Research Paper

Volume : 4 | Issue : 3 | March 2015 • ISSN No 2277 - 8179

Impact of Maternal Education on DPT Vaccine Coverage in an urban setup of Assam

Statistics

KEYWORDS : DPT vaccine, generalized linear model, systematic sampling, two-stage cluster sampling

Dilip C Nath — Department of Statistics, Gauhati University, Guwahati, Assam,

Atanu Bhattacharjee — Division of Clinical Research and Biostatistics, Malabar Cancer Centre,

Bhushita Patowari — Department of Statistics, Gauhati University, Guwahati, Assam

ABSTRACT

According to WHO immunization currently averts an estimated two to three million deaths every year in all age groups from diphtheria, tetanus, pertussis (whooping cough), and measles. For better immunization coverage, consideration progress to be made to improve the knowledge and awareness regarding importance of vaccines particularly in developing and underdeveloped countries. The present study evaluates the importance of mother's education on diphtheria- pertussis-tetanus (DPT) vaccine coverage using generalized linear models under Bayesian setup. The data has been taken from the survey "Comparison of Two Survey Methodologies to Estimate Total Vaccination Coverage" sponsored by Indian Council of Medical Research, New Delhi. The data has been collected in an urban set up of Assam using appropriate sampling techniques where children are in the age group of 6 months to 5 years of age. The results show that there is an impact of mother's education on DPT vaccine coverage.

Introduction:

Even after 40 years of the adoption of the Expanded Programme on Immunisation, there is failure to achieve satisfactory vaccine coverage to protect children from diphtheria (Datta et al., 2010). Diphtheria, Pertussis and Tetanus (DPT) are the vaccine preventable diseases of childhood. Diphtheria is an acute bacterial disease involving primarily tonsils, pharynx, larynx and nose of the non-immunized children less than 15 years of age. Pertussis is another acute bacterial disease involving the respiratory tract of the young children. Tetanus is also an acute disease induced by an exotoxin of the bacteria. The disease is characterized by painful muscular contractions, primarily of the masseter and neck muscles, and secondarily of the trunk muscles (Jha and Kumar, 2008). There have been substantial improvements in coverage of all individual vaccines except DPT vaccine against diphtheria, pertussis, and tetanus.

The incidence of Diphtheria has declined dramatically and some developed countries have virtually eliminated the disease over the last three decades (Saikia et al., 2010). The incidence of tetanus has decreased considerably in industrialized countries, but it remains rather common in many developing countries where the heaviest burden is borne by neonates, and children or young adults up to the age 20 years. India is a representative example (Satwekar et al., 2011). In 2012, an estimated 83% (111 million) of infants worldwide were vaccinated with three doses of diphtheria-tetanus-pertussis (DTP3) vaccine (Global immunization data, 2014). The World Health Organization (WHO) recommends three doses of triple diphtheria-tetanus-pertussis vaccine (DTP) at age of 6, 10 and 14 weeks, followed by a booster in the second year of life. To maintain the protection, a second booster of diphtheria-tetanus (DT) vaccine is recommended at the preschool age of 4 to 7 years (Satwekar et al., 2011).

The lowest coverage is for all 3 doses of the DPT vaccine (55 percent) (NFHS 3). According to WHO, India takes place at 26th position having 72% DTP3 vaccine coverage in 2011 whereas global coverage with DPT3 vaccine is 83% (WHO Vaccine Preventable Diseases: Monitoring System 2012 Global Summary). There were no reports of outbreaks of diphtheria in Assam since last few years, though sporadic cases were reported in UIP monthly report, which were never investigated and documented (Nath and Mahanta, 2010). In the late 1980s, the World Health Organization (WHO) developed the Expanded Program on Immunization (EPI) survey methodology also known as two stage (30×30) cluster sampling (recommended by WHO), which has since been widely used to assess vaccination coverage (Luman et al., 2007; Nath and Patowari, 2014).

