

On the Behavior of Child Mortality through different Survival Models in India

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ABSTRACT

This paper discussed the implication of parametric and semi-parametric survival models to measure the unobserved heterogeneity (frailty) caused by omitted or unmeasured factors using 21906 childbirth in India. This study particularly compare the child survival risk due to observed factor extent to standard survival model and unobserved factors that extent to frailty models and log rank test is utilized for the comparison of survival trends of children in India. Data is taken from 2005-06 National Family Health Survey (NFHS III), a largest survey report of India. Findings of standard survival models present that almost all the factors included in the study are explaining the child mortality but the parameters estimated in these models are either overestimated or underestimated that resulted biased estimates a major issue in the analysis. Frailty effects are highly significant in both parametric and nonparametric survival models and are having similar conclusion.

Keywords: Under Five Child Mortality, Proportional Hazard Model, Cox Proportional Hazard Model, Weibull Frailty Model, Cox Frailty Model, Log Rank Test.

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1 Introduction

Children are valuable assets for a country as they play a significant role of a nation's present and it's future. Human society's future depends on children being able to attain their psychological development and physical growth. Development in the initial childhood stage is contemplated as the most important period in life which resolves the quality of health, learning, behaviour and well-being across the life span. Child mortality rate (CMR) is explained as the total number of death of child under the age five year per thousand live birth and it is a significant indicator for above mentioned issues. World's officers acknowledged on the Millennium

Development Goals (MDGs) in 2000 and MDG 4 target was to decreased the mortality rate of child under the age of five years by two third since 1990 to 2015.

On the ending of MDG stages, the international community has been agreeing on a new structure i.e. Sustainable Development Goals (SDGs) and the target of SDG for child mortality presents a revived commitment to the children of world: "By 2030, end avoidable deaths of newborns and children under the age of five years, with all countries focusing to decrease mortality of neonatals (child death under the age of one month per 1000 live birth) to at least as low as 12 deaths per 1000 live births and child mortality (child death under the age of five year per 1000 live birth) to at least as low as 25 deaths per 1000 live births". CMR for developed region and developing region was 6 and 47 per 1000 live birth respectively (UN, 2015) whereas MDG target was 5 and 33 per 1000 live birth.

India is a developing country having child (under-five years) mortality rate 48 per thousand live births (SRS, 2015). In 1990, child (under five years) mortality rate was 118 death per thousand live birth, it have a nice decrement in under-five mortality since 1990-2015 but it is still high as compare to developed nations. This high mortality requires more systematic and analytical research related to the covariates of child mortality in India. Literature shows that vital research has been done to show the association of child survival with various demographic, environmental, socio-economic and biological factors in different countries (Jelliffe and Jelliffe, 1978; Caldwell, 1979; Palloni, 1986; Maturi and Curtis, 1995; Masuy-Stoorbant, 2001; White, 2006; Singh et al., 2007; Muluye and Wencheke, 2012; Chowdhary, 2013; Lakshmi and Geetha, 2017).

Above studies done on the basis of observed covariates that means it is considered as all heterogeneity is captured by observed covariates but it is almost impossible to have all essential risk factors due to less/no information at individual level. Moreover, it may be possible that we do not know the importance of the risk factors. To assess the unmeasured heterogeneity in time duration resulting from unmeasured /unobserved risk factors, first Beard (1959) and later Vaupel et al. (1979) proposed a mixture/random effect (frailty) model. Here Beard used the word longevity factor at the place of frailty.

Several simulation and empirical studies have shown that the consideration of unobserved/unmeasured heterogeneity improve the fitness of model (Sastry, 1997; Blossfeld and Hamerle, 1992). A different approach utilize the term frailty, to account the associations between event/survival times (shared frailty) is considered by the Clayton (1978). Few literatures is available where it is considered that multiple observation share the same frailty of individual (Vaupel, 1989; Curtis et al., 1993; Sastry, 1996; Das Gupta, 1997; Sastry, 1997b; Cleves et al. 2004).

This study evaluates the association of socioeconomic, sociocultural determinants with the child survival in India after accounting parametric and nonparametric frailty and non frailty models. This analysis considers the child of age under-five and clustering the sibling's survival experiences. Analysis suggests that the survival durations of the children who share the same mother are dependent therefore their survival risk are also associated. In this aspect frailty models play an crucial role which allow association in the survival experiences of siblings and then determine the authentic estimates of factors related to mortality.

