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# COX'S PROPORTIONAL HAZARD MODEL AND CONSTRUCTION OF LIFE TABLE FOR UNDER-FIVE

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## ABSTRACT

A primary data of 836 eligible women in the age group of 15-49 years is used to determine the causal effects of covariates on under-five mortality. The eight covariates viz., Number of family Members (NHM), Type of Toilet Facility (TTF), Total Children ever Born (TCB), Parity (PAR), Duration of Breastfeeding (DBF), use Contraceptive (CMT), DPT and Ideal Number of Girl (ING) are considered as covariates of the study. By applying Cox's regression analysis, six covariates viz., TTF, NHM, CMT, DBF, DPT and ING have substantially and significantly effect on under-five mortality. Further, a life table of under-five children under study is constructed using the estimate of survival function obtained from Cox's regression model.

**Keywords:** Under-Five, Covariates, Cox's Regression, Hazard Function and Life Table

## 1. INTRODUCTION

The first five years of life are the most crucial to the physical and intellectual development of children and can determine their potential to learn and thrive for a life time. That is why it is specifically stated as one of the goals of the Millennium Development Goals (MDGs) to reduce child mortality by two-thirds by 2015. Although there has been a substantial reduction in infant and child mortality rates in most developing countries in the recent past, it still remains a major public health issue in South Asian countries particularly in India.

Mortality and its converse indicator, longevity or life expectancy are among the most important measures of well-being and development in developing countries. Since child mortality has an overwhelming influence on life expectancy, it is important to analyze the determinants of child mortality in India and particularly in the state of Manipur. Moreover, child mortality indicates the health status of not only child but also the health status of mothers as well as society as a whole. The child mortality has received a new momentum of the study since there is a strong associationship between mortality and fertility as high mortality corresponds high fertility and vice-versa. Thus, the study of especially on child has as immense contribution towards the regulation of population growth and enhancing the health status of the society.

The general medical definition distinguishes mortality of a child with respect to the child age: Death within the first week of life is included with prenatal mortality (which also includes late foetal mortality) and death within the first month is referred to as neonatal mortality and death within one year is referred to as infant mortality. The death under five is referred to as child mortality (WHO, 2005). Since peri and neonatal mortality is heavily influenced by prematurity, fatal genetic conditions of the foetus and problems associated with delivery. The mortality after first month, which is mostly related to socio-economic and health conditions of the household. It is possible to analysis the determinants of child mortality at various levels of causality Mosley and Chen (1984). The biomedical and epidemiological literature typically focuses on the immediate determinants of child mortality, in particular the impact of various diseases

and weakened resistance. In contrast, socio-economic, environment and sanitation, medical and health care, demographic, exposure to mass media, are usually focused on underlying determinants of child mortality that make children more vulnerable to the attack of various diseases. Moreover, the child mortality rates vary from countries to countries and even within the country also it is varied in region to region and state to state. In developed countries, the main factor influencing on child mortality is demographic factors whereas socio-economic, health care, are main factors influencing on child mortality in developing countries. Thus, the study of child mortality is different from country to country and region to region.

## 2. MATERIALS AND METHODS

The study design is cross sectional with survey period started from 1st May, 2008 to 30th April, 2009 in four districts of Manipur, India. A sample of 836 eligible women (age 15-49 years) have been selected by using two stage sampling with proportionately allocated to districts and villages. The Cox's proportional hazard regression analysis (Cox, 1972) is used to analyze the data. The effects of covariates on under-five are measured by using relative risk of each covariate and a life table of under-five children is constructed after estimating the survival function.

### 2.1. Cox's Proportional Hazard Model

The general form of Cox's proportional hazard model is Equation 1:

$$\lambda(t,Z) = \lambda 0(t)\ \psi(Z) \tag{1}$$

where, $Z$ is a column vector of p-covariates.

The hazard function, as expressed in (1), is the product of two functions. The function $\lambda 0(t)$ characterizes how the hazard function changes as a function of survival time t. The other function, $\psi(Z)$ characterizes how the hazard function changes as a function of subject covariates. The functions must be chosen such that $\lambda(t, Z)\geq 0$ Note that $\lambda 0(t)$ is the hazard function when $\psi(Z) = 1$. When the function $\psi(Z)$ is such that $\psi(0) = 1, \lambda 0(t)$ is generally referred to as the baseline hazard function. Under the model (1), the ratio of the hazard functions for two subjects with covariate values denoted by $Z_1$ and $Z_0$ is Equation 2:

$$HR(t,\underline{Z}) = \frac{\lambda_0(t)\psi(Z_1)}{\lambda_0(t)\psi(Z_0)} = \frac{\psi(Z_1)}{\psi(Z_0)} \tag{2}$$

