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IMPORTANCE OF MOTHER'S EDUCATION IN VACCINATION COVERAGE USING KAPLAN-MEIER SURVIVAL ANALYSIS

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ABSTRACT

According to World Health Organization the burden of vaccine preventable diseases remains high in developing country compared to developed countries. To overcome from this burden different types of immunization programmes have been implemented. For better immunization coverage in developing countries, consideration progress to be made to improve the knowledge and awareness regarding importance of vaccines. The present study tries to find the role of mother's education in DPT (diphtheria-pertussis-tetanus), Hepatitis B and Measles vaccine coverage in an urban society of India. The study area is an urban area of Assam and data are collected by using systematic random sampling. Altogether 900 children are taken in the age group 6 months to 5 years. Kaplan-Meier survival method is used to find the impact of mother's education on failure of vaccination coverage. Results show that increasing mother's education level decreases the probability of failure for age-appropriate DPT, Hepatitis B and Measles vaccine coverage. Education level of mother is very important regarding coverage of vaccines.

KEYWORDS: Diphtheria-Pertussis-Tetanus, Hepatitis B, Immunization, Measles, Systematic Random Sampling

INTRODUCTION

The aim of childhood vaccination programmes is to provide protection at the earliest possible age (Laubereau et al. 2002). Vaccination coverage is a basic indicator of vaccination programme performance and a measure of compliance with preventive medicine guidelines (Dayan et al. 2006). The WHO Expanded Programme on Immunization (EPI) has promoted performance monitoring since its inception. A central feature of this system is the assessment of the programme's reach that is, how many people benefit from immunization services (Delamonica et al. 2005). India was one of the first countries to adopt the World Health Organization's Expanded Programme on Immunization. Despite these achievements and tremendous advances in economic and technological spheres in recent years, the burden of vaccine-preventable diseases remains unacceptably high, in comparison to developed countries and also many developing countries (Mathew 2012). The immunization coverage of children in various parts of the country has been evaluated using various types of sampling method (Singh et al. 1996; Kadri et al. 2010; Singh and Yadav 2000).

DPT (D→ Diphtheria, P→ Pertussis, T→ Tetanus) vaccine is one of the important vaccine that must be given to every child at 6, 10, 14 weeks of age (primary immunisation) and a booster at 18 months of age. This vaccine is given against diphtheria, pertussis and tetanus. It is important to continue to immunise children against diphtheria and pertussis. Globally coverage of DPT vaccine was 85% during 2010 (Brown et al. 2011). Hepatitis B is a liver disease caused by hepatitis B virus (Hepatitis B 2012). This vaccine is given at birth, at 6 weeks and at 14 weeks (Mittal et al. 1994). Measles is endemic in India and is given once at 9 months of age.

The education level of mother's plays an important role in immunization coverage (Singh et al. 2012; Yadav and Singh 2004; Manna et al. 2009; Munsawaengsub et al. 2011). Barman (2012) studies the age-appropriate vaccination pattern using survival analysis. Dayan et al. (2006) applied survival analysis methods to data from a vaccination coverage survey among children aged 13–59 months. Hirve and Ganatra (1997) studied the role of birth weight, nutrition, immunization and other medical as well as social factors in determining child survival using Kaplan-Meier survival analysis. Aaby et al. (2007) applied observational studies of diphtheria–tetanus–pertussis vaccine and used case–control design, survival analysis with interval-fixed vaccination status (landmark approach), and survival analysis with retrospective updating of vaccination status.

It is to be mention that children should receive scheduled vaccination to prevent from diseases. Scheduled vaccination minimizes the need to repeat doses of vaccines. Luman et al., (2002) studied the timeliness of vaccine administration among infants and young children in the United States. Here the main objective is to study the failure of vaccination coverage w.r.t. mother's education level among children (6 months to 5 years of age) in an urban society of Guwahati city. The survival analysis has been applied to explore the failure rate of DPT, hepatitis B and measles vaccine coverage.