2 Data, Models and estimation

This paper utilizes data from the third round of the National Family Health Survey (NFHS III) of India which carried out as "the principal activity of a collaborative project to strengthen the research capabilities of the Population Research Centers in India, initiated by the Ministry of Health and Family Welfare, Government of India, and coordinated by the International Institute for Population Science Mumbai". This survey recorded complete history of married women of age 15-49 years in 2005-06, including the survival experiences of their children. Information related to birth history was compiled from 11,253 mothers of age 15-49 years (reproductive age) and 21907 births were reported under the age five years. In this study it is assumed that demographic, socio-economic, socio-cultural and environmental factor are not changed over the time therefore factors are considered under the condition at the time of the survey.

2.1 Analytical Methods

In the study, outcome variable is the time of children's survival from their birth to survey which is quantified in months. Consequently, Cox (1972) proposed a model to examine the impact of different variables on childhood mortality namely, Cox Proportional Hazard Model/semiparametric hazard model which is termed as:

$$\lambda_i(\tau | x_i) = \lambda_0(\tau | x_i) \exp(\beta x_i) \quad (2.1)$$

where, $\lambda_i(\tau | x_i)$ is the child death hazard for i^{th} observation at the time τ , $\lambda_0(\tau | x_i)$ is the baseline hazard, β and x_i are vectors of parameters and covariates respectively. In parametric proportional hazard model it is assumed that the response variable has some distribution that means the shape of baseline hazard is known which is not feasible practically. This study utilized Weibull proportional hazard regression model and the form of this model is given below,

$$\lambda_i(\tau | x_i) = p\gamma\tau^{\gamma-1}\exp(\beta x_i) \quad (2.2)$$

where, γ and p are shape and scale parameters. In this paper Weibull model is chosen on the basis of Akaike Information Criterion (AIC) values.

Basic survival models consider only observable factors whereas, frailty model assumes that, individual death risk is a function of observable variables and a random effect term. Random effect term is used to measure the unobservable risk and all the individuals in a cluster shared this risk. In survival analysis Frailty model is a mixture model with the variation in groups and individual, defined by hazard function. The form of such model is given below,

$$\lambda_{ij}(\tau | x_{ij}, \alpha_j) = \alpha_j h_{ij}(\tau | x_{ij}) \quad (2.3)$$

where, $\lambda_{ij}(\tau | x_{ij}) = \lambda_0(\tau | x_{ij}) \exp(\beta x_{ij})$ and data include n cluster with j^{th} cluster comprised of n_i individuals. The j^{th} index indicates the cluster ($j = 1, 2, \dots, n$), whereas i indicates the individual observation within cluster, ($i = 1, 2, \dots, n_i$). In this paper, i and j represent children and mother, respectively. α_j is the frailty i.e. a random positive quantity which is shared within the families and assumed to have a mean of 1 and variance σ^2 . If estimated variance is

significantly non zero that means unobservable variables shared by siblings have impact on their lifetime and their risk of surviving are correlated. Frailty models measure the death risk on the basis of both measured/observed and unmeasured/unobserved factors.

Some studies assumed that the unobserved frailty follow a gamma distribution and captured by its variance σ^2 (Sastry, 1996; Oakes, 1982). In this study, the choice, of the frailty variable which follows gamma distribution is based on AIC values. If baseline hazard follow some distribution then frailty model is called parametric gamma frailty model otherwise it is said to be a semi-parametric gamma frailty model. Here it is assumed that the lifetime of children up to age five year follow Weibull distribution therefore Weibull-gamma frailty model is utilized. If there no information available on the form of baseline hazard function then a semiparametric approach is often preferable.

3 Results

3.1 Descriptive Analysis

The main focus of this study is to analyze child mortality in India, in respect of different determinants (observable and unobservable) of mortality by using different survival models and to see how these factors behave with each survival model included in this study, in addition, it also describe that which one model is more sophisticated for this type of data. Observed factors are selected on the basis of Mosley and Chen (1984) structure and from some literature available on the mortality of child (Rutstein, 2000; Sastry, 1997c). Mosley and Chen operate all socioeconomic and sociocultural factors of child mortality in a set of five proximate variables (household environmental contamination, maternal factors, injury, personal illness and nutrient deficiency). This study includes socio-economic factors as mother literacy, standard of living while socio-cultural as ethnicity, and religion. The proximate factors included as mother age at child birth, source of drinking water and toilet facility types. Table 1, shows the distribution of births and deaths with different covariates in India 2005-06. This data have only few missing observations, the number of missing observation are 5 in mother literacy, 7 in mother age and 292 in religion. The size of missing observations is very small relative to overall sample which will have minimal impact on results, therefore we excluded these observation from data which used in modelling of child mortality. Out of 21906 births, information was missing on 303 births, now, our data have full information on 21603 births.