Thus the Hazard Ratio (HR) depends only on the function $\psi(Z)$. Cox (1972) was the first to propose the model (1) when he suggested using $\psi(Z) = \psi(Z; \beta) = \exp(\beta' Z)$, where $\beta$ is a column vector of p unknown regression coefficients. With this parameterization the hazard function is Equation 3:

$$\lambda(t;Z) = \lambda 0(t)\ \exp(\beta' Z) \tag{3}$$

And the hazard ratio is Equation 4:

$$HR(t,Z) = e^{\beta'(Z_1 - Z_0)} \tag{4}$$

This model is referred to as the Cox model, the Cox proportional hazards model or simply the proportional hazard model. The model in (3) is the most frequently used form of the hazard function in (1). The term proportional hazards refers to the fact that in (3) the hazard functions are multiplicatively related, that is, their ratio is constant over survival time.

Particularly, let $Z = \begin{pmatrix} Z_1 \\ Z_2 \end{pmatrix}$ and $\beta = \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix}$ each a column vector of order 2×1, then Equation 5:

$$\lambda(t,Z) = \lambda 0(t) = e^{\beta_1 z_1 + \beta_2 Z_2} \tag{5}$$

Instead of assigning z1 and z2 = 0 as reference category we assume that they are assigned some other values, than Equation 6:

$$\lambda(t,\underline{Z}) = \lambda 0(t) = e^{\beta_1 z_1 + \beta_2 Z_2} e^{-(e^{\beta_1 z_1 + \beta_2 Z_2})} e^{\beta_1 z_1 + \beta_2 Z_2} \tag{6}$$

where, $z_1$ and $z_2$are arbitrary chosen values of z1 and z2.

Here, we may define Equation 7 and 8:

$$\lambda\square(t) = \lambda 0(t) = e^{\beta_1 z_1 + \beta_2 Z_2} \tag{7}$$

$$a = -(\beta_1 Z_1 + \beta_2 Z_2) \tag{8}$$

Then Equation 9 and 10:

$$\lambda(t) = \lambda'(t) e^{a} e^{\beta_1 Z_1 + \beta_2 Z_2} \tag{9}$$

$$or, \lambda(t) = \lambda'(t) e^{a + \beta_1 Z_1 + \beta_2 Z_2} \tag{10}$$

Now (10) can be written as Equation 11:

$$\lambda(t) = \lambda'(t)e^{(\beta_1 Z_1 + \beta_2 Z_2) + \beta_1 Z_1 + \beta_2 Z_2} = \lambda'(t)e^{\beta_1 (Z_1 - Z_1) + \beta_2 (Z_2 - Z_2)} \quad (11)$$

We may choose the baseline values $z_1^{'}$ and $z_2^{'}$ on the basis of analytical convenience (Retherford and Choe, 1993). If we set them to their mean values $\bar{z}_1$ and $\bar{z}_2$ so that $\lambda'(t)$ becomes $\bar{\lambda}$ (t) representing the typical hazard, then (10) becomes Equation 12:

$$\lambda(t) = \bar{\lambda}(t)e^{a + \beta_1 Z_1 + \beta_2 Z_2} \quad (12)$$

where, $a = (-\beta_1 \bar{z}_1 + -\beta_2 \bar{z}_2)$

And (4.2.11) becomes:

$$\lambda(t) = \bar{\lambda}(t)e^{\beta_1 (z_1 - \bar{z}_1) + \beta_2 (z_2 - \bar{z}_2)}$$

Thus, the conversion formula is Equation 13:

$$\lambda(t) = \bar{\lambda}(t)e^{\beta_1 (Z_1 - \bar{Z}_1) + \beta_2 (Z_1 - \bar{Z}_2)} \quad (13)$$

### 2.1.1. Relative Risk as Measures of Effect on the Hazard

Let the hazard function be:

$$\lambda(t) = \bar{\lambda}(t)e^{a + bZ_1 + cZ_2}$$

Suppose that we increase $Z_1$ by one unit holding $Z_2$ constant. Let $\lambda$* be the new value of $\lambda$ after changing the value of $Z_1$, then Equation 14 and 15:

$$\lambda^*(t) = \bar{\lambda}(t)e^{a + b(Z_1 + 1) + cZ_2} = \bar{\lambda}(t)e^{a + bZ_1 + cZ_2 + b} = (\bar{\lambda}(t)e^{a + bZ_1 + cZ_2})e^b = \bar{\lambda}(t)e^b \quad (14)$$

$$\therefore \frac{\lambda^*(t)}{\lambda(t)} = e^b \quad (15)$$

It is witnessed from (14) that a one unit increases in $Z_1$, holding $Z_2$ constant, multiplies the hazard function by $e^b$. Thus, the quantity $e^b$ is called a relative risk.