Literacy among women is the key for better compliance of immunization (Yadav and Singh, 2004). Nankabirwa et al. (2010) stated that women with secondary education were at least 50% less likely to miss their infants' scheduled vaccinations compared to women with only a primary school education. Resources for routine childhood vaccinations should specifically be targeted at women with low formal education. Mother's education plays a very important role regarding their children's vaccination coverage (Nath et al., 2014). Maternal education was found to have a relationship with the immunisation status of the children. Children of mothers with a higher education had higher rates of correct immunisation than had the children of less educated mothers (Ibnouf et al., 2007). Munthali (2007) found that mother's education is major determinants of the immunization status of the child. According to Singh et al. (2012) literacy status of parents was significantly associated with the percentage of fully immunized children and the drop-out rate was also found to be higher among children of illiterate mothers. So there is need and scope of more focused information, education and communication efforts towards parents regarding immunization services.

The main objective is to study the influence of mother's education for better DPT vaccine coverage. The booster dose of DPT has been plotted with mother's education level. The study is based on primary data which has been collected in an urban set up of Assam.

Materials and methods:

The study considers coverage of DTP vaccine that has been es The timated for Guwahati, an urban area of Assam by using two stage (30×30) cluster sampling method and systematic random sampling method. The data for this study has been taken from a recently (2011) conducted survey "Comparison of Two Survey Methodologies to Estimate Total Vaccination Coverage" sponsored by Indian Council of Medical Research (ICMR), New Delhi.

The questionnaire has been developed to collect information of household details, information of the eligible members (the children of age from 6 months to 5years) of the household and their parents and information related to vaccination. The survey is conducted in Guwahati, Assam. Also to get the idea of geographical location and assesses of Guwahati city we have taken the ward map of the city and a listing of its wards from Guwa-

hati Municipal Corporation (GMC) that gives a lot of idea about the proper location of different wards of the city. And the listing of its wards given the information about the number of assesses per ward. The city is comprised of a total of 60 wards. Out of 60, 30 wards are selected where selections are being made with the help of random number table.

With the 30×30 cluster sampling method, only the first household is randomly selected. After the first household is visited, the surveyor moves to the "next" household, which is defined as the one whose front door is closest to the one just visited. This process continues until all 30 eligible subjects are found. After completing the 30×30 cluster sampling method, systematic sampling is carried out in same ward. In this sampling technique a random number is selected on the basis of the number of household in a lane (which is easily obtained from the 30×30 sampling technique) and after that each household is selected at an interval of 10 household and continuing the process until the 30 eligible subjects are not completed.

Model:

Pourhoseingholi et al. (2008) investigate the relation between demographic factors and type of gastrointestinal cancer using probit and logit models. Also Pourhoseingholi et al. (2011) studied the relation between body mass index and symptoms of gastro-esophageal reflux disease using Logit, Probit and Complementary log-log models. The models that are used in this study are briefly explained.

The logit function is the inverse of the sigmoidal logistic function. The logit of a number p between 0 and 1 is given by the-Here, the data on DTP vaccine coverage in an urban area (Guwahati) of Assam has been explored and compared using the above mentioned link functions. This work is especially on DPT vaccine coverage on 4th level in relation to education level of mothers. The education level of mother are categorized through "1=No formal education", "2=high school", "3=matriculate", "4=intermediate", "5=graduate", and "6=higher (post graduate)" respectively. The model has been performed with respect to no formal education of the mother's education. The output variable DPT given or not are observed with binomial link function. The link functions are applied to represent the presence of response variable through Logistic, Normal, Extreme value or Generalized Logistic error distribution respectively.

The model is defined as $\eta=\mu+\tau_i+\gamma_j$, i=1,2,.....n, j=1,2,... 30. Here, i stands for number of individuals and j as the number of cluster.

$$logit(\pi_{ij}) = \eta_{ij}$$
$$r_{ij} \sim Bin(\pi_{ij}, m_{ij})$$

Here, r and m are the response variable of DPT vaccinated and total number of vaccinated respectively. αi are the effects of the factor study and γij the effects of the factor cluster. A burn in of 10,000 followed by 10,000 samples after a one-fifth thinning is selected for the MCMC performance. The DIC statistics are opted for the model checking purpose.