Out of 21603 births, 11723 experienced the event i.e. death and 9880 are censored observation and in these children 49% are male and 51% are female child. About 21% mother are those who are illiterate and 4% are those who gave birth under the age 18 years. Hindu seems to be predominant religion in India, approximate 76% children belong to Hindu household, 15% to Muslim household and 5% to Christian household. Approximately, 77% children live in household without any toilet facility and 80% children belong to rural residence. About 77% children live in the house where, source of drinking water is river/lake and 70% of children have high standard of living. Table 2, presents the results of log rank test which is used to compare the survivorship function among groups. In all covariates except place of residence, the significance of chi-square values and p-values indicate that the null hypothesis (survivorship

Table 1: Child distribution by covariates

Variables	Birth		Death	
	Number	Percent	Number	percent
Source of Drinking Water				
Piped water	1013	4.62	430	3.62
Well water	3594	16.41	1952	16.44
River, lake water	16942	77.34	9310	78.43
other	357	1.63	179	1.51
Sex				
Male	10709	48.88	5922	49.89
Female	11197	51.12	5949	50.11
Religion				
Hindu	16741	76.42	9573	80.64
Muslim	3306	15.09	1581	13.32
Christian	1122	5.12	351	2.96
Sikh	240	1.10	136	1.15
Buddhist	157	0.72	63	0.53
Jain	11	0.05	8	0.07
Other	329	1.50	159	1.34
Place of Residence				
Rural	17513	79.95	9517	80.17
Urban	4393	20.05	2354	19.83
Mother Literacy				
Literate	4543	20.74	1983	16.71
Illiterate	17358	79.26	9886	83.29
Standard of living				
Low	15360	70.12	8362	70.44
Medium	5120	23.37	2711	22.84
High	1426	6.51	798	6.72
Mother age (year)				
<18	863	3.94	721	6.08
18-24	9033	41.25	5509	46.43
25-29	8550	39.04	4266	35.96
30-34	2832	12.93	1198	10.10
35 and more	621	2.84	170	1.43
Type of toilet facility				
No toilet	16895	77.12	9501	80.04
Public community toilet	182	0.83	99	0.83
Shared toilet	543	2.48	237	2.00
Own pit toilet	2368	10.81	1037	8.74
Own flush toilet	1918	8.76	997	8.40
Caste				
Scheduled caste	5298	24.51	3064	26.12
Scheduled tribes	4027	18.63	1838	15.67
Other backward caste	8395	38.84	4662	39.74
Other	3894	18.02	2167	18.47

functions are same) is rejected.

Table 2: Log rank test

Covariates	Chi Square	d.f.	p-value
Source of drinking water	57.358	3	0.000
Sex	44.13	1	0.000
Religion	317.044	6	0.000
Place of residence	0.002	1	0.967
Mother literacy	194.695	1	0.000
Standard of living	8.012	2	0.018
Mother age	443.323	4	0.000
Type of toilet facility	127.912	4	0.000
Caste	170.046	3	0.000

3.2 Parametric, semi-parametric and non parametric Survival Curves

This study included the parametric, semi-parametric and nonparametric survival curves for showing the survival patterns of children with respect to different categories. In non-parametric methods, Kaplan-Meier (1958) estimates are used to show the survival curves. From the figures (1 to 8), it seems that the parametric curves are going nicely through the Kaplan-Meier estimates, this gives the weightage to the decision to use a Weibull distribution in parametric models. In this paper, survival plots of Weibull model illustrate that, the parametric survival curves are much smoother than those based on the Kaplan-Meier (nonparametric) estimates and Cox hazard (semiparametric) model. The reason is that, in parametric models, the age profile of mortality is determined by the distribution, whereas in nonparametric and semiparametric approaches, the shape is not fixed, but is a step function.

Figure 1, shows the survival curve of child in respect of their sex in India, in case of Kaplan-Meier estimates and Weibull hazard model, female child survival is better than the male child, whereas, in semi-parametric survival model male child have better survival than female but survivals of both are very close to each other. Figure 2, shows the survival curves of children with the literacy of their mothers, child have nice survival if their mother are literate as compare to those who do not have literate mothers, in this case all parametric, non-parametric and semi-parametric have similar results. Survival of children in respect of other categories can be seen in the same manner. Survival curves of children in respect of place of residence are not shown in this paper because, log rank test has been presented that in the case of place of residence, our data is in the favour of null hypothesis (survivorship functions are same).