METHODS

The data set for this analysis is primary data and the study area is Guwahati, the capital city of Assam. It has been collected using convenient sampling method during January to October, 2011.

Systematic Random Sampling: Systematic sampling is a random method of sampling in which only the first unit is selected with the help of random numbers and the rest get selected automatically according to some pre-designed pattern. The systematic survey, in which households are selected using a fixed sampling interval, provides a more representative sample than the cluster sampling (Rose et al. 2006).

According to Guwahati Municipal Corporation the study area consists of 60 numbers of municipal wards and from that 30 wards are selected randomly. After random selection of the municipal wards of the study area 30 units from each ward are selected. For this purpose first household is selected where an eligible child is found in a particular area of a selected ward and thereafter each household at an interval of 10 households are selected till the required number (30 numbers of eligible households) is not completed. This procedure is carried out in each selected ward. Altogether 900 numbers of sampling unit is here. All children aged between 6 months to 5 years have been considered as the subject of the study population. Information of immunization is collected from record of vaccination cards.

In this study probability of failure of DPT, hepatitis B and measles vaccine coverage have been estimated for different ages of the children w. r. t. different levels of mother's education using Kaplan-Meier method. Here survival time is taken as the age of children. Age of children is considered in months that is from 6 months to 60 months and education of mother is categorised as No formal education & primary level (1), High school (2), H.S.L.C. (3), H.S.S.L.C. (4), and Graduate (5) and above Graduate (6). DPT vaccine is considered upto 4^{th} level that is DPT1 given at 6 weeks of age, DPT2 given at 10 weeks of age, DPT3 given at 14 weeks of age and DPT4 given at 18 months of age. Hepatitis B vaccine is considered at birth (as HepB1) and at 6 weeks (as HepB2).

Statistical Analysis

The continuum that time reflects also implies that the probability of an event at an infinitely small single point in time is zero. Therefore it is necessary to define the distribution of events over that continuum instead of at an instant in time. In survival analysis, one can rely on four functions to describe the distribution of event times: 1) probability density function (pdf), 2) cumulative distribution function (cdf), 3) hazard function and 4) survival function. The pdf of a random variable T, denoted $f_T(t)$, is defined by $f_T(t) = \frac{d}{dt}F_T(t)$. The cdf of a random variable T, denoted $F_T(t)$, is defined by $F_T(t) = P_T(T < t)$. F (t) ranges from 0 < F (t) < 1. The hazard function $h(t)$ is given by the following:

$$h(t) = P\{t < T < (t + \Delta)|T > t\} = \frac{f(t)}{1-F(t)} = \frac{f(t)}{S(t)}$$

Let T > 0 have a pdf $f(t)$ and cdf $F(t)$ then the survival function is denoted by $S(t)$ and is defined by $S(t) = P\{T > t\} = 1 - F(t)$ (Kaplan Meier And Cox Proportional Hazards Modeling: Hands On Survival Analysis 2013).

Statistical techniques of survival analysis are developed to analyse time-to-event data. Kaplan-Meier method is one of the non-parametric methods for describing time to event data. It may be to estimate the vaccination coverage, which quantifies the proportion of infants immunised across specific age group. Vaccination of a particular dose may be considered as the event[15]. The Kaplan-Meier method is based on individual survival times and assumes that censoring is independent of survival time (that is, the reason an observation is censored is unrelated to the cause of failure). The Kaplan-Meier estimator of survival at time t is

$$\widehat{S}(t) = \prod_{j:t_j<t} \frac{(r_j - d_j)}{r_j}, for\ 0 \le t \le t^+$$

where t_j, $j = 1,2, \dots, n$ is the total set of failure times recorded (with t+ the maximum failure time), d_j is the number of failures at time t_j, and r_j is the number of individuals at risk at time t_j (An Introduction to Survival Analysis 2013).

