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# Predictors of Age-Specific Childhood Mortality in India

**G. Naline and Brinda Viswanathan**

## Abstract

*Like many other developing nations, the age-specific mortality vary across regions and decline at different pace for India. Using a multinomial logit model, this study analyses the predictors for neonatal, post-neonatal, infant and under-five mortality. Mother's height, age of mother at first birth, dietary pattern of the mother and education of parents are significant predictors for all the age-specific mortality. Equally important are access and usage of appropriate health inputs like tetanus shots, regular consumption of iron tablets and ante-natal visits.*

*Compared to other age-specific mortality, neonatal mortality has the largest number of predictors that are statistically significant. Girls of higher birth order survive more during the first month than boys and reversal is true where later born boys have survival advantage after the first month. This highlights the biological advantage of girl-child survival only up to the first month and son-preference seems to create a disadvantage for girl child survival at later age-groups. Keeping all other factors constant, domestic violence is also an important predictor for neonatal mortality. .*

**Key words**: *Child Mortality, Multinomial logit, India.*

**JEL Codes:** *C35, C38, C51, I12, I15.*

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# INTRODUCTION

In 2015, industrialized countries had child mortality at below 5 per 1000 live births largely from improvements in technology and awareness of health while the developing nations show higher rates of mortality that hovers around 30 per 1000 live births (Roser, 2017). In the assessment of health status, child survival is a significant feature to focus upon, which involves strategies and interventions to reduce child mortality. At a macro level, childhood mortality rate is inversely associated with Gross Domestic Product (GDP) per capita and high levels of child mortality are taken as an indicator of underdevelopment. Higher economic growth contributes to lower mortality rates (Cutler *et. al.*, 2006 and Bhalotra, 2006) with rural infant mortality being higher would expectedly have large elasticity. That is for a given change in economic growth by keeping everything else constant, rural mortality rates reduces more than urban mortality rates. Currie (2000) argues that child mortality is often sensitive to socio economic conditions of the economy in developing countries where due to economic crisis child mortality increased in Zimbabwe from 80 to 126 per 1000 live births between 1990 and 2003. Similarly, using Demographic Health Survey (DHS) data for middle income countries, another study identified that negative economic shocks increases infant mortality for example, when Peru was in crisis during 1998 and 1990, the infant mortality increased from 61 to 72 per 1000 births (Schady and Smithz, 2010). Further, children of poorer households (low socio-economic status) are affected more from the health shocks. This was elucidated by a study that uses the cohort data of Andhra Pradesh which analyzes the intergenerational effects of parental health shocks that affects the human capital investment on children (Dhanraj, 2015). At a sectoral level, it has been observed that agricultural growth has a stronger influence in reducing child mortality (Kapoor, 2010). Shanmugam and Venkatramani (2006) show that districts that had lower infant mortality rates in India had higher efficiency in agricultural output.

Once a country develops, the mortality rate tends to decline. In any nation, if IMR is high, it is an indicator of risk to death during the first year of life and also symbolizes unmet environmental conditions and health needs. The U5MR is a cumulative exposure of death in first five years of life, and this is a widely accepted global indicator and socio-economic status of a given population. Interventions and policies that reduce mortality rates would result in increased economic growth. In this sense there is also reverse causality between mortality rates and growth where the health concerns are to be addressed exogenously. One of the targets of Sustainable Development Goals (Griggs *et. al.*, 2013) is to reduce under-five mortality by two thirds by 2030. This target was originally set for the MDG target 4 by 2015 which could not be met and this clearly highlights that child survival continues to be a big priority. The recent UNICEF estimates show that in 2015, an estimated 5.9 million children under the age of five died (United Nations Inter-agency Group for Child Mortality Estimation, 2015). This gap between developed and developing countries needs to be bridged and there is continuous effort to examine the multiple pathways which cause mortality so that appropriate policy decisions could be more effectively implemented.