3.3 Results of Survival Models

In this paper, four models are estimated for India; the Weibull standard model (parametric survival model), Weibull frailty model (parametric frailty model), Cox standard model (semiparametric survival model) and Cox frailty model (semiparametric frailty model). Standard survival models allow observed variables, whereas, frailty models allow both observed and unobserved

variables. In this study frailty measured the unobserved risk shared by siblings introduced as gamma.

Table 3, shows the findings of Weibull standard model and Weibull frailty model on the timing of survival of child under the age five years in respect of measured factors (without frailty) and unmeasured factors (with frailty) respectively, in India. Hazard ratio ($\text{Exp}(\beta)$) less than one indicate a decreased mortality risk, while those greater than unity indicate an increased risk and the interpretation of hazard ratio is either in the number of times risk changes or in percentage change in the risk of death. Some significant results of Weibull standard model are given as: Female child have 29% lower risk of death as compare to male child and results are highly significant. In India, a big part of population belongs to Hindu religion, this study said that children who belong to Muslim and Christian household have 50% and 58% lower risk of death of child as compare to reference category (Hindu household) respectively and these results are highly significant. Children, where mother is illiterate, have approximately twice risk of death than the children those mothers are illiterate. Low standard household of children are in the reference category. If child belong to medium and high standard of living then they have 37% and 47% lesser risk of death than reference category. Mother age is also playing a significant role in the survival of their child. If mother age of a child is less than 18 years than child have high risk of death as compare to mother age greater than eighteen year. In India marriage in the age less than 18 year is illegal due to its negative impact on many social factors. Approximate two third population have no toilet facility in their household. Children have 26% and 25% lower risk of death if they have their own pit and flush toilet respectively.

The Caste System in India is historically one of the main dimension where population is socially differentiated through religion, tribe, region, class, language and gender. For caste, this study categorized people on the basis of Indian constitution. Schedule caste (Dalit) and Schedule tribe (Adivasi) caste was depressed caste during nineteenth century. Children belong to Schedule tribe (ST) have 35% lower risk of dying, while in case of other (general) caste child have 1.4 times risk of death than reference category (SC).

But are these results of Weibull standard model valid? It may be possible that the findings of basic survival models are biased and misleading. To test the strength of results described earlier, the model is again estimated with gamma frailty. The interest of methodology here is that how regressors behave when frailty is introduced to unmeasured heterogeneity follow to gamma distribution. Second model of Table 3, shows the findings of Weibull frailty model and frailty variance is denoted as sigma square. The null hypothesis ($\sigma^2 = 0$) is rejected, indicating that unmeasured heterogeneity is shared by siblings. This significant result of frailty recommends that the mortality risk of child the function of both measured/observed variables and frailty. Log likelihood values in Table 3 suggest that Weibull frailty models are more preferable than Weibull standard model.

In both the models of Table 3, some significance difference are noticeable, whereas the behaviour of covariates in both models are almost similar, two different patterns on their magnitude are quite visible. Gyimah et al. (2012) described that "standard log normal models underestimate the negative coefficients(degree of positive duration dependence) but overestimate the positive coefficient(degree of negative duration dependence)". Here, Weibull standard

model underestimate the negative coefficients of variables such as sex, standard of living and mother age. Conversely, overestimate the positive coefficients of variables such as mother literacy and place of residence.

Table 3, presented the results, when the form of baseline hazard is considered to be known, but this study wants to see the overall behaviour of measured and unmeasured covariates in the case of parametric and semiparametric survival models. Table 4, shows the findings of Cox proportional hazard model (Cox standard model) and Cox gamma frailty model (Cox frailty model). In Cox model, the nature of baseline hazard is not known and the directions of regressors in Cox standard model and Cox frailty model are consistent. As earlier defined for Weibull frailty model, here also the null hypothesis that $\sigma^2 = 0$ is rejected. Here log likelihood values indicate that the Cox frailty model is more preferable than Cox standard model.

In all these four models, presented in Table 3 and Table 4, place of residence do not have any significance impact on child mortality, where as the significance impact of mother age is varying. In the case of Weibull standard model, Cox standard model and Cox frailty model, mother age is significantly associated with the child survival while the findings are not significant in Weibull frailty model. In all these models goodness of fit is checked by log likelihood values, here these values evident that the Weibull frailty is nicely fitted for this data of India.