### 2.1.2. Hazard Regression Coefficients as Measures of Effect on the Log Hazard

Suppose that the hazard function is:

$$\lambda(t) = (t)e^{a + bZ^1 + cZ_2}$$

Taking the log of both sides, we have Equation 16:

$$Log[\lambda(t)] = \log[\bar{\lambda}(t)] + a + bZ_1 + cZ_2 \quad Or \log[\lambda(t)] = a + bZ_1 + cZ_2 \quad (16)$$

where, $a = \log[\bar{\lambda}](t) + a$

From (16), it is known that when the log hazard is taken as the response variable, the effects are additive and the proportional hazard model is viewed as an additive model.

### 2.1.3. Fitting of Cox' Proportional Hazard Regression Model

Let us consider Cox's multivariate hazard model be:

$$\lambda(t, Z) = \lambda_0(t)\exp(\beta_1 Z_1 + \beta_2 Z_2 + ... + \beta_p Z_p)$$

Let $Y_i$ denote the observed time (either censoring or event time) for subject $i$ and let $C_i$ be the indicator function defined as:

$$C_i = \begin{cases} 1, if\ event\ occur \\ 0, if\ the\ time\ is\ censoring\ time \end{cases}$$

The partial likelihood function is given by:

$$l(\beta) = \prod_{i:C_i = 1} \frac{\theta_i}{\Sigma_j :\geq Y_i \ ^{\theta_j}}$$

where, θj = exp(β′Zj) and Z1, Z2, ..., Zn are the covariate vectors for the n independently sampled individuals.

The corresponding log partial likelihood is:

$$L(\beta) = \sum_{I:C_i = 1} \left[ \beta Z_i - \log\left( \sum_{j:Y_j \geq Y_i} \theta_j \right) \right]$$

This function can be maximized over β to produce maximum partial likelihood estimates of the model parameters.

The partial score function is:

$$L(\beta) = \sum_{I:C_i=1} \left[ Z_i - \frac{\log \Sigma_{j:Y_j \geq Yi} \theta_j Z_j}{(\Sigma_{j:Y_j \geq Yi} \theta_j)} \right]$$

And the Hessian matrix of the partial log likelihood is:

$$L''(\beta) = -\sum_{I:C_i=1} \left( \frac{\Sigma_{j:Y_j \geq Yi} \theta_j Z_j Z_j'}{\Sigma_{j:Y_j \geq Yi} \theta_j} - \frac{\Sigma_{j:Y_j \geq Yi} \theta_j Z_j \times \Sigma_{j:Y_j \geq Yi} \theta_j Z_j'}{(\Sigma_{j:Y_j \geq Yi} \theta_j)^2} \right)$$

Using this score function and Hessian matrix, the partial likelihood can be maximized using the Newton-Raphson algorithm. The inverse of the Hessian matrix, evaluated at the estimate of β, can be used as an approximate variance-covariance matrix for the estimate and used to produce approximate standard errors for the regression coefficients.

Several approaches have been proposed to handle situations in which there are ties in the time data. Breslow's method (Breslow and Crowley, 1974) describes the approach in which the procedure described above is used unmodified, even when ties are present. An alternative approach that is considered to give better results is Efron's method (Efron, 1974).

The procedures for model development and assessment of model adequacy or goodness of fit are almost same as the procedures applied in the logistic regression analysis mentioned in chapter-III.

## 2.4. Variable Specification

In this present study, the survival time of a child is considered as response variable and it is considered with respect to reference period. The children who live start within the reference period are taken into consideration. The children died within the reference period are taken as uncensored cases the children alive in that period are censored cases. To identify whether a case is censored or not, an indicator variable called Survival States of Child (SSC) is assigned as 1, if the child is death (event occur) in the reference period and 0, otherwise (alive or censoring). Along with these, 8 covariates are taken into account such as Type of Toilet Facility (TTF), Number of Family Members (NHM), number of ever born Children (TCB), use Contraceptive (CMT), Duration of Breastfeeding (DBF), Ideal Number of Girls (ING), DPT and Parity (PAR). Again, the Cox's regression by stepwise method (Forward) is proposed to selection the best set of covariates to be included in the model. The following are the defined variables used in the Cox's regression analysis.