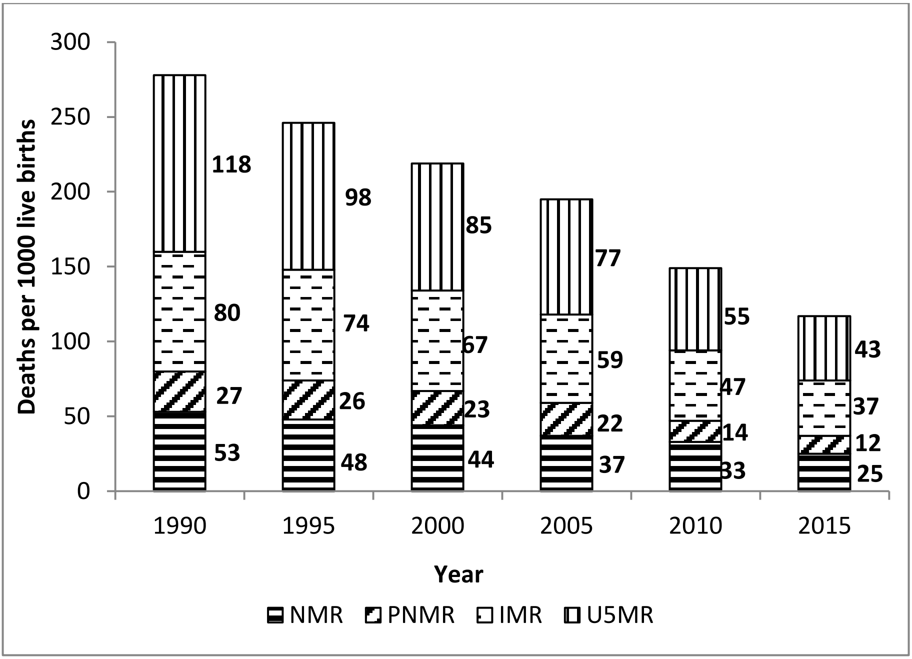
Child mortality rate refers to the number of deaths of children in the age group of 0-5 years per 100 live births. Depending on the child's period of survival child mortality can be further classified as neonatal - death of child within 28 days of birth, infant - child survival is only within a year, post neonatal - between neonatal and infant, under - five mortality - dies before the age of five. Given the infant and under-five child mortality rates are 40 and 49 per 1000 live births in 2013 in India, respectively, 70% of total infant deaths and more than half of under-five deaths fall in the neonatal period. Moreover, the rates of mortality are not uniform across the states of the country, where states like Kerala, Tamil Nadu have low rates (<20 per 1000 live births) in contrast to states like Madhya Pradesh, Uttar Pradesh and Odisha have higher rates (more than 35 deaths per 1000 live births). The determinants of childhood mortality are a combination of several factors. Each type of mortality is usually studied separately with parental, child, household, community level factors and interventions. It has been found that though the determinants are largely similar across the mortality types but the impacts of the determinants varies. There is a need to address different categories of mortality simultaneously so that the overall pace of childhood reduction is enhanced. This study makes an attempt to understand the variation in impacts of determinants across different mortality categories.

The next section gives an overview of the recent trends and patterns of childhood age specific mortality categories in India. Following section discusses the gaps in the literature arising from the determinants at child, mother, household characteristics and interventions of childhood mortality rates in India. The review also focuses on the modeling framework used to analyze mortality rates caused by these variables. The next section presents the specific objectives of the chapter and subsequent section gives the description of the methodology of the study. Next section explains the data used in the econometric analysis while the later section discusses the results of the estimated model and last section concludes the chapter.

## RECENT PATTERNS IN AGE-SPECIFIC CHILDHOOD MORTALITY

Even though the rates are declining, India lacks the pace in meeting its targeted rates. Further it shows inequity in the reduction across mortality rates. Figure 1 below clearly shows the recent trends of various childhood mortality rates in India from three waves of NFHS rounds. Under-five mortality includes neonatal mortality and infant mortality rates in the figure below. This trend of improvement shows that there is unequal pace of improvement in child health conditions across mortality sub-categories. This graph is drawn from the reports of sample registration system and there is a difference in the data collection methods of sample registration system and NFHS where NFHS- 3 collected more numbers of neonatal deaths that leads to small variation between the samples. The neonatal death was 53 per 1000 live births in 1990 which reduced to 25 per 1000 live births in 2015.

**Figure 1: Trends of Childhood Mortality Categories in India**




**Source:** Sample Registration System Reports, Registrar General of India; NMR- Neonatal Mortality Rate, PNMR- Postnatal Mortality rate, IMR- Infant Mortality Rate, U5MR- Under-five Mortality Rate.

Apart from all India trends across time, there are regional disparities in the death rates across time and states. Table 1 shows the top and bottom ranking states of neonatal mortality rate in 1990, 2000 and 2015 from the SRS reports. Out of the 29 states, Kerala has lower NMR rate and it reduced from 13 in 1990 to 6 deaths per 1000 live births in 2015. Among the low ranking states, Himachal Pradesh reduced NMR drastically in 2000 from 41 to 31 deaths. But this cannot be achieved in 2015 which may be due to various factors.