4 Discussion and Conclusion

This study analyzed the association of socioeconomic, sociocultural, and biodemographic variables on the risk of child mortality in India and simultaneously controlled for correlation among the risk of mortality of siblings using shared frailty models. Rejection of null hypothesis associated with frailty described that the life time of siblings are associated and estimated frailty variance define that a child death in a family increase the death risk of index child in that family. A noticeable but not well known hypothesis in the literature of demography is maternal depression (Zenger, 1993; Palloni and Rafalimanana, 1999; Gyimah and Rajulton, 2004;). Depression of mother due to the loss of child could undermine the health of her previous child and subsequent birth. Depression may have impact on the women's childrearing and childbearing behaviour such as, a depress women may suffer from sleep loss, improper dietary habits during pregnancy and it may affect the general ability to care for her child. Negative pregnancy outcomes such as, preterm delivery, small gestation period and low birth weights are also significantly associated with depression (Steer et al., 1992). If it reflects the child death then it should be improve the birth spacing mechanism such as, use of contraceptions and peoples should be aware for the treatments related to depression in the case of sever stage.

An important determinant related to the death of child is women literacy which is important for improving women's decision-making power and autonomy (Caldwell, 1979). Child death is significantly high in illiterate mother due to the lack of child care strategies, child illness management, and less awareness related to modern health services (Das Gupta, 1997). Findings of this study related to mother literacy are consistent with the above discussed studies. Ethnic mortality discriminations are highly attributed at different level of socio-economic development among areas inhabited by the various classes (Brockerhoff and Hewett, 2000). Besides socio-

Table 3: Weibull survival model with and without frailty variable

Variables	Weibull standard model		Weibull frailty model	
	β	$\text{Exp}(\beta)$	β	$\text{Exp}(\beta)$
Source of Drinking Water				
Piped water ^a	-	-	-	-
Well water	0.037	1.038	0.116	1.123
River, lake water	0.071	1.074	0.144	1.155
other	-0.291	0.748	0.019	1.019
Sex				
Male ^a	-	-	-	-
Female	-0.348***	0.706	-0.207***	0.813
Religion				
Hindu ^a	-	-	-	-
Muslim	-0.709***	0.492	-0.354***	0.702
Christian	-0.862***	0.422	-0.632***	0.532
Sikh	0.014	1.014	0.104	1.110
Buddhist	-0.399	0.671	-0.476*	0.621
Jain	1.155	3.175	0.852	2.344
Other	-0.031	0.970	-0.374	0.688
Place of Residence				
Rural ^a	-	-	-	-
Urban	0.105	1.111	0.050	1.051
Mother Literacy				
Literate ^a	-	-	-	-
Illiterate	0.689***	1.991	0.360***	1.433
Standard of living				
Low ^a	-	-	-	-
Medium	-0.460***	0.631	-0.378***	0.685
High	-0.641***	0.527	-0.569***	0.566
Mother age (year)				
<18 ^a	-	-	-	-
18-24	-1.093***	0.335	-0.104	0.901
25-29	-1.266***	0.282	-0.041	0.960
30-34	-1.463***	0.232	-0.090	0.914
35 and more	-2.275***	0.103	-0.463***	0.629
Type of toilet facility				
No toilet ^a	-	-	-	-
Public community toilet	-0.145	0.865	-0.018	0.982
Shared toilet	-0.439**	0.645	-0.230	0.795
Own pit toilet	-0.299***	0.741	-0.236**	0.790
Own flush toilet	-0.281**	0.755	-0.285**	0.752
Caste				
Scheduled caste ^a	-	-	-	-
Scheduled tribes	-0.420***	0.657	-0.280***	0.756
Other backward caste	0.069	1.071	0.078	1.081
Other	0.343***	1.409	0.269***	1.309
Log likelihood	-42373.8		-39337.6	
σ^2			2.357***	