(post graduate) educated mother's vaccinated their children 100%. Similar results are obtained for DPT 2, DPT 3 and DPT 4 va

formula: $logit(p) = log\left(\frac{p}{1-p}\right)$ The logit in logistic regression is a special case of a link function in a generalized linear model. It is the canonical link function for the binomial distribution. The probit function is the quantile function, i.e., the inverse cumulative distribution function (CDF), associated with the standard normal distribution. It has applications in exploratory statistical graphics and specialized regression modelling of binary res$X^T_{p\times n}\beta_{p\times 1}$. ables. The probit function gives the inverse computation, generating a

value of an N(0,1) random variable, associated with specified cumulative probability. Formally, the probit function is the inverse of Φ(z), denoted by Φ^{-1} (p). The generalized logistic curve or function is a widely-used and flexible sigmoid function for growth modelling, extending the well-known logistic curve. $Y(t)=A+\frac{K-A}{(1+Qe^{-B(t-M)})^{1/v}}$ where A, K, B, v, Q, M are all parameters. Complementary log-log model sayslog{-log[1-π(x)] }=

The expression on the left-hand side is called Complementary Log-Log transformation. Like the logit and the probit transformation, the complementary log-log transformation takes a response restricted to the (0,1) interval and converts it into something in $(-\infty, \infty)$ interval. Complementary log-log models represent a third alternative to logistic regression and probit analysis for binary response variables. The Deviance Information Criterion (DIC) is a hierarchical modelling generalization of the AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion). The DIC is Calculated as $DIC = p_D + D$ where

$$p_D = \bar{D} - D(\bar{\theta}),\ \bar{\theta} \text{ is the expectation of } \theta;$$
$$\bar{D} = E^{\theta}[D(\theta)];\ D(\theta) = -2log\big(p(y|\theta)\big) +$$

C where y are the data, θ are the unknown parameters of the model, $p(y|\theta)$ is the likelihood function and C is a constant. The model with the smallest DIC is estimated to be the model that would best predict a replicate dataset.

Result and discussion:

Percentage of coverage of DTP vaccine w.r.t. mother's education is given in Table 1 where 1, 2, 3 and 4 represent DPT vaccine given at 6 weeks, 10 weeks, 14 weeks and 18 months respectively. Here we see that percentage of coverage of DPT vaccine increases as the level of mother's education increases. 89.3 % children are vaccinated against DPT 1 (given at 6 weeks) vaccine whose mother's having no formal education while graduate and higher ccine.

Table 1: Coverage of DTP vaccine w.r.t. mother's education

Coverage of DTP vaccine w.r.t. mother's education through two stage (30×30) cluster sampling technique				
Mother's education	DTP vaccine (in %)			
	1 (6 weeks)	2 (10 weeks)	3 (14 weeks)	4 (18 months)
No formal education	89.3	89.3	85.7	53.6
High school	97.9	97.9	97.9	68.4
Matriculate	96.9	94.5	93.6	74.3
Intermediate	99.7	99.7	99.3	78.6
Graduate	100	99.7	99.7	80.3
Higher (Post Graduate)	100	100	100	83.3
Coverage of DTP vaccine w.r.t. mother's education through systematic sampling technique				
No formal education	97.1	97.1	97.1	71.4
High school	98.8	98.8	97.6	58.8
Matriculate	96.9	95.9	95.9	73.5
Intermediate	99.7	99.3	99.3	79.5
Graduate	100	100	100	77.8
Higher (Post Graduate)	100	100	100	84.6

Here we conduct a model section to choose one best fitted model considering logit, probit, complementory log-log and generalized logit model. The posterior estimates of regression coefficeint of parameter of interest like formal education, level of schooling observed through mean (SD) and 95% credible interval are given in Table 2. It shows a mixture result of insignifi-

cant and significant in case of all the considered models under the two sampling scheme and the combined one. But the best fitted model is chosen on the basis of the value of DIC as it is known that lower the value of DIC corresponding model will be considered as best fitted model. Computed value of DIC shows that 'GenLogit" is more suitable in this situation in comparison to other models. The maximum value of DIC obtained from the model with link function Probit. It can be stated that the model with probit is least effective in this specific problem.