To compare failure of vaccination coverage corresponding to different education level of mother log-rank statistics has been used and is given by

$$Log - rank\ statistic = \frac{(O_i - E_i)^2}{var(O_i - E_i)} \sim \mathcal{X}_1^2$$

If the number of groups being compared is G (≥2), then the log-rank statistic has approximately a large sample chi-square distribution with G-1 degrees of freedom and is given by

$$\mathcal{X}^2 = \sum_{i=1}^{G} \frac{(O_i - E_i)^2}{E_i}$$

where G= number of groups (Kleinbaum and Klein 2012).

RESULTS

Table 1 presenting family related information of respondents' show that 91.1% of the people belong to Hindu religion whereas 7.3% belong to Muslim religion and only 1.6% are others (including Christian, Jain); also category wise most of the people belong to general category. Here it is seen that very less number of people living in joint family.

Table 1: Family Related Information of the Respondents

Variable	Percent
Religion	
Hindu	91.1
Islam	7.3
Others	1.6
Caste	
General	71.6
SC	16.0
ST	4.8
OBC	7.7
Source of Drinking Water	
Tap Water	23.9
Tube Well	3.9
Well	56.0
Others	16.2
Toilet Facility	
Sanitary Latrine	95.9
Pit Latrine	4.1
Type of Family	
Nuclear	94.4
Joint	5.6
Monthly Household Income	
Low	12.4
Middle	75.4
High	12.1
Age of Mother	
15-25	5.8
25-35	84.1
35 and above	10.0
Education of Mother	
No or primary education	4.0
High school	9.4
Matriculate	10.9
Intermediate	33.7
Graduation	36.1
Higher	5.9
Occupation of Mother	
Home maker	90.2
Employee	9.8
Place of Vaccination	
Govt. health sector	43.2
Private health sector	56.8

Only 5.6% of the respondents are living in joint family and remaining 94.4% are nuclear type family. Families identified mostly obtain their water from a tap or well. In case of sanitation it is seen that people (4.1%) still uses pit latrine. 75.4% of respondents are middle class family where class of families are categorised on the basis of parents' occupation and the number of earning members in households. 84.1% mothers are belong to age group 25-35 and most of them are graduate or H.S.S.L.C. passed. More than 90 % mothers are homemaker. In case of place of vaccination 56.8% of respondents prefer private health sector. Vaccination coverage (Table 2) shows that DPT vaccine coverage is quite good (particularly DPT1, DPT2 and DPT 3) whereas hepatitis B and measles vaccine coverage is poor.

Table 2: Coverage of DPT, Hepatitis B and Measles Vaccine

Vaccine	Coverage (in %)
DPT1	99.3
DPT2	99.1
DPT3	99.0
DPT4	76.3
Hepatitis B1	55.8
Hepatitis B2	55.7
Measles	61.1

Cumulative probability of failure of DPT (DPT1, DPT2, DPT3 and DPT4) vaccine coverage corresponding to different levels of mother's education is presented in Figure 1, Figure 2, Figure 3 and Figure 4 respectively. It shows that there is no significant differences (p=0.46) among different education level of mother corresponding to failure of DPT1 vaccine. Similar result has been obtained in case of DPT2 and DPT3 vaccines with p-values 0.48 and 0.47 respectively.