^aReference Category

Statistical significance: ***p<.001, **p<.01, *p<.05

Table 4: Cox survival model with and without frailty

Variables	Cox standard model		Cox frailty model	
	β	$\text{Exp}(\beta)$	β	$\text{Exp}(\beta)$
Source of Drinking Water				
Piped water ^a	-	-	-	-
Well water	0.013	1.013	0.066	1.068
River, lake water	0.029	1.030	0.089	1.093
other	-0.135	0.874	-0.051	0.950
Sex				
Male ^a	-	-	-	-
Female	-0.138***	0.871	-0.166***	0.847
Religion				
Hindu ^a	-	-	-	-
Muslim	-0.299***	0.742	-0.339***	0.712
Christian	-0.355***	0.701	-0.480***	0.619
Sikh	0.004	1.005	0.076	1.079
Buddhist	-0.177	0.838	-0.353	0.703
Jain	0.575	1.777	0.797	2.219
Other	-0.023	0.977	-0.219	0.803
Place of Residence				
Rural ^a	-	-	-	-
Urban	0.037	1.038	0.047	1.048
Mother Literacy				
Literate ^a	-	-	-	-
Illiterate	0.290***	1.336	0.330***	1.391
Standard of living				
Low ^a	-	-	-	-
Medium	-0.198***	0.820	-0.327***	0.721
High	-0.274***	0.760	-0.478***	0.620
Mother age (year)				
<18 ^a	-	-	-	-
18-24	-0.475***	0.622	-0.211***	0.810
25-29	-0.613***	0.542	-0.279***	0.757
30-34	-0.743***	0.476	-0.410***	0.664
35 and more	-1.157***	0.314	-0.866***	0.421
Type of toilet facility				
No toilet ^a	-	-	-	-
Public community toilet	-0.055	0.946	-0.031	0.969
Shared toilet	-0.172**	0.842	-0.227**	0.797
Own pit toilet	-0.122***	0.885	-0.196**	0.822
Own flush toilet	-0.111**	0.895	-0.226**	0.798
Caste				
Scheduled caste ^a	-	-	-	-
Scheduled tribes	-0.178***	0.837	-0.245***	0.783
Other backward caste	0.031	1.031	0.070	1.073
Other	0.144***	1.155	0.234***	1.264
Log likelihood	-113625.4		-110681.0	
σ^2			1.370***	

^aReference Category

Statistical significance: ***p<.001, **p<.01, *p<.05

economic factors, socio-cultural variables are analyzed to see the relationship of child death according to their cultural traditions and societies norms. Cultural tradition and norm are significantly associated with child mortality due to food preferences, children's value and beliefs about diseases causation. In India, religion differences in childcare practices, pattern and belief on the causes of diseases are important, for example child mortality risk is significantly higher among Hindu than Muslim and Christian due to the big differences in their culture and societies norms especially in food preferences. Hindu is one of the oldest religion in the world and it have a way of life and a code of behaviour as other religions. But a big discrimination is the vegetarian food, in this culture peoples give preference to vegetarian food. For balancing of food nutrition's, they include some more nutritious vegetarian food in their diet but, it depends on the awareness and financial ability to get such type of food. As we discussed earlier, SC and ST are backward classes in India, but they have good child survival as compare to other caste. In these caste their economical conditions are not to good, in most-of the cases they live near about the natural environment that's why they have a strong immune system and have lower risk of child death.

Source of drinking water and toilet facility types reflects the environmental pollution level, which defines the transmission infection to children (Mosley and Chen 1984). These variables are proxy variables for unavailable information from the surveys, for example, standards of cleanliness, household hygiene, storage practices and food preparation etc. Results on the factor type of toilet facility are consistent with previous research and theoretical expectations, while the source of drinking water is insignificant. Only 5% children live in the households with the facility of piped water which is a shocking result, since most of the population depend on unsafe water sources.

In India sex selection abortion is illegal by Medical Termination of Pregnancy (MTP) Act, 1971. Although Indian household give a big importance to male child due to the mentality that, male child would be support them in future, this study results are surprising, because female child have a nice survival as compare to male child, this confirms with the biological heardlines of the girl child in India. This result is consistent with the current situation in India, which shows that the female life expectancy is higher than male. This study recommends that to avoid child death teenage pregnancy should be discouraged. Government should take further initiatives in respect of the construction of new toilets. Some health supplements should be distributed among children and pregnant women to bridge the nutritional gap.

The study suggests the factors, those are important for child mortality so that strengthen policies could be construct to reduce child mortality in India. Although our study focus on the risk of child mortality due to unmeasured covariates at family level, unmeasured heterogeneity at the level of community is also an interest. Children belong to same community share similar environmental, climatic, cultural and socioeconomic conditions and causes the same diseases and illness in the community (Sastry, 1997b). A major limitation of NFHS data is that, it does not provide the information at community level. Future studies can take place for seeing the behavior of child mortality at community level, where the information at community level is available.