Table 2: Posterior means, standard deviation (SD) and 95% credible intervals of the model parameters under four models

Link Function Mean(SD)		Cluster Sampling		Systematic sampling		Combined with systematic and cluster	
		Parameters	Mean(SD)	Parameters	Mean(SD)	Parameters	
Glogit	CONSTANT	-21.70(7.90)	(-33.18, -8.29)	-21.70(7.90)	(-33.18, -8.29)	-9.15(2.72)	(-13.41, -4.41)
	Intercept at 0	-33.44(12.14)	(-49.08,11.66)	-33.44(12.14)	(-49.08, -11.66)	-14.99(4.39)	(-22.22, -7.38)
	Edu	3.35(1.48)	(0.91, 6.11)	3.35(1.48)	(0.91, 6.11)	1.66(0.53)	(0.79, 2.66)
	Deviance	38.25(1.95)	(36.29, 43.24)	38.25(1.95)	(36.29, 43.24)	41.85(2.02)	(39.84, 47.58)
	DIC	32.01		32.01		38.84	
Logit	CONSTANT	1.06(0.08)	(0.89, 1.23)	1.06(0.08)	(0.89, 1.23)	1.07(0.05)	(0.97, 1.19)
	Intercept at 0	0.31(0.26)	(-0.20, 0.83)	0.31(0.26)	(-0.20, 0.83)	0.24(0.17)	(-0.10, 0.59)
	Edu	0.21(0.06)	(0.09, 0.34)	0.21(0.06)	(0.09, 0.34)	0.23(0.04)	(0.14, 0.32)
	Deviance	37.86(1.96)	(35.86, 43.04)	37.86(1.96)	(35.86, 43.04)	39.77(1.94)	(37.79, 45.27)
	DIC	39.91		39.91		41.80	
Probit	CONSTANT	0.65(0.05)	(0.55, 0.75)	0.65(0.05)	(0.55, 0.75)	1.07(0.05)	(0.97, 1.19)
	Intercept at 0	0.20(0.15)	(-0.08, 0.51)	0.20(0.15)	(-0.08, 0.51)	0.24(0.17)	(-0.10, 0.59)
	Edu	0.12(0.03)	(0.05, 0.20)	0.12(0.03)	(0.05, 0.20)	0.23(0.04)	(0.14, 0.32)
	Deviance	37.90(2.01)	(35.90, 43.31)	37.90(2.01)	(35.90, 43.31)	39.77(1.94)	(37.79, 45.27)
	DIC	39.95		39.95		41.80	
Clo-glog	CONSTANT	0.30(0.05)	(0.20, 0.42)	0.30(0.05)	(0.20, 0.42)	0.30(0.03)	(0.24, 0.36)
	Intercept at 0	-0.07(0.18)	(-0.40, 0.37)	-0.07(0.18)	(-0.40, 0.37)	-0.13(0.10)	(-0.33, 0.05)
	Edu	0.10(0.04)	(0.01, 0.18)	0.10(0.04)	(0.01, 0.18)	0.12(0.02)	(0.08, 0.17)
	Deviance	37.45(2.34)	(32.02, 43.07)	37.45(2.34)	(32.02, 43.07)	40.44(1.91)	(38.52, 45.36)
	DIC	43.21		44.01		42.04	

The parameters in the model and a summary of their marginal posterior distribution are given in Table 3. The result shows that as the level of mother's education increases value of estimates are also increases that is coverage of DPT vaccine increases as the mother's education increases.

Table3:-The Predicted Probability of DPT Coverage with respect to Education Level of Mothers in total sample population

Link Function	Education	Mean(SD)	95% Credible Interval (HPD)
Glogit	Primary	0.64(0.03)	(0.59, 0.69)
	High School	0.68(0.02)	(0.64, 0.72)
	Matriculate	0.72(0.01)	(0.69, 0.74)
	Intermediate	0.76(0.01)	(0.74, 0.78)
	Graduate	0.80(0.01)	(0.78, 0.82)
	Higher (Post Graduate)	0.84(0.02)	(0.81, 0.88)
Logit	Primary	0.61(0.03)	0.55, 0.67
	High School	0.67(0.02)	0.62, 0.71
	Matriculate	0.72(0.01)	0.69, 0.74
	Intermediate	0.76(0.01)	0.74, 0.78
	Graduate	0.80(0.01)	0.78, 0.82
	Higher (Post Graduate)	0.84(0.02)	0.80, 0.86
Probit	Primary	0.61(0.03)	(0.55, 0.67)
	High School	0.67(0.02)	(0.62, 0.71)
	Matriculate	0.72(0.01)	(0.69, 0.74)
	Intermediate	0.76(0.01)	(0.74, 0.78)
	Graduate	0.80(0.01)	(0.78, 0.82)
	Higher (Post Graduate)	0.84(0.02)	(0.80, 0.86)
Cloglog	Primary	0.62(0.03)	(0.57, 0.68)
	High School	0.67(0.02)	(0.63, 0.71
	Matriculate	0.72(0.01)	(0.69, 0.74)
	Intermediate	0.76(0.00)	(0.74, 0.78)
	Graduate	0.80(0.01)	(0.78, 0.83)
	Higher (Post Graduate)	0.84(0.02)	(0.81, 0.87)