### 2.4.1. Response Variable

TIME (Survival Time of Child): Number of months of surviving starting from date of birth

### 2.4.2. Indicator Variable

Survival Status of Child (SSC): 1 if event occur (death), 0 otherwise

### 2.4.3. Covariates

1. Number of Family Members (NHM): Number
2. Type of Toilet Facility (TTF): 1if sanitation, 0 otherwise
3. Total children ever born (TCB): Numbers
4. Parity (PAR): Number
5. Duration of Breastfeeding (DBF): 1if less 6 months, 0 otherwise
6. Use Contraceptive (CMT): 1 if yes, 0 otherwise
7. DPT (DPT): 1 if given, 0 otherwise
8. Ideal Number of Girl (ING): Number

The main purpose of this analysis is to obtain the values of the survivorship function $[\bar{S}(t)]$ at the mean values of the covariates. With these values, the survivorship function S(t) can be estimated.

## 2.5. Estimation of Survivorship Function

From Equation (4.3.3), we have:

$$S(t) = [\bar{S}(t)]^{e^{-\Sigma_{i=1}^{p} \beta_i \bar{Z}_i + \Sigma_{i=1}^{p} \beta_i z_i}}$$

And from **Table 3**, we have:

$$\sum_{i=1}^{p} \beta_i \bar{Z}_i = 3.21$$
$$\Rightarrow -\sum_{i=1}^{p} \beta_i \bar{Z}_i = -3.21$$

Hence:

$$e^{-\Sigma_{i=1}^{p} \beta_i \bar{Z}_i + \Sigma_{i=1}^{p} \beta_i z_i} = e^{-3.21 + \Sigma_{i=1}^{p} \beta_i z_i} = A(say)$$
$$\Rightarrow S(t) = [\bar{S}(t)]^{e^{\Sigma_{i=1}^{p} \beta_i \bar{Z}_i + \Sigma_{i=1}^{p} \beta_i Z_i}} = S(t) = [\bar{S}(t)]^A$$

The estimated value of $S(t)$ is given below in **Table 4** with the values of $\bar{S}(t)$.

# 3. RESULTS AND DISCUSSION

The Cox's proportional hazard regression model is fitted to the data along with 8 covariates. The purposeful selection of variables and fix for a best subset of the

covariates out of these 8 covariates has been conducted by stepwise method (Wald's forward) with p- value 0.05 for entry level of a covariate in the model and 0.10 for deletion level of a covariate in the model. For assessing the best fit of the model particularly model coefficients, overall model and goodness of fit are conducted by Wald's test, likelihood ratio test and score test. From this analysis, further, interpretation of the effects of covariates on the survival status of child is made with the help of relative risks ($e^{\beta}$) of each covariate.

**Table 1** depicts the Omnibus test for model coefficients of in 6 steps of the analysis. It has been confirmed from the score tests which are statistically significant for all possible 6 models and thus overall coefficients of the models up to 6 steps are significant.

Again, chi-square tests for change of next step from previous step are also found to be statistically significant and hence there is some improvement of the model from its previous model. Therefore, the model obtained at 6th step is the best model fitted to the present data. Further, the improvement of a particular block from the previous block is also significant statistically up to 6th step. In summary, it is said that the model obtained at the 6th step is the best model in all aspects.

**Table 2** shows the Cox's regression analysis by stepwise method (Wald's forward). In the table, estimated coefficients (β) of covariates, standard error of β Estimates (SE), Wald's test statistic values, p-values of Wald's test, relative risks of covariates on child survival ($e^{\beta}$) and 95% confidence interval of relative risks are shown. In first step, the Duration of Breastfeeding (DBF) is entered in the model and selected as the most important covariate out of 8 variables.

**Table 1.** Omnibus tests of model coefficients for Cox's Proportional hazard regression

| | | Overall (score) | | | Change from previous step | | | Change from previous block | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Step | -2 Log Likelihood | Chi-square | df | P-value | Chi-square | df | P-value | Chi-square | df | P-value |
| 1 | 402.163 | 195.617 | 1 | <0.001 | 69.706 | 1 | <0.001 | 69.706 | 1 | <0.001 |
| 2 | 359.144 | 251.174 | 2 | <0.001 | 43.018 | 1 | <0.001 | 112.724 | 2 | <0.001 |
| 3 | 350.393 | 291.080 | 3 | <0.001 | 8.752 | 1 | 0.003 | 21.476 | 3 | <0.001 |
| 4 | 340.966 | 304.156 | 4 | <0.001 | 9.427 | 1 | 0.002 | 130.902 | 4 | <0.001 |
| 5 | 326.259 | 317.242 | 5 | <0.001 | 14.707 | 1 | <0.001 | 145.609 | 5 | <0.001 |
| 6 | 315.155 | 325.667 | 6 | <0.001 | 11.104 | 1 | 0.001 | 156.713 | 6 | <0.001 |