References

- [1] Ata, N. 2013. Parametric proportional hazard model with time dependent covariates for non-proportional hazards. *International Journal of Ecological Economics and Statistics* **29(2)**: 1-12.
- [2] Beard, R. E. 1959. Note on some mathematical mortality models. In: The Lifespan of Animals. G.E.W. Wolstenholme, M.OConner (eds.), Ciba Foundation Colloquium on Ageing, Little, Brown, Boston: 302-311.
- [3] Blossfeld, H. P. and Hamerle, A. 1992. Unobserved heterogeneity in event history models. *Qual. Quant.* **26(2)**: 157-168.
- [4] Brockerhoff, M., and Hewitt, P. 2000. Inequality of child mortality among ethnic groups in sub-Saharan Africa. *Bulletin of the World Health Organization* **78(1)**: 30-41.
- [5] Caldwell, J. C. 1979. Education as a factor in mortality decline: An examination of Nigerian data. *Population Studies* **33(3)**: 395-413.
- [6] Chowdhury, A. H. 2013. Determinants of under five mortality in Bangladesh. *Open Journal of Statistics* **3**: 213-219.
- [7] Clayton, D. 1978. A model for association in bivariate life tables and its application in epidemiological studies of familial tendency in chronic disease incidence. *Biometrika* **65**: 141-151.
- [8] Cleves, M. A., Gould, W. W., and Gutierrez, R. G. 2004. An introduction to survival analysis using Stata. College Station, TX: Stata Corporation.
- [9] Cox, D. R. 1972. Regression models and life tables (with discussion). *Journal of the Royal Statistical Society B* **34**: 187-220.
- [10] Curtis, S. L., Diamond, I., and McDonald, J. W. 1993. Birth interval and family effects on postneonatal and mortality in Brazil. *Demography* **30(1)**: 33-43.
- [11] Das Gupta, M. 1997. Socioeconomic status and clustering of child deaths in rural Punjab. *Population Studies* **51**: 191-202.
- [12] Gyimah, S. O., and Rajulton, F. 2004. Intentional replacement of dead children in sub-Saharan Africa: Evidence from Ghana and Kenya. *Canadian Studies in Population* **31(1)**: 33-53.
- [13] Gyimah, S. O., Ezech, A. and Fotso, J. C. 2012. Frailty models with applications to the study of infant death on birth timing in Ghana and Kenya. *Qual. Quant.* **46**: 1505-1521.
- [14] Jelliffe, D. B. and Jelliffe, E. F. P. 1978. Human Milk in the Modern World. Oxford University Press, Oxford, 84-96.
- [15] Kaplan, E. L. and Meier, P. 1958. Nonparametric estimation from incomplete observations. *Journal of American Statistical Association* **53**: 457-481.

- [16] Lakshmi, S. S. and Geetha, R. 2017. Tweedie distribution in statistical modeling of infant survival time. *International Journal of Ecological Economics and Statistics* **38(1)**: 144-153.
- [17] Mosley, W. and Chen, L. 1984. An analytical framework for the study of child survival in developing countries. *Population and Development Review* **10**: 25-45.
- [18] Mturi, A. J. and Curtis S. L. 1995. The determinants of infant and child mortality in Tanzania. *Health Policy Plan*, **10**: 384-94.
- [19] Muluye, S. and Wencheke, E. 2012. Determinants of infant mortality in Ethiopia: A study based on the 2005 EDHS data. *Ethiopian Journal of Health Devision* **26(2)**: 72-77.
- [20] Oakes, D. 1982. A model for association in bivariate survival data. *Journal of Royal Statistical Society B* **44(3)**: 414-422.
- [21] Palloni, A. 1986. Does increase contraception decrease infant mortality. Centre for Demography and Ecology, University of Wisconsin in USA.
- [22] Palloni, A., and Rafalimanana, H. 1999. The effects of infant mortality on fertility revisited: New evidence from Latin America. *Demography* **36(1)**: 41-58.
- [23] Report 2015, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation.
- [24] Rutstein, S. O. 2000. Factors associated with trends in infant and child mortality in developing countries during the 1990s. *Bulletin of the World Health Organization* **78**: 1256-1270.
- [25] Sastry, N. 1996. Community characteristics, individual and household attributes, and child survival in Brazil. *Demography* **33(2)**: 211-229.
- [26] Sastry, N. 1997b. Family-level clustering of childhood mortality risk in northeast Brazil. *Population Studies* **51**: 245-261.
- [27] Sastry, N. 1997c. What explains ruralurban differentials in child mortality in Brazil? *Social Science and Medicine* **44(7)**: 899-1002.
- [28] Sastry, N. 1997. A nested frailty model for survival data, with an application to the study of child survival in Northeast Brazil. *Journal of American Statistical Association* **92**: 426-435.
- [29] Singh, K. K., Pandey, N. and Gautam A. 2007. Effect of Breastfeeding and Maternal Health Care programme on infant mortality. *Demography India* **36(2)**: 253-266.
- [30] Steer, R. A., Scholl, T.O., Hediger, M. L. and Fischer, R. L. 1992. Self-reported depression and negative pregnancy outcomes, *Journal of Clinical Epidemiology* **45(10)**: 1093-1099.