**Table 1: Trends of Neonatal Mortality across Indian States: Top and Bottom Five States**

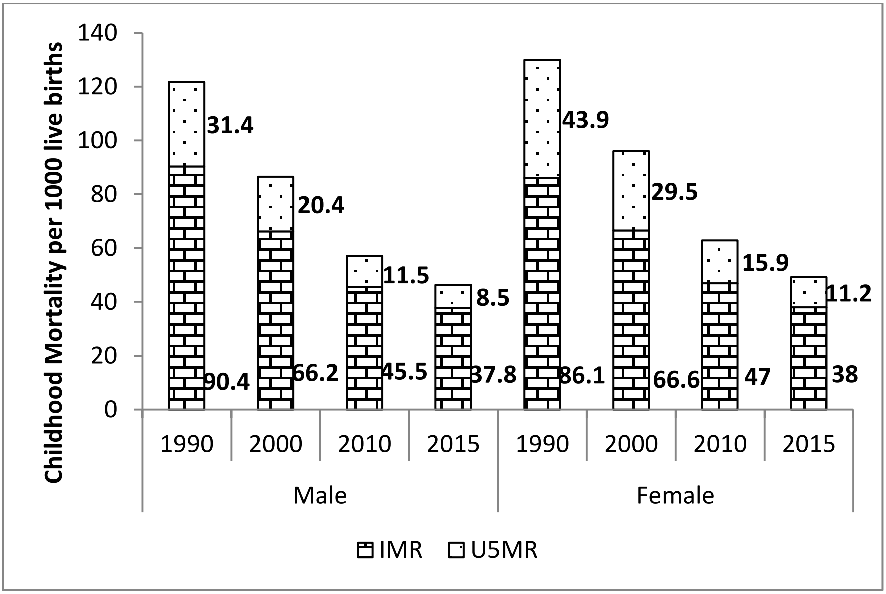
| *Low Ranking States* | | | | | |
|---|---|---|---|---|---|
| **States** | **1990** | **States** | **2000** | **States** | **2015** |
| Kerala | 13 | Kerala | 10 | Kerala | 6 |
| Punjab | 34 | Punjab | 29 | Punjab | 13 |
| West Bengal | 37 | West Bengal | 31 | Delhi | 14 |
| Haryana | 39 | Himachal Pradesh | 31 | Maharashtra | 15 |
| Himachal Pradesh | 41 | Maharashtra | 33 | West Bengal | 18 |
| *High Ranking States* | | | | | |
| **States** | **1990** | **States** | **2000** | **States** | **2015** |
| Odisha | 79 | Odisha | 61 | Odisha | 35 |
| Madhya Pradesh | 72 | Madhya Pradesh | 59 | Madhya Pradesh | 34 |
| Uttar Pradesh | 65 | Uttar Pradesh | 53 | Uttar Pradesh | 31 |
| Rajasthan | 52 | Rajasthan | 49 | Rajasthan | 30 |
| Karnataka | 51 | Karnataka | 47 | Bihar | 28 |

**Source:** Sample Registration System Reports, Registrar General of India.

Out of bottom ranking states, Odisha stands out to be with higher rates of NMR throughout from 1990 to 2015. Inspite of the reduction in the rates, still the bottom ranking states needs to do lot of improvements. On the other hand, gender differences also exist across the childhood mortality rates.

Figure 2 below shows the trend of decline of the number of deaths in infant and under-five mortality in India from 1990-2015 across gender. The gender difference is converging in the year 2015 to almost 38 per 1000 live births in case of infant mortality. The fastest decline started from 1990 where the rates started to converge but the rate of decline could not meet the MDG targets.

**Figure 2: Trends of Infant and Under-five Mortality per 1000 Live Births across Gender**




**Source:** Sample Registration System Reports, Registrar General of India; IMR- Infant Mortality Rate, U5MR- Under-five Mortality Rate.

In India the rates are declining but it is less impressive than the poorer counterparts of other South and South- East Asian countries (Claeson *et. al.*, 2000). This figure depicts not only that decline in rates of deaths across mortality classification is different but also it varies across gender. The number of deaths in female is higher in both cases. However, the rate of decline between male and female children across U5MR and IMR differs. For instance, in 2010, the number of male deaths was 45.5 and that of female were 47 which denotes that the difference is smaller when compared with U5MR.