The fitted models are plotted under the two sampling schemes and combined one.

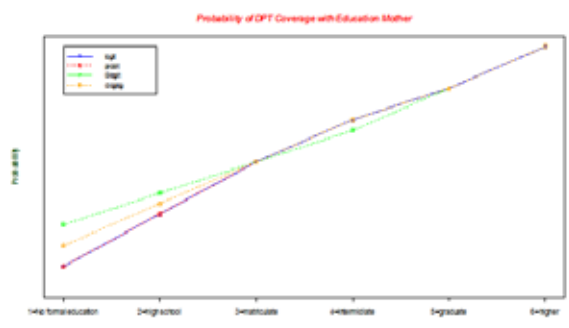

Figure 1: Model under cluster sampling

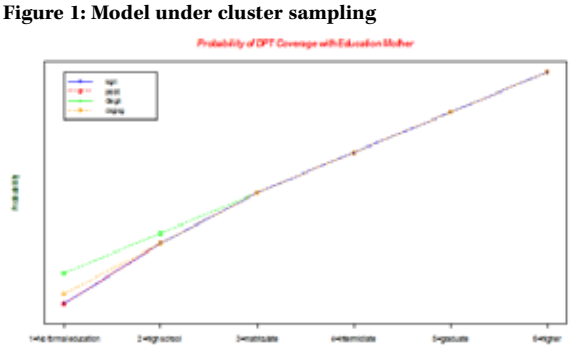

Figure 3: Model under combined sampling

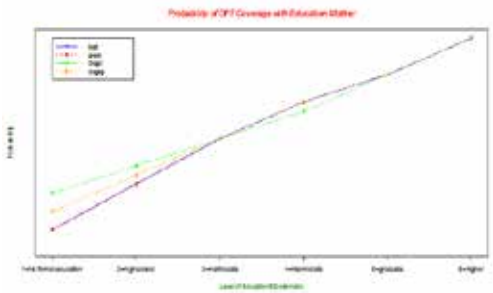

Figure 2: Model under systematic sampling

From the figures, we see that all link functions are increasing and continuous. The predicted mean values obtained through different link function are observed. The plot shows that in all case of link function the 4th level DPT coverage is better accordance to high education level of mother. That is as the education level of mother increases coverage of DTP vaccine is also increases. However, in low level of education a little bit fluctuation on predicted value is observed. Here we see that logit and probit curve are extremly similar that is the logit and probit functions are almost linearly related and we can say that it simply does not matter whether we use a logit or a probit link function for this study population. In general, the probit model assumes that the higher the value of probit the greater the probability to the coverage of DPT vaccine. On the other hand for small value of p, the complementary log-log closes to logit and probit but there is a deviation in case of Glogit from logit, probit and complementary log-log function. For larger value of p all the four link functions have shown same result.

Conclusions:

the study it has been observed that Glogit model is the best fit From ted model for this study population. It can be concluded that mother's education play a crucial role in case of DPT vaccine coverage. In this regard various types of awareness programme for parents will be helpful especially in developing and underdeveloped countries.

Acknowledgement:

The research was supported by the grant (number 69/40/2008-ECD-II) from Indian Council of Medical Research (ICMR), New Delhi and provided to the first author.

Conflict of Interest:

Authors declare that they have no conflict of interest.