**Table 2.** Cox's regression analysis of survival time of child by stepwise method

| | | | | | | | 95.0% CI for Exp(B) | |
|---|---|---|---|---|---|---|---|---|
| Sept | Covariates | B | SE | Wald | P-value | Exp(B) | Lower | Upper |
| 1 | DBF | -3.170 | 0.334 | 90.060 | <0.001 | 0.042 | 0.022 | 0.081 |
| 2 | DBF | -2.879 | 0.338 | 72.424 | <0.001 | 0.056 | 0.029 | 0.109 |
| | DPT | -2.228 | 0.382 | 34.051 | <0.001 | 0.108 | 0.051 | 0.228 |
| | TTF | -1.085 | 0.361 | 9.018 | 0.003 | 0.338 | 0.166 | 0.686 |
| 3 | DBF | -2.524 | 0.365 | 47.935 | <0.001 | 0.080 | 0.039 | 0.164 |
| | DPT | -1.915 | 0.404 | 22.414 | <0.001 | 0.147 | 0.067 | 0.326 |
| | TTF | -1.173 | 0.363 | 10.433 | 0.001 | 0.309 | 0.152 | 0.630 |
| 4 | CMT | -1.228 | 0.438 | 7.868 | 0.005 | 0.293 | 0.124 | 0.691 |
| | DBF | -2.233 | 0.376 | 35.263 | <0.001 | 0.107 | 0.051 | 0.224 |
| | DPT | -1.617 | 0.415 | 15.220 | <0.001 | 0.198 | 0.088 | 0.447 |
| | TTF | -1.573 | 0.366 | 18.479 | <0.001 | 0.207 | 0.101 | 0.425 |
| | NHM | -0.297 | 0.092 | 10.443 | 0.001 | 0.743 | 0.620 | 0.890 |
| 5 | CMT | -1.461 | 0.436 | 11.216 | 0.001 | 0.232 | 0.099 | 0.546 |
| | DBF | -2.162 | 0.370 | 34.210 | <0.001 | 0.115 | 0.056 | 0.237 |
| | DPT | -1.731 | 0.406 | 18.180 | <0.001 | 0.177 | 0.080 | 0.393 |
| | TTF | -1.836 | 0.371 | 24.542 | <0.001 | 0.159 | 0.077 | 0.330 |
| | NHM | -0.339 | 0.080 | 17.977 | <0.001 | 0.713 | 0.609 | 0.834 |
| 6 | CMT | -1.398 | 0.447 | 9.798 | 0.002 | 0.247 | 0.103 | 0.593 |
| | DBF | -2.342 | 0.367 | 40.780 | <0.001 | 0.096 | 0.047 | 0.197 |
| | DPT | -1.920 | 0.404 | 22.609 | <0.001 | 0.147 | 0.066 | 0.323 |
| | ING | -0.678 | 0.209 | 10.481 | 0.001 | 0.508 | 0.337 | 0.765 |

**Table 3.** Mean of covariates

| Covariates | Mean |
|---|---|
| TTF | 0.91 |
| NHM | 6.13 |
| TCB | 2.80 |
| CMT | 0.55 |
| DBF | 0.95 |
| DPT | 0.76 |
| PAR | 2.54 |
| ING | 1.30 |