From these two figures, one can witness the disparities within sub-groups (eg- gender) and also within mortality rates. This call for the further research to assess the underlying factors responsible for these differences so that it will give us a clear understanding of whether to adopt equity focused approach or targeted group approach in the policy decisions. It is highly important to identify the causes to reduce the mortality rates to meet the SDG targets by 2030. In India, even these inequities exists with several dimensions.

## REVIEW OF EMPIRICAL LITERATURE

For policy decisions knowing the trends as discussed in previous section is just one aspect, where the relative importance of determinants helps us in policy interventions. Prior to 1980's, the literary works assessed largely the impact of infant mortality on social and economic indicators like income at household level (wealth) and at country level (GDP, Per Capita Income). This chapter highlights three aspects of the gaps in the literature that this study would address. Firstly, there are various mortality categories specific to the child age's death. They are neonatal mortality, post neonatal mortality, infant mortality and under-five mortality. All these categories are cumulative addition of deaths per 1000 live births till the child reaches age five. Most of the studies assess the age-specific mortality as s single group by considering all upto age five or restricting it to lower age-group like upto 28 days (neonatal) or upto 11 months (infant) mortality. Secondly, it focuses on a few determinants that have not been adequately captured in the empirical literature. Factors such as maternal height, diet practices, domestic violence at maternal level and household factors such as open defecation, usage of clean fuel have been less used and interpreted in the child survival literature. The third aspect documents the differences in impacts of the determinants of mortality across studies that define mortality for one or the other age specific category.

*Combined Approach-Unified or Binary*

The mortality variable differs across studies and literature often concentrates either on neonatal mortality because of its high prevalence or on under-five mortality. A few studies choose even a smaller survival period like early neonatal mortality rate (death within 7 days of birth) and late neonatal mortality rate (death between 7days and 28 days) for 58 countries of Demographic Health Survey (DHS) dataset. They found that in the Eastern and the Southern Africa, the decline of late neonatal mortality rate is higher than early neonatal mortality rate (Hill and Choi, 2006). There are variations in the mortality rates even in the shorter survival periods due to the impact of various determinants.

In Indian scenario also, the northern and the eastern states exhibited a rapid decline in late neonatal mortality rate in 2013. Later, Hobcraft *et. al.* (1985) synthesized that mortality types are specific to age of the child and the impact of the determinants vary between and across the types. Some studies for example (Justine *et. al.*, 2015; Pandey *et. al.*, 1998; Mekonen *et. al.*, 2011 and Sahu *et. al.*, 2015) considered survival time of the child as continuous variable and used survival analysis techniques. This technique is relatively better because we can include time varying effects on the survival period of the child. This analysis is different from other analysis because either the individual or person must wait till the event to occur; where before the time frame of study, some individuals/child will not have faced the event, so the data will be always incomplete. Aalen and Gjessing (2008) suggested that using other methods of analysis for this incomplete data like ordinary regression models will not yield appropriate results because of the dropout of observations within the study period. Hazard ratios for each independent variable will be calculated in this model and that depicts the risk of the survival of the child due to the variables.

There was a paradigm shift later in 1990's where the scope of determinants got enlarged and assessed in the empirical model. For example, household infrastructure variables like access to safe drinking water, usage of fuel in the household, proper sanitation practices and other demographic factors like caste, age, gender, ethnicity, religion were included. In 2000's, new approaches in the methodology, critical thinking on analysing the public interventions (clinical and non-clinical), linking the other sectors like agriculture, employment, education with health were evolved. Variables like farm practices, dietary practices, behavioural and lifestyle practices were incorporated into the model. The differential impacts of determinants needs to be analyzed for the right mix of policy decisions.

*Child Characteristics*

Initially, a brief review of studies pertaining to child characteristics is discussed. Amongst, child level variables, gender discrimination in terms of preference of the child, intra household allocation of resources for the child, care practices favours either male or female child survival and growth. By and large, in Sub-Saharan Africa, most of the literary studies proved there is no gender discrimination (Caldwell, 1979 and Hill and Upchurch, 1995) and male deaths are higher than female deaths (Adedini *et. al.*, 2012), excess female mortality in India and China (Sawyer, 2012). Higher male under-five mortality is observed in 8 African countries namely Cameroon, Congo, Ethiopia, Ghana, Kenya, Nigeria, Zambia and Zimbabwe in 2011(Adedini *et. al.*, 2012) whereas strong evidence for son preference found in Northern part of Africa (Anderson and Ray, 2010). Most of the Asian countries, especially in India, both son preference and female infanticide are deeply rooted in social, cultural and religious beliefs for centuries. Most of the studies documented that there are wide female bias in South-Asia (Sen, 1984 and Levine, 1987 for Nepal; Fauveau *et. al.*, 1990 for Bangladesh; Subramanian and Deaton, 1991 for India). The United Nations Report (2013) pointed out that amongst the South Asian countries, only in China and India, excessive female deaths occurred in 2000's.