- [31] Stoorbant, M. G. 2001. The Determinants of infant mortality: How far are conceptual frameworks really modeled? Institute demographic Universities Catholique de Louvain.
- [32] Vaupel, J. W. 1989. Kindred lifetimes: Frailty models in population genetics. In J. Adams, D. A. Lam, A. I. Hermalin, & P. E. Smouse (Eds.), *Convergent issues in genetics and demography* (pp. 155-170). New York: Oxford University Press.
- [33] Vaupel, J., Manton, K. and Stallard, E. 1979. Impact of heterogeneity in individual frailty on the dynamics of mortality. *Demography* **16(3)**: 439-454
- [34] White, H. 2006. Determinants of infant and child mortality in Andhra Pradesh. University Library of Munich, Germany.
- [35] Zenger, E. 1993. Siblings neonatal mortality risks and birth spacing in Bangladesh. *Demography* **30(3)**: 477-488.

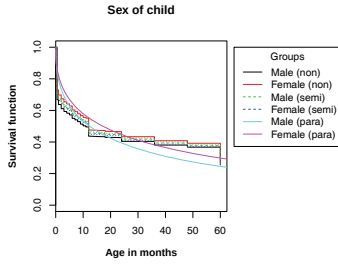


Figure 1: Survival curves of child in respect of their sex

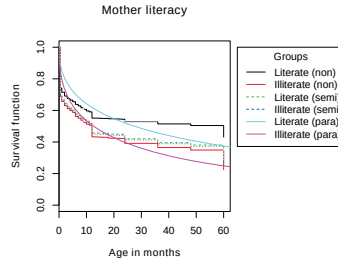


Figure 2: Survival curves of child with mother literacy

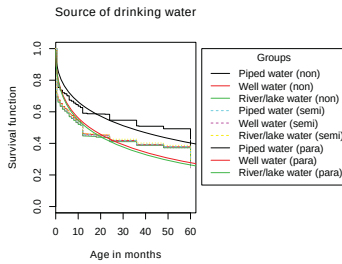


Figure 3: Survival curves of child with drinking water

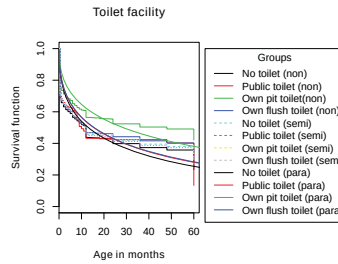


Figure 4: Survival curves of child with toilet facility

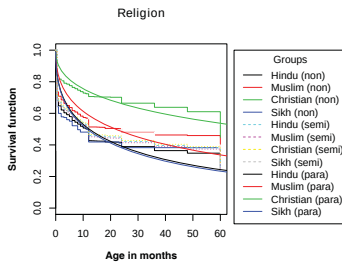


Figure 5: Survival curves of child with their religion

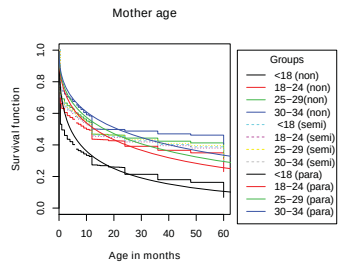


Figure 6: Survival curves of child with mother age

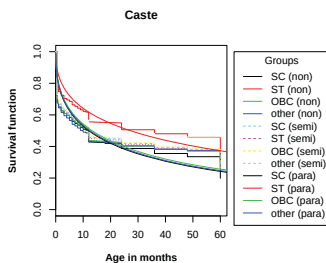


Figure 7: Survival curves of child with their caste

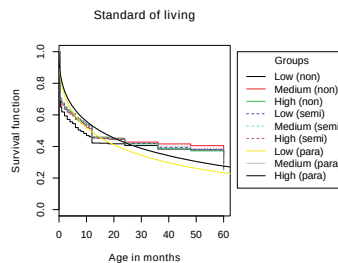


Figure 8: Survival curves of child with standard of living