and the rest 57% belong to mothers who did not get antenatal visit. Religion is another important characteristic of the population under study and the descriptive result depicts that about 39.5% of the mothers were Christians, 59.3% were Muslim and the remaining 1.2 % were accounted into other religion category (Table 1).

Place of birth is another important variable used to characterize the surveyed population of the study. Accordingly, the result showed that 26.3% of the children those received full immunization were born by getting health facilities either in government hospital or private hospitals or clinics while the rest 73.6% were born without getting health facility such as at mother's home. Occupation of mother is regarded as an important factor to assess child full vaccination and the surveyed mothers were categorized in to different occupation categories. The result confirmed that 60.4% of the children who received

full immunization were belong to market oriented mothers, and the rest about 39.6% were belong to mothers with occupation categories such as, armed forces, managers and legislators, professionals, associate professionals, clerks and support worker, personal care and service workers, technical and vocational workers; drivers, assemblers and operators; and cleaners, helpers and laborers (Table 2).

The status of the child full immunization is different from region to region due to the accessibility of health facilities. The study explored percentages of children who received full immunization across rural regions of Ethiopia and accordingly those children from Amhara region takes the highest proportion, 46.3%, whereas those from Afar region shares smallest proportion, 21.2%. The result of the study further generalized that 34.9% of children born from rural Ethiopia had received full immunization prior to the survey year (Table 3).

**Table 1. Proportions of mothers and children by general characteristics**

Variables	Item	Frequency	Percent
Sex of child	Male	2579	50.9
	Female	2484	49.1
Level of Educational	No education	1342	26.5
	Primary	2047	40.4
	Secondary	939	18.5
	Higher	735	14.6
aggregate of antenatal	No	2887	57.0
	Yes	2167	42.8
Religion	Orthodox	803	15.9
	Catholic	115	2.3
	Protestant	1084	21.4
	Muslim	3001	59.3
	Traditional	21	0.4
	Other	39	0.8
wealth index	Poor	3601	71.1
	Middle	738	14.6
	Rich	724	14.3

Source: Source: Computed from EDHS, 2016.

**Table 2. Proportion of mothers by place of delivery and occupation**

Variable	Item	Frequency	Percent
place of delivery	Home	3725	73.6
	Health center	1338	26.4
Occupation of mother	Other occupations	160	3.2
	Managers and legislators	41	.8
	Professionals'	209	4.1
	Associate professionals	121	2.4
	Clerks and support workers	52	1.0
	Personal care and service workers	465	9.2
	Market oriented workers	3056	60.4
	Technical and vocational workers	377	7.4
	Drivers, assemblers and operators	141	2.8
Cleaners, helpers and laborers	441	8.7	

Source: Computed from EDHS, 2016.

**Table 3. Cross tabulation of Region versus child full immunization**

Regions	Child full immunization			
	Yes		No	
	Frequency	Percent	Frequency	Percent
Tigray	127	33.2	255	66.8
Afar	151	21.2	561	78.8
Amhara	222	46.3	257	53.7
Oromiya	300	30.3	690	69.7
Somali	290	35.8	520	64.2
Benishangul	173	42.6	233	57.4
SNNPR	294	45.1	358	54.9
Gambela	80	25.3	236	74.7
Harari	89	45.2	108	54.8
Dire-Dawa	40	33.6	79	66.4
Overall status	1766	34.9	3297	65.1

Source: Computed from EDHS, 2016.

### 3.1.2. Determinants of Child Full Immunization

As outlined in the methodology part, binary logistic model was used to explore determinants of child full immunization in rural Ethiopia. This model uses maximum likelihood technique which is an iterative procedure for estimation of parameters. The Wald  $\chi^2$  statistic as indicated by statistically significant P- value ( $P < 0.000$ ) indicates that the model has strong explanatory power to predict the probability of child full immunization. The coefficients and odds ratio of the logistic model are given in Table 4 and possible discussion and interpretations of these variables are as follows.

Region is one of the significant variables influenced child full vaccination in rural Ethiopia. The result of odd ratio confirmed that the children living in Afar region are 0.5 times less likely to receive full vaccination compared to the children living in Dire-Dawa region whereas the children living in Amhara region were 1.6 times more likely to receive full vaccination compared to the children living in Dire-Dawa region. The study result further depicted that the children living in Harari region were 1.5 times more likely to receive full vaccination than the children living in Dire-Dawa region. Education status of mother is another significant determinant of child full immunization. Children born to mother with primary education were 0.8 times less likely to receive full immunization compared to those born to mothers without formal education. Mother's antenatal care significantly affected child full immunization. Children who born to mothers who have attended antenatal care were 0.7 times more likely to receive full immunization than children born to mothers who have not attended antenatal care in rural Ethiopia. Similarly, the result of this study explored that children whose mothers follow Orthodox, Catholic, Protestant, Islamic, Traditional religion were 11, 6, 3 and 6 times more likely to receive full immunization than that of those following other religion, respectively. Wealth index is among the important variables significantly influenced child full immunization and accordingly children born to poor mothers were 0.8 times less likely to receive full immunization than children born to rich

mothers whereas children born to middle wealth mothers were 1.2 times more likely to receive full immunization. Birth place became positive and significant determinant of child full immunization. The model result highly confirmed that children that born at home were 0.5 times less likely to receive full immunization than those born at private or government hospitals and/or clinics. Age of mother negatively and significantly affected child full vaccination and the result depicted that children born to

aged mothers (more than the sample mean age) were 0.98 times less likely to receive full vaccination than those born to young mothers. Children born to mothers with managers and legislators occupation category were 0.5 times less likely to receive full vaccination whereas those born to professionals and associate professionals were 0.7 and 0.6 times less likely to receive full immunization, respectively compared to mothers with other occupation categories.