In the recent census (2011) data a substantial decline in sex ratio in the age group of 0-6 years is observed; from 927 girls in 2001, the ratio has dropped to 919 girls for every 1000 boys in 2011 which clealry reflects an unnatural survival of boys over girls in this age group. Particularly in India, female infant mortality was slightly higher than male infant mortality, but girl's survival disadvantage was particularly acute in the 1-4 age groups from 1995 to 2010. In 2013, India's rank in Gender Inequality Index (GNI) was 132 out of 148 countries (UNDP, 2013). With respect to gender, some studies documented that male mortality exceeds childhood female mortality rates (Boco, 2010), while other studies revealed that gender differentials are driven by excess female mortality (Muhuri and Preston, 1991; Svedberg, 1990; Subramanian, 2006 and Kuntla *et. al.*, 2014). Koenig and D'Souza (1986) brought out that male children enjoys genetic endowments advantage and superiority at birth. Once the child is born, female disadvantage increases not by gentic factors but by discrimation in favour of boys (Svedberg, 1990; Muhuri and Preston, 1991 and Rosenblum, 2013) which leads to the acute difference in the age group of 1-4 or 2-5 years.

Son preference is quite common in many parts of India and is more observed amongst Northern states (Arokiasamy, 2004) and amongst Hindus (Booroah and Iyer, 2005 and Bhalotra *et. al.*, 2010). As a result more studies find the coefficients of female child dummy is statistically significant and negative implying excess mortality among girl children. Similarly, three rounds of NFHS are examined for the scheduled tribes in rural areas. Hazard rate was higher for male children and 42% higher when there is an increase in birth order of the child (Sahu *et. al.*, 2015). A recent study which used all rounds of NFHS data illustrated that factors like feeding, birth order, antenatal care are the critical contributors of gender differentials for the excess female child mortality in India (Kuntla *et. al.*, 2014). Excess mortality was observed for girls in the age group of 2-5 years from the NFHS- 2 data (Jha *et. al.*, 2006 and Subramanian *et. al.*, 2006). Arokiaswamy (2004) found that gender bias was more severe in north western regions and the male mortality was higher when the birth order increases.

One more important aspect widely discussed in the gender focussed literature with respect to childhood mortality is the effect of sibling deaths. Bhargava (2003) noted the correlation between the survival status of the previous children with the following index child. Makepeace and Pal (2006) found that from NFHS- 2 data death of previous children increases the risk of the surviving female children and also if the first child is daughter followed by son, boys were more likely to survive. Arulampalam and Bhalotra (2006) argued that death of a sibling in infancy increases the probability of the death of the index child even after controlling all child, family and community level unobservable characteristics by taking into account infant and child mortality.

Other studies that focused only on neonatal mortality (Silverman *et. al.*, 2011; Rammohan *et. al.*, 2013; Sankar *et. al.*, 2016 and Chowdhury *et. al.*, 2017) found that *among neonates male deaths are more* than females, whereas *among postnatal mortality*, there are *higher female deaths*(Chowdhury, 2017). Moreover, studies by (Gupta, 1987; Griffiths *et. al.*, 2001; Pande, 2003; Boorah, 2004; Mishra *et. al.*, 2004; Oster, 2009 and Chaudhuri, 2015) documents that *among infants females are dying more* than males. Most states exhibit excess male mortality during neonatal period but excess female mortality during childhood (Pandey *et. al.*, 1998). Therefore, on an average, at birth females have survival advantage but once they started growing, due to lack of care and nutritious food they are dying more at later stages.

Birth size and birth interval are the other important characteristics that impacts child mortality. Birth size is usually taken as the proxy for birth weight and many children who born at home are not properly recorded. Low birth weight (Shrimpton, 2003; Bharadwaj *et. al.* (2013) tends to increase the risk of neonatal mortality. Mekonnen (2011) found child level characteristics like birth order, type of birth (singleton/twin/triplets) and birth interval are strong predictors of infant and child mortality in Ethiopia and their study confirmed the U- shaped relationship between birth order and infant mortality. This study also highlights that multiple births are a serious concern in Ethiopia during 2000 and 2005 time periods, the effect of which increases the infant mortality. Similarly, Adam and Akkaro (2013) assessed that the number of children born, size of the child at birth, age and gender of the child are important indicators in determining infant and child mortality in Tanzania.