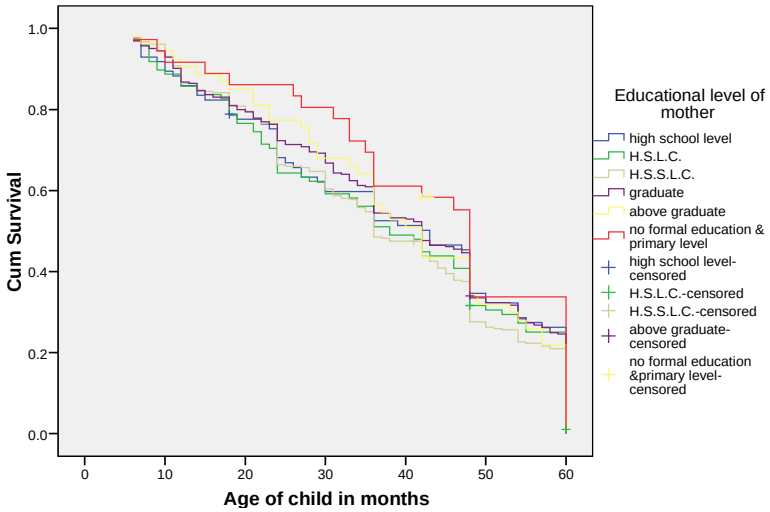

Figure 1: Probability of Failure of DPT1 Vaccine Coverage

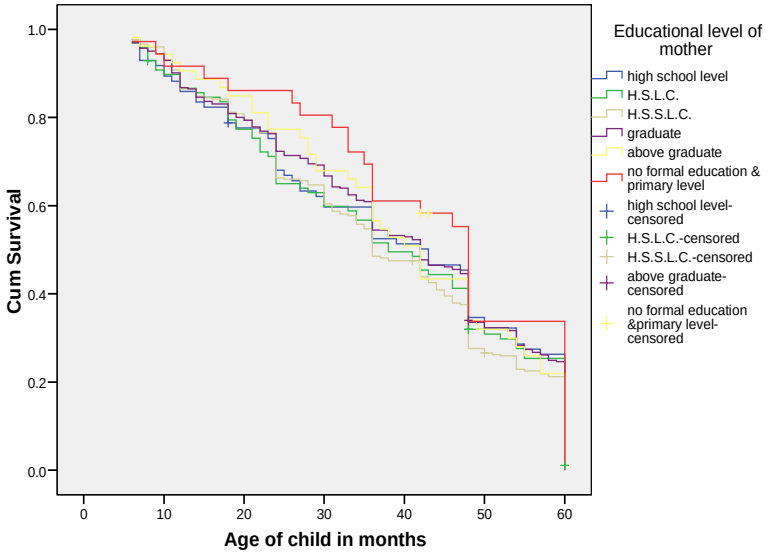

Figure 2: Probability of Failure of DPT2 Vaccine Coverage

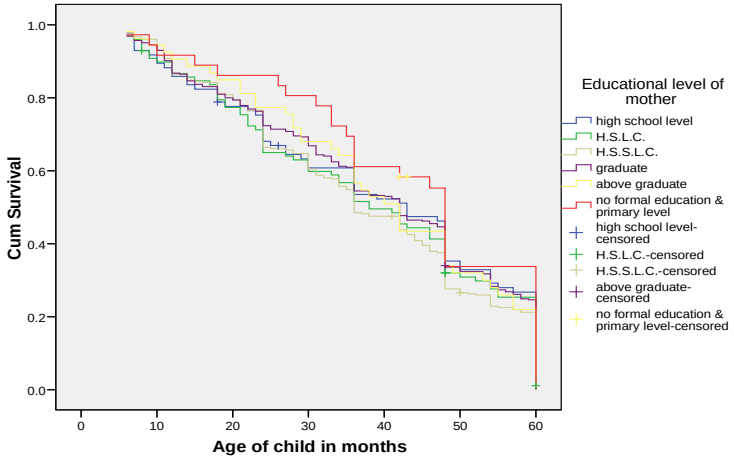

Figure 3: Probability of Failure of DPT3 Vaccine Coverage

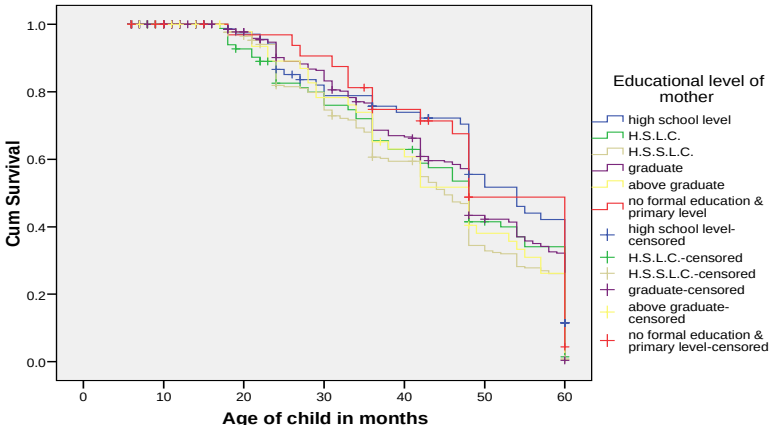

Figure 4: Probability of Failure of DPT4 Vaccine Coverage

In case of DPT4 vaccine (Figure 4) it is seen that there is a significant differences (p=0.01) among different levels of mother's education corresponding to their children's vaccination coverage.

Cumulative probability of failure for hepatitis B1 and hepatitis B2 vaccine is presented in Figure 5 and Figure 6 respectively. It is seen that probability of failure of hepatitis B1 and hepatitis B2 vaccine is very high for uneducated mothers. Also there is a highly significant difference among different groups of mother's education level corresponding to failure of hepatitis B vaccine coverage (p=0.00 for both hepatitis B1 and hepatitis B2). Figure 7 represents failure of measles vaccine coverage also shows same result of highly significant difference with p=0.00.