**Table 4. The estimates of coefficients and odds ratio of binary logistic regression**

Variables	B	S.E.	Wald	Df	Sig.	Odds ratio
<b>Region</b>			104.977	9	0.000	
Tigray	-0.009	0.231	0.001	1	0.970	0.991
Afar	-0.634	0.224	7.995	1	0.005	0.530
Amhara	0.458	0.224	4.197	1	0.040	1.581
Oromiya	-0.165	0.217	0.577	1	0.448	0.848
Somali	0.150	0.218	0.473	1	0.491	1.162
Benishangul	0.308	0.228	1.820	1	0.177	1.361
SNNPR	0.301	0.220	1.868	1	0.172	1.351
Gambela	-0.306	0.243	1.584	1	0.208	0.737
Harari	0.426	0.253	2.829	1	0.093	1.531
<b>Marital Status</b>			9.821	5	0.080	
Married	1.048	0.627	2.792	1	0.095	2.851
Living with partner	-0.296	0.379	0.609	1	0.435	0.744
Widowed	-0.573	0.511	1.255	1	0.263	0.564
Divorced	-0.561	0.495	1.284	1	0.257	0.571
Separated	-0.130	0.428	0.093	1	0.761	0.878
<b>Sex of child (1 = Male)</b>	0.084	0.063	1.786	1	0.181	1.088
<b>Education of Mother</b>			14.574	3	0.002	
Primary	-0.216	0.104	4.368	1	0.037	0.805
Secondary	0.072	0.096	0.570	1	0.450	1.075
Higher	0.057	0.109	0.278	1	0.598	1.059
<b>Antenatal Care</b>			22.652	2	0.000	
Yes	0.324	0.066	0.000	1	0.000	0.723
<b>Religion</b>			139.390	5	0.000	
Orthodox	2.403	0.542	19.680	1	0.000	11.055
Catholic	1.789	0.575	9.696	1	0.002	5.986
Protestant	1.193	0.542	4.840	1	0.028	3.296
Muslim	1.842	0.538	11.725	1	0.001	6.309
Traditional	-18.285	8497.889	0.000	1	0.998	0.002
<b>Wealth Index</b>			17.870	2	0.000	
Poor	-0.180	0.095	3.566	1	0.059	0.836
Middle	0.206	0.112	3.370	1	0.066	1.228
<b>Place of delivery</b>			75.004	2	0.000	
Home	-0.594	0.069	73.763	1	0.000	0.552
<b>Age of Mother</b>	-0.015	0.004	14.673	1	0.000	0.986
<b>Occupation</b>			13.288	9	0.150	
Managers and legislators	-0.624	0.223	7.811	1	0.005	0.536
Professionals'	-0.354	0.363	0.954	1	0.329	0.702
Associate professionals	-0.326	0.191	2.918	1	0.088	0.722
Clerks and support workers	-0.434	0.236	3.374	1	0.066	0.648
Personal care and service workers	0.067	0.319	0.044	1	0.834	1.069
Market oriented workers	-0.155	0.147	1.119	1	0.290	0.856
Technical and vocational workers	-0.114	0.111	1.044	1	0.307	0.892
Drivers, assemblers and operators	-0.031	0.154	0.041	1	0.839	0.969
Cleaners, helpers and laborers	-0.190	0.218	0.760	1	0.383	0.827
Constant	-41.430	20466.57	0.000	1	0.998	0.000

Significance levels: 1%, 5% and 10%, N = 5063 P > 0.000 Wald Statistic = 516.90  
 Source: Computed from EDHS, 2016.

### 3.2. Discussion

The study result showed that region was significantly associated with children full immunization in rural Ethiopia which is in line with study findings by [10]. Our results show that variables such as maternal education and use of antenatal care during pregnancy were significantly associated with full vaccination status. Children with mothers who have at least secondary level of education were more likely to complete the recommended vaccination series than children with mothers with no formal education which is consistent with study result obtained by [4,11].

Another finding of this study also indicated that antenatal care utilization and place of delivery were significantly associated with children full immunization in rural Ethiopia which is in line with study findings by [10]. This study also revealed that the religion of parents is significantly associated with full children immunization at 5% level of significance from which we conclude religion of parents determines the full child immunization in rural Ethiopia which is consistent with [12].

This study also showed that the wealth of parents is significantly associated with children full immunization. Children were more likely to be fully vaccinated if their parents are rich compared with those from poor parents which is consistent with the study result obtained by [10]. Sex of children and marital status were not associated with vaccination status of children in rural Ethiopia. This means these two variables didn't have any influence on child full immunization in the study area.

### 4. Conclusion and Recommendations

The result of this study has clearly indicated that child full immunization uptake in the rural Ethiopia has improved compared to previous reports. The study further generalized that 34.9% of children from rural Ethiopia had received full immunization. The challenges however are that most orthodox religion follower women, women without education, women with poor wealth category still seem not to take their children for immunization and this affects the percentage of children fully immunized in rural Ethiopia. Our study adds to the existing body of literature regarding the factors that influence childhood vaccination in low and middle income countries. Study findings highlight several potential avenues to improve childhood vaccination rates. In addition, in contexts characterized by low literacy levels, providing information and education about the benefits of childhood vaccination are important. Antenatal care, age of mother, wealth index

and place of delivery provide a good opportunity to enhance the awareness of mothers about full vaccination of children and other maternal and child health services.

Based on the result of the study, the following recommendations are forwarded. Firstly, government, health bureau, Health workers and others should increase the awareness of mothers with no education and poor wealth category about child full immunization by providing equal accessibility of health facilities. Secondly, Special attention should be given by the Health workers and government for the children born in remote areas of rural regions to decrease mortality rate.

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