REFERENCE

1. Datta SS, Purty AJ, Boratne AV, Singh Z (2010) Epidemiological Investigation of a Case of Diphtheria. Indian Journal of Medical Specialities 1(2):115-117. | 2. Ibnouf AH, Van den Borne HW, Maarse JAM (2007) Factors influencing immunisation coverage among children under five years of age in Khartoum State, Sudan. South African Family Practice 49(8): 14. | 3. Jha N, Kumar S (2008) Are we progressing towards elimination of diphtheria, pertusis, tetanus from Nepal?. Kathmandu University Medical Journal 6(4): 520-525. | 4. Luman ET, Worku A, Berhane Y, Martin R, Cairns L (2007) Comparison of two survey methodologies to assess vaccination coverage. International journal of epidemiology 36(3):633-641. | 5. Munthali AC (2007) Determinants of Vaccination Coverage In Malawi: Evidence From the Demographic And Health Surveys. Malawi Medical Journal 19(2):79 - 82. | 6. Nankabirwa V, Tylleskär T, Tumwine JK, Sommerfelt H, Promise-ebf Study Group (2010) Maternal education is associated with vaccination status of infants less than 6 months in Eastern Uganda: a cohort study. BMC Pediatrics 10:92. | 7. Nath B, Mahanta TG (2010) Investigation of an outbreak of diphtheria in Borborooah block of Dibrugarh district, Assam. Indian journal of community medicine 35(3):436-438. | 8. Nath DC, Bhattacarjee A, Patowari B (2014) Importance of Mother's Education in Vaccination Coverage Using Kaplan-Meier Survival Analysis. International Journal of Humanities, Arts, Medicine and Sciences 2(8): 35-44. | 9. Nath DC and Patowari B (2014) Estimation and comparison of immunization coverage under different sampling methods for health surveys; International journal of population research doi:10.1155/2014/850479 | 10. Pourhoseingholi A, Pourhoseingholi MA, Vahedi M, Safaee A, Moghimi-Dehkordi B, Ghafarnejad F, Zali MR (2008) Relation between Demographic Factors and Type of Gastrointestinal Cancer using Probit and Logit Regression. Asian Pacific Journal of Cancer Prevention 9(4): 753-5. | 11. Pourhoseingholi MA, Pourhoseingholi A, Moghimi-Dehkordi B, Safaee A, Solhpour A (2011) Assessment the relationship between reflux and body mass index with comparing different regression models. Gastroenterology and Hepatology From Bed to Bench 4(1): 23-28. | 12. Saikia L, Nath R, Saikia NJ, Choudhury G, Sarkar M (2010) A Diphtheria Outbreak in Assam, India. Southeast Asian Journal of Tropical Medicine and Public Health 41(3): 647-652. | 13. Satwekar AM, Telang SS, Ghorpade NA, Barde PJ, Patwardhan MR, Kulkarni PS (2011) Diphtheria and Tetanus Antibody Persistence in Indian Pre-school Children and Response to a Booster dose of DT Vaccine. World Journal of Vaccines 1(1): 5-9. | 14. Singh CM, Kaushik A, Jain PK, Kumar S, Srivastava DK, Singh NP, Chandra S, Singh AP (2012) Immunization coverage in Etawah: A border District of Uttar Pradesh. Indian Journal of Community Health 24(2): 134-139. | 15. Yadav RJ, Singh P (2004) Immunization of Children and Mothers in Northeastern States. Health and Population-Perspectives and Issues 27(3): 185-193. | 16. Global Immunization Data (February 2014); source:http://www.who.int/immunization/monitoring_surveillance/Global_Immunization_Data.pdf | 17. National Family Health Survey 3 (2005-06). | 18. DTP3 Immunization Coverage Rate (Percent of 1-Year-Olds) 2011; WHO, WHO Vaccine Preventable Diseases: Monitoring System 2012 Global Summary, source: http://www.who.int/vaccines/globalsummary/immunization/timeseries/tswucoveragedtp3.htm. | 19. Logit; source: en.wikipedia.org/wiki/Logit. | 20. Probit; source: en.wikipedia.org/wiki/Probit. | 21. Generalised logistic function; source: en.wikipedia.org/wiki/Generalised_logistic_function. | 22. Complementary log-log model; source: www.stat.ualberta.ca/~kcarrier/STAT562/comp_log_log.pdf. | 23. Deviance Information Criterion; source: en.wikipedia.org/wiki/Deviance_information_criterion. |