Manda (1999) found that preceding birth interval was a major dominant factor for infant mortality at Malawi. By considering only birth interval as a specific determinant for neonatal mortality for 47 countries was analyzed to explore the association of birth interval on mortality. They showed that children of mothers with high completed fertility history had strong association with short intervals and mortality (Kozuki and Walker, 2013). Short birth interval increases not only childhood mortality but also results in poor health condition of the mother and increased competition of household resources. On the contrary in India, Jain *et. al.* (2013) depicted that irrespective of the birth order, newborns with a birth interval less than 24 months had a higher risk of mortality during infancy than with the children of greater birth interval. It is clear that these factors at child level like gender, birth order, birth size, type of birth, birth interval at child level highly impacts childhood mortality. The above discussed papers considered any one or two outcomes as binary (child alive or dead) or unordered (types of mortality) and determined the relevant factors of childhood mortality.

Though the above discussed factors are at child level, factors like birth order and birth interval are pre-determined decisions made by parents at household. Apart from these factors that impacts childhood mortality, there are some peculiar factors at maternal level that highly influences childhood mortality.

*Maternal Characteristics*

Factors such as mother's height, BMI, optimal age at first birth, mother education, domestic violence, diet practices and breastfeeding for the children are shown prominent in shaping the survival of the child. Maternal height is an indicator that reflects the intergeneration linkage of the mother to the child through genetic transmission. Adult height is a long term nutritional indicator and hence a strength of health potential. Apart from genetic potential, for a developing country adult height also reflects the exposures and deprivations faced by the mother during her childhood and adolescent stages. Pollet and Nettle (2008) found that maternal height has a negative relationship with infant mortality under stressed circumstances amongst rural Gautemala women. Similarly, Monden and Smits (2009) analyzed the association of maternal height with the child survival in 42 developing countries and found a non-linear quadratic relationship between maternal height and child mortality where the likelihood of the death of child is smaller if the mother is taller with the height of on an average of 160cm. For other countries similar findings are observed with positive effect of mother's height on infant's survival (Sear *et. al.*, 2004; Christian, 2010 and Venkatramani, 2011). Within the Indian context, Subramanian et al (2009) analyze the association of maternal height with child mortality, child's anthropometric failure and childhood anaemia in India with the NFHS-3 data set. In this study, a mother with a height of less than 145cm was more likely (1.71 times) to lose her child by the age of five compared to a mother whose height was above 160cm. Both Indian and International evidence confirms that taller mother produces better offspring's.

However, none of the studies considered paternal height which is another pathway of intergeneration transmission of undernutrition. On the one hand, it could be possible that due to gender discrimination, height attained by mothers (women) and its improvement over time could be far lower than for father's height. For instance, Guntupalli and Moradi (2009) find that in a gap of 25 years (1950-75) men increase their height by 165.2 cm while women increase their height by 138.2 cm. This would mean that possible a better nutrition status of the father may compensate for the lower nutritional status of the mother and hence important to include both heights. On the other hand, due to assortative mating shorter men may be married to shorter women so that only one of the heights explains the variation in mortality. It would perhaps be expected to have only mother's height to be significant after controlling for other factors. However this needs to be empirically verified and is being attempted in this study for the first time in the Indian context. This study compares the coefficients of the mother's height with and without BMI to ascertain this.

The other related predictor at mother level considered is BMI and age at first birth. Even if the mother is short, but if she is healthy enough with normal range BMI termed as "small but healthy hypothesis" (Sukhatme, 1982 and Seckler, 1982) then the coefficient on mother's height should be lower once BMI is controlled for. Though most studies do not include mother's BMI after controlling for maternal height in their analysis, citing small but healthy hypothesis as the reason, Subramanian and Corsi (2016) do not find support for this hypothesis. This could be because they test this hypothesis only on a smaller sample of women who are in the BMI range of less than 18.5.

Studies mentioned above (Sear *et. al.*, 2004; Pollet and Nettle, 2008 and Monden and Smiths, 2009) in the international context included BMI variable and found to be insignificant where heavier women had highest child mortality, whereas in the Indian setting, without including maternal height variable, Sharma (2008) found that maternal weight (underweight mothers less than 35kgs) recorded 30% of infant mortality rates.