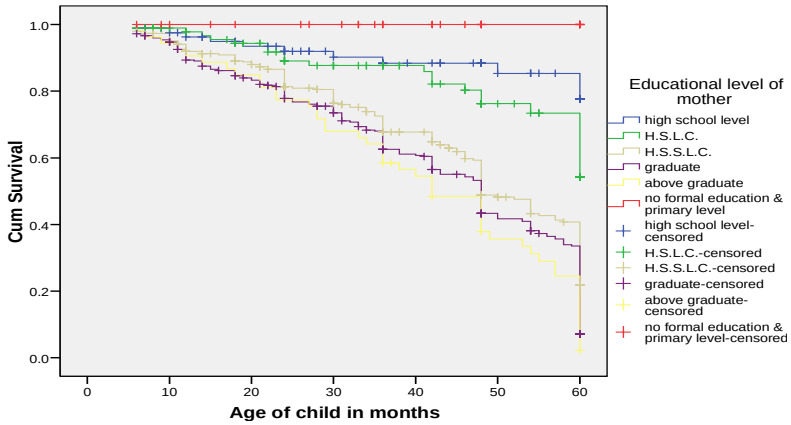

Figure 5: Probability of Failure of Hepatitis B1 Vaccine Coverage

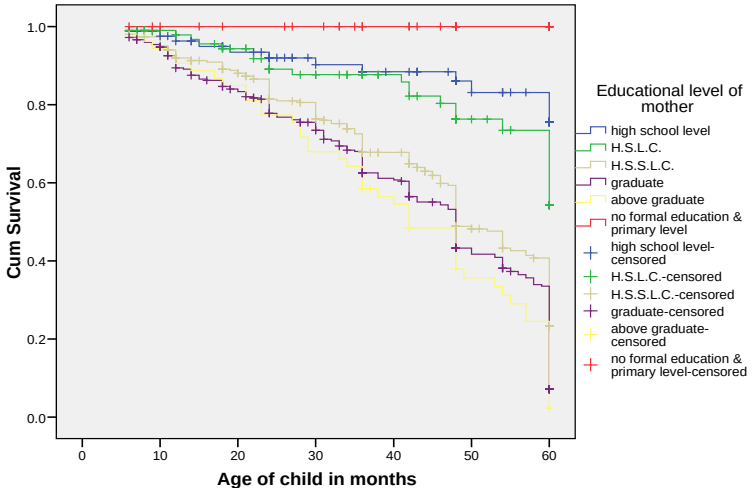

Figure 6: Probability of Failure of Hepatitis B2 Vaccine Coverage

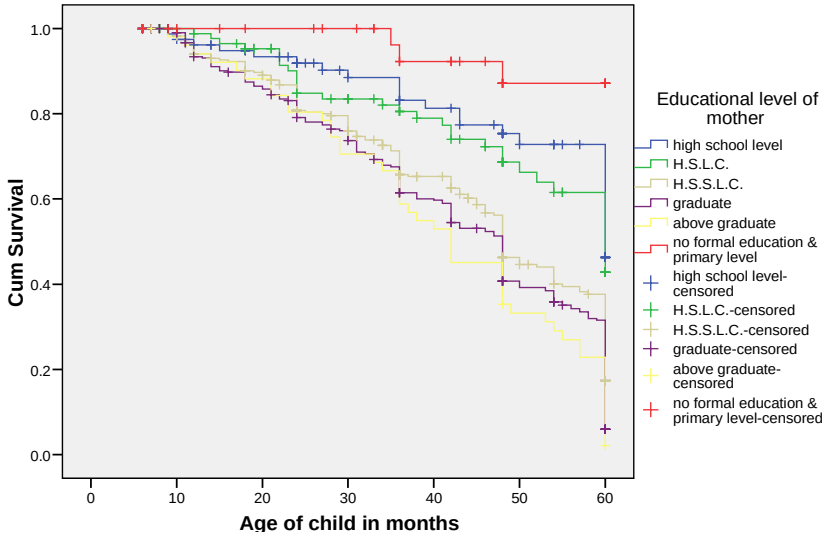

Figure 7: Probability of Failure of Measles Vaccine Coverage

DISCUSSIONS

In a study Usman et al. (2010) provides strong evidence that a very low proportion of children who received DTP1 at selected rural EPI centres in Pakistan returned to complete DTP3. In a study of "Comparative analysis of patterns of survival by season of birth in rural Bangladeshi and Gambian populations" Moore et al. (2004) has used Kaplan–Meier survival plots by season of birth in rural Gambia and Kaplan-Meier survival estimates by country and season. Chan et al. (2007) uses Kaplan–Meier cumulative mortality curves by DTP immunization status and sex, in Cebu, Philippines to examine the association between DTP vaccination and survival. Laubereau et al. (2002) has stated that the WHO recommendation of early immunizations against some particular vaccine is insufficiently achieved in Germany. Timely uptake of certain vaccines is clinically and epidemiologically important and thus should be monitored.

They think the Kaplan-Meier method presents an instructive and comprehensive approach to describe timing of vaccination and it is a useful tool for comparisons of vaccination schedules in different populations or in the same populations over time, if the progress of a vaccination campaign is to be monitored. Dayan et al. (2006) also suggest that survival analysis techniques applied to a vaccination coverage survey were useful to measure vaccine uptake and provided clinically and epidemiologically relevant information regarding timeliness of vaccination and person-time at risk for

vaccine-preventable diseases. Survival analysis methods should be considered for analysis of data from coverage surveys when assessing delay in age-appropriate vaccination.

Fadnes et al. (2011) has used Kaplan-Meier time-to-event analysis to describe vaccination coverage and timeliness in line with the Expanded Program on Immunization for the first eight vaccines. In this study it is observed that as the level of mother's education is increasing, probability of failure of age-appropriate vaccination becomes slowly downwards. That is educated mothers are more aware about vaccination and to vaccinate their children in time. Another important aspect is that the children of Assam in the North-East Region of India have consistently evidenced of low rates for routine childhood immunizations. Lack of information among the parents was one of the major causes of drop out of vaccinations (Phukan et al. 2009).

CONCLUSIONS

The study reveals the importance of literacy of mother's which is related to the coverage of immunization. The level of mother's education is playing a contributing role in case of failure of age-appropriate vaccination coverage. The increase awareness among parents will also play an important role regarding increasing the immunization coverage in developing country like India.

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