**Table 4.** Survival function constructed by Cox's hazard regression model

| | | | At mean of covariates | |
|---|---|---|---|---|
| Time | Baseline cum hazard | Survival[$\bar{S}$(t)] | SE | Cum hazard |
| 0 | 0.87106 | 0.99990 | 0.00011 | 0.00010 |
| 3 | 2.78165 | 0.99969 | 0.00023 | 0.00031 |
| 6 | 3.82533 | 0.99957 | 0.00030 | 0.00043 |
| 8 | 4.90377 | 0.99945 | 0.00036 | 0.00055 |
| 10 | 7.38622 | 0.99917 | 0.00050 | 0.00083 |
| 12 | 12.92744 | 0.99855 | 0.00074 | 0.00145 |
| 13 | 17.79104 | 0.99801 | 0.00098 | 0.00199 |
| 18 | 20.56871 | 0.99770 | 0.00111 | 0.00230 |
| 19 | 26.66845 | 0.99702 | 0.00137 | 0.00299 |
| 20 | 33.21565 | 0.99629 | 0.00165 | 0.00372 |
| 21 | 48.71900 | 0.99456 | 0.00224 | 0.00546 |
| 22 | 52.98561 | 0.99408 | 0.00240 | 0.00594 |
| 27 | 57.65226 | 0.99356 | 0.00257 | 0.00646 |
| 29 | 62.63949 | 0.99301 | 0.00276 | 0.00702 |
| 31 | 68.03814 | 0.99241 | 0.00296 | 0.00762 |
| 33 | 80.38848 | 0.99103 | 0.00342 | 0.00901 |
| 35 | 93.66622 | 0.98956 | 0.00390 | 0.01049 |
| 36 | 100.71857 | 0.98878 | 0.00416 | 0.01128 |
| 37 | 107.91505 | 0.98798 | 0.00442 | 0.01209 |
| 44 | 118.18458 | 0.98685 | 0.00485 | 0.01324 |
| 46 | 130.25732 | 0.98551 | 0.00534 | 0.01459 |
| 47 | 142.62395 | 0.98415 | 0.00585 | 0.01598 |
| 49 | 155.69708 | 0.98271 | 0.00639 | 0.01744 |
| 53 | 173.02629 | 0.98080 | 0.00704 | 0.01938 |
| 55 | 211.44446 | 0.97659 | 0.00893 | 0.02369 |
| 57 | 261.32690 | 0.97115 | 0.01132 | 0.02928 |
| 58 | 434.57864 | 0.95248 | 0.01927 | 0.04869 |

In the second step, in addition to DBF, DPT is entered in the model and subsequently at the 6th step, the six covariates viz., Type of Toilet Facility (TTF), Number of Household Members (NHM), CMT (use contraceptive), Duration of Breastfeeding (DBF), DPT and Ideal Number of Girls (ING) are entered in the model and these six covariates comprise the best set of the covariates which can explained the survival status of child. These six covariates have negative relationship with the survival status of child.

The hazard ratio or relative risk of the covariate TTF is 0.159 and it is as little as 0.077 or as much as 0.330 with 95% confidence. It means that the hazard rate of child reduces by 15.9% in households with sanitary latrine as compared with the households without sanitary latrine, at any time and a reduction in the hazard rate of between 70.5 and 76.8% is consistent with the data.

In favour of this finding, Roth and Kurup (1990) suggest that good public sanitation systems may constitute a more important preventive aspect of child survival. In the latter study of Kabir and Amin (1993) in Bangladesh also highlights that the households with sanitary latrines have low risks of child mortality. The similar finding is also reported by Pandey *et al*. (1998) on their study of infant and child mortality in India, a subject report of

NFHS-2 and they have mentioned that access to a flush or pit toilet households have substantial and often statistically significant adjusted effects on infant and child mortality. The adjusted effect on mortality of household access to a flush or pit toilet is strongest for the neonatal period and becomes weaker at later ages. The adjusted effect tends to be significant in states with relatively high levels of neonatal mortality: Uttar Pradesh, Orissa, West Bengal and Assam. This pattern suggests that the lack of access to a flush or pit toilet is associated with increased risk of neonatal tetanus. As highlighted by Klaauw and Wang (2004), access to sanitation facilities i.e., access to toilet facility can reduce under-five mortality rate significantly in rural areas of India as a whole. In urban Kenya, access to modern sanitation facilities (flush toilets) reduces diarrhea prevalence in urban areas and ultimately reduces the child mortality (Mutunga, 2004). In a study of Balk *et al*. (2005), the principal component analysis is used to combine the correlated variables which influence on mortality. From this analysis it is found that the mortality is correlated positively with the complete lack of toilet facilities and negatively with access to flush toilets. It is also suggested by Vos and Cuesto (2005) that the availability of better sanitation will decrease the probability of infant death since better sanitation and drinking water access by the household should positively improve hygienic and health conditions for all members. On the other hand, Baker (1999) and Rutstein (2000), in contrary to above findings, observe that access of pit latrine does not have a significant effect on child mortality in the country.

The hazard ratio of NHM is 0.713 with 95% confidence interval (0.609-0.839) and it suggests that the total hazard rate of child reduces by 71.3% when one member is increased at any time in the existing number of family members. And, the hazard ratio as low as 0.609 or as high as 0.839 is consistent with the observed data at 5% level of significance. Many researchers like Srivastava (1994) and Kabagenyl and Rutaremwa (2013) also suggest the same finding and concluded that the effect of family size on child mortality is statistically and substantially strong.

The estimated hazard ratio of CMT (use contraceptive) by mother is 0.247 with 95% confidence interval (0.103-0.593) and it infers that risk of child death is 24.7 less in those children born to mother using contraceptive than those children born to mother not using contraceptive, throughout the study period and the hazard ratio between 0.103 and 0.593 is consistent with the observed data at 0.05 level of significance.

The present finding is in line of the findings of Tsui and Creanga (2009) and Saha and Soest (2013). Mensch in his study on the effect of child mortality on contraceptive use and fertility in Colombia, Costa Rica and Korea, suggests that contraceptive use by women tends to reduce child mortality. Saha and Soest (2013) also express that complete contraceptive use could reduce infant mortality of birth order two and higher by 7.9%. The net effect of complete contraceptive use on the total infant mortality rate is small, because the favorable effect on higher order births is partly offset by the rise in the proportion of high-risk first births.

The hazard rate of Duration of Breastfeeding (DBF) is 0.096 with 95% confidence interval (0.047-0.197). It suggests that child reduces by 9.6% when duration of breastfeeding is less than 6 months and it may be as little as 4.7% or as much as 19.7% with 95% confidence with the study data, at any time, given other covariates held constant.

The present statement is in collusion with elsewhere findings of Palloni and Millman (1985; Fauveau *et al*., 1990; Sandiford *et al*., 1991; Basics, 1997; Pandey *et al*., 1998; Claeson *et al*., 1999), as they highlight that breastfeeding promotion might be expected to have its largest effect on infant mortality. And it is also reported by Bhuyan (2000) that duration of breastfeeding and age at marriage of mother have some influence in reducing mortality level of children. Bhuyan (2000) suggests that an increase in the duration of breastfeeding entails with a fall in post-neonatal mortality. A rise in the percentage of children aged 7-9 months who were both breastfed and getting solid foods is associated with decrease in both post natal and infant mortality rates. Biswas *et al*. (2000) also report in their study on impact of some biosocial variables on infant and child mortality that breastfeeding appears to be prime factor influencing infant during second year (12-23 months) and early child (24-59 months). Further they suggest breastfeeding more than one year appears to have greatest potential for reducing infant and childhood mortality.

Further, (Mahy, 2003) indicates that the vertical transmission of HIV occurs in approximately 32% of births to HIV infected mothers in countries where breastfeeding is prevalent and it will directly affect on childhood mortality too.

The Diphtheria, Pertussis, Tetanus (DPT) vaccine given to mothers during pregnancy has likely to have 14.7% less chance of their child death as compared with others as evident by hazard ratio 0.147 with 95% confidence interval (0.066-0.323) keeping effects of other covariates constant.

The estimated hazard ratio for Ideal Number of Girls (ING) is 0.508 with 95% confidence interval (0.337-0.765) and it interprets that the hazard rate reduces by 50.8% for every one increase in ideal number of girls desired by parents and a decrease in the hazard rate of between 33.7 and 76.5% is consistent with the data.

**Table 5.** Life table of children under study

| Age of child (month) | No. of deaths | Cumulative number of deaths | No. of alive | $\bar{S}(t)$ | S(t) |
|---|---|---|---|---|---|
| 0 | 1 | 1 | 835 | 0.99990 | 0.99473 |
| 3 | 2 | 3 | 833 | 0.99969 | 0.99717 |
| 6 | 1 | 4 | 832 | 0.99957 | 0.94629 |
| 8 | 1 | 5 | 831 | 0.99945 | 0.99956 |
| 10 | 2 | 7 | 829 | 0.99917 | 0.85694 |
| 12 | 3 | 10 | 826 | 0.99855 | 0.72724 |
| 13 | 2 | 12 | 824 | 0.99801 | 0.88604 |
| 18 | 1 | 13 | 823 | 0.99770 | 0.92966 |
| 19 | 2 | 15 | 821 | 0.99702 | 0.82320 |
| 20 | 2 | 17 | 819 | 0.99629 | 0.85390 |
| 21 | 4 | 21 | 815 | 0.99456 | 0.81115 |
| 22 | 1 | 22 | 814 | 0.99408 | 0.98098 |
| 27 | 1 | 23 | 813 | 0.99356 | 0.88597 |
| 29 | 1 | 24 | 812 | 0.99301 | 0.97971 |
| 31 | 1 | 25 | 811 | 0.99241 | 0.92344 |
| 33 | 2 | 27 | 809 | 0.99103 | 0.93884 |
| 35 | 2 | 29 | 807 | 0.98956 | 0.91925 |
| 36 | 1 | 30 | 806 | 0.98878 | 0.97568 |
| 37 | 1 | 31 | 805 | 0.98798 | 0.98896 |
| 44 | 1 | 32 | 804 | 0.98685 | 0.86233 |
| 46 | 1 | 33 | 803 | 0.98551 | 0.86999 |
| 47 | 1 | 34 | 802 | 0.98415 | 0.97254 |
| 49 | 1 | 35 | 801 | 0.98271 | 0.99190 |
| 53 | 1 | 36 | 800 | 0.98080 | 0.86962 |
| 55 | 1 | 37 | 799 | 0.97659 | 0.99172 |
| 57 | 1 | 38 | 798 | 0.97115 | 0.87707 |
| 58 | 2 | 40 | 796 | 0.95248 | 0.77214 |

**Table 5** shows the life table of children under study. One child is death before reaching one month after birth and the estimated survival chances of children within one month is 0.99473. The two children are died in between first and third months after birth and their survival chances at that time is 0.99717. Another one child is died at 6th month of birth and its survival chance is 0.94629. Similarly, the survival chances of the children on 8th, 10th and 12th months after birth are estimated at 0.99956, 0.85694 and 0.72724 respectively. At the end of the table, two children are died and the survival chance of each of them on 58th month is 0.77214.

Further, it is observed that the survival chances of children are sometimes increase in some months and then reduces in other months i.e., there is no uniform trend of either decrease or increase of survival chances of children with respect to time.

## 4. CONCLUSION

The present study is confined in four valley districts of Manipur, India due to financial and time constraints Moreover, only eight covariates are used to analyze the effects of them on under-five mortality. If it can cover whole state and the country as a whole as well as other covariates relating to socio-economic, demographic, health, environment, sanitation then the new pattern of the effects covariates on under-five mortality may be realized and it will help to government agencies, policymaker and health practitioners to reduce under-five mortality.

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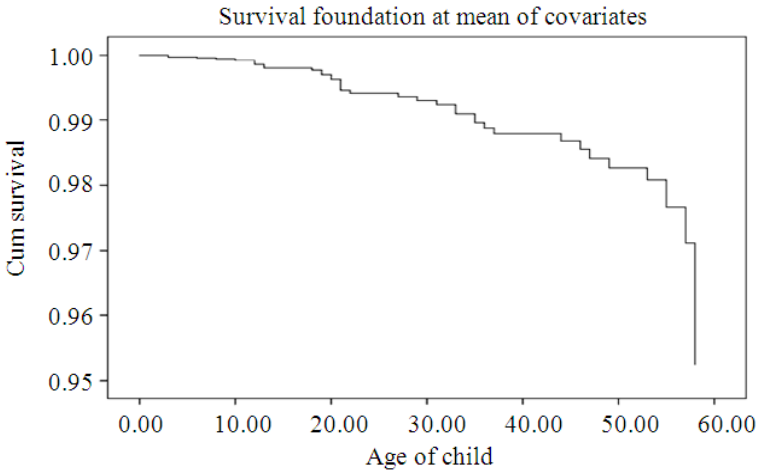


**Fig. 1.** Survival function at the mean of covariates

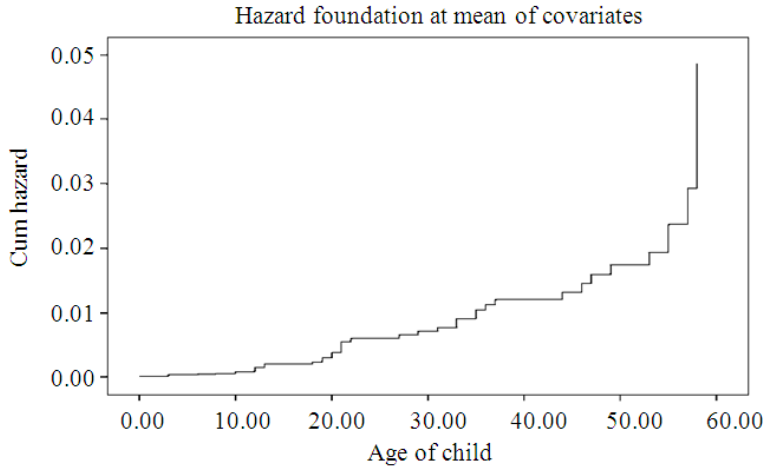


**Fig. 2.** Hazard function at mean of covariates