Appropriate age at first birth is another variable that highly influences child mortality. Mekonen *et. al.* (2013) explained that the risk of neonatal mortality is more than 40% for younger mothers (18-23 years) and no significant association for older age mothers(>35 years) for Ethiopia. Children of teenage mothers are at higher risk of perinatal mortality (0-11 months) and child bearing at higher ages contribute substantially to still births in India (Sinha *et. al.*, 2016). Subramanian and Corsi (2016) included both maternal and paternal age at birth for NFHS-3 data and found that younger fathers and mothers seem to show larger effects on child perinatal mortality. The study does not explain the reason to include paternal age at birth as it is not clear whether paternal age at first birth would play the same role as maternal age at first birth as the child bearing and nursing role is specific only to the mother.

*Feeding and Care Practices*

Other than the genetic component, other factors such as breastfeeding, dietary habits of the mother, education, domestic violence are also important factors. However, paternal under-nutritional status can be transmitted in the similar manner as maternal under-nutritional status as explained above for the height variable where it is more relevant to compare the relative roles played by mother's and father height and BMI to understand the inter-generational transmission of undernutrition. This thesis tries to attempt this in the Indian context for the first time.

Bello and Joseph (2014) found a significant impact of breastfeeding in reducing child mortality in Nigeria. Kuntla *et. al.* (2014) described that those children who were breastfed less than six months brings about nearly 40% of survival differences between female and male children mortality. A systematic review and meta-analysis work by Sankar *et. al.* (2015) proved that partial breastfeeding practices increases the risk of all infections cause related mortality.

Dietary diversity is another major component that influences childhood mortality. The consumption of nutritious food when the mother is pregnant and after the birth of the baby will increase the survival status of the child. However, NFHS-3 data does not collect detailed information of dietary habits during pregnancy of women and hence this aspect cannot be directly captured. Therefore we expect that current dietary habits of the mother would also have been relatively similar during pregnancy and lactation and hence could be used as a proxy for this aspect. Dietary intake of the mother has not been included in many studies while assessing the childhood mortality. Only one study by Menon *et. al.* (2015) considered the food consumption of the mother and found that high diversity in food groups helps to arrest mortality. Inequalities in child mortality at district level were assessed by Bhattacharya and Chikwama (2011) where mother literacy and employment alone contributes to 20% of inequality in under-five mortality.

*Empowerment*

Maternal education is yet another significant variable where most of the studies find a significant impact that highly educated women are able to provide better care and nutritious food to children and moreover they are aware of necessary interventions required for the child survival. Even after controlling for maternal height and BMI, maternal education proves to have a positive impact on child growth and survival. In developing countries, mother's literacy has a strong impact on child mortality (Mosley and Chen, 1984; Hobcraft *et. al.*, 1985; Davanzo *et. al.*, 2004; Basu and Stephenson, 2005; Addam and Akkaro, 2013 and Angela and Ujulu, 2015). Literate mothers will produce better offspring's because they are more aware of health facilities and nutritional requirements needed for the child. Inequalities in child mortality at district level were assessed by Bhattacharya and Chikwama (2012) where mother literacy and employment alone contributes to 20% of inequality in under-five mortality.

Domestic violence gives mental stress, physical pain and depression for women and especially it causes heavy damage when a woman is pregnant and affects child adversely. Careful analysis on the contribution of domestic violence of women on child mortality helps to safeguard the rights and protection for vulnerable women and children. Those women who experience domestic violence impacts the quality of care and their children are in higher risk of death especially in perinatal and neonatal stages. The risk is 68% higher than the women who reported no violence (Koenig *et. al.*, 2010). WHO (2016) reported around 30% of women around the world report that they experience domestic violence from their partner. However, domestic violence variable association with childhood mortality is very limited in the past studies in Indian context. Menon (2014) reports that the association between domestic violence and mortality is doubled (17.5% of infant deaths) in rural households but do not find a significant association in richer households in India.

*Household Economic Status*

The focus is next on the economic and the household infrastructure factors. Adam and Akkaro (2013) explored that there is a strong correlation between demographic and socio-economic characteristics which explained 43.81% of variance through Principal Component Analysis (PCA) in Tanzania for infant and child mortality. Socio- economic inequalities in childhood mortality have been a considerable interest among policy makers and researchers in India (Wagstaff and Doorsaler, 2000; Pathak and Singh, 2011; Mohanty and Pathak, 2009). In this aspect, wide range of literature focussed on any *one age specific mortality* and estimate the differences across economic status, religion, caste and other disadvantaged sections of the society and findings from these studies proved that wealth related inequalities were concentrated particularly among the poor which leads to the competition in the utilization of resources at the household (Balhotra, 2006; Joe *et. al.*, 2009; Jain *et. al.*, 2013; Kuntla *et. al.*, 2014 and Pande and Jayachandran, 2015). Aremu *et. al.* (2011) pinpointed that those children lives in socio-economically deprived community or neighborhood (same environmental conditions) faces the higher risk of infections and death. Mortality risks for girls were 1.33 times higher than boys among the economically disadvantaged sections of the society (Subramanian *et. al.*, 2009).

In all studies the economically disadvantaged people experiences high child death, for example, neonatal mortality rate is 2.5 times higher in the lower strata of economic group (poorest 20% of population) (IIPS,2007). Even amongst States, high focus states like Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, Odisha, Assam, Rajasthan and Uttarakhand have higher rates of child deaths which comprises of more than 50 deaths of children per 1000 live births in the age group of 0 to 5 in 2015, whereas economically developed states like Tamil Nadu, Kerala, Karnataka have on an average of 25 deaths per 1000 live births in 2015. (SRS, 2015). Often in health economics, equality is shown through a famous technique called concentration curves. These curves quantify the degree of wealth-related inequality in infant and child survival where the value ranges from -1 to 1. Either the lowest economic group or the highest economic group bears the higher burden of mortality. Many studies (Gwatkin *et. al.*, 2007; WHO, 2009; Joe *et. al.*, 2009; Pradhan and Arokiaswamy, 2010; Pathak and Singh, 2011; Behl, 2012 and Jain *et. al.*, 2013) used this technique in the Indian context and analyzed the socio- economic inequalities impact on child and infant mortality. They could witness large economic inequalities in the lower (poorest strata) have higher deaths with negative indices and also interregional variations. Moreover, they observed decline in the death rates over time periods across wealth index groups but the decline is not uniform across the childhood mortality types.

Health inequality measurement has benefitted more from the theories of income inequality. A multi-country study of WHO regions confirms the relationship between economic status and child mortality as inverse for India, that is higher the income, lower the mortality rate (Gwatkin *et. al.*, 2007). National average is negative which indicates that inequality in mortality rates are more among poor households (Joe *et. al.*, 2008). Jain *et. al.* (2013) examined the trends of economic inequality with three waves of NFHS rounds and illustrated that decreasing trend is observed between infant mortality and wealth whereas an upward trend is observed for child mortality and wealth. This gives us the further insight that how one variable itself affects mortality differently. Interestingly, most of the above said studies analyzed the determinants with either one or two outcomes of mortality separately.

*Household Infrastructure*

Apart from financial stability of the household, environment and infrastructure with respect to the area or the place they dwell, facilities in kitchen, usage of cooking fuel, access to safe drinking water, sanitation practices highly influences the mortality of the child. Inspite of outdoor air pollution, the exposure of indoor air pollution due to the combustion of usage of dirty fuel practices increases the risk of lives of child, as the women and child spend most of the time in their homes. Many studies associated the relationship of cooking fuel and childhood mortality, where Wichmann and Voyi (2006) documented 80% of higher risk of under-five mortality is observed in Sub- Saharan Africa due to the usage of dirty heating and cooking fuels. Ezeh *et. al.* (2014) in Nigeria, showed that usage of solid fuels increased the postnatal deaths and do not find association with neonatal deaths.  In India, Bassani *et. al.* (2010) pointed out that usage of solid fuels increases the child deaths in the age group of 1-4 years and more girls are dying than boys. Other recent studies (Naz *et. al.*, 2015; Naz *et. al.*, 2016; Olugbemisola *et. al.*, 2016 and Owili *et. al.*, 2017) found strong association of dirty fuels with under-five mortality. Bhargava (2003), using data from Uttar Pradesh found that households which have proper access to sanitation facilities were able to reduce infant mortality significantly. In similar lines, Klaaw and Wang (2011) by using NFHS- 2 data decomposed the state effects and pointed that access to piped water and proper sanitation significantly reduces the risk of neonatal and child mortality.

Religious differentials were widely noted in India and in the large sample survey various information helps us to get the differentials more systematically. Customs, lifestyle, tradition and beliefs differ across caste/tribes/ religions and their customary practices related to child birth, feeding and dietary practices is shown to bring differences in the childhood mortality. Recent work by Brainerd and Menon (2015) at South Asia level argued that control over household resources, women autonomy and exposure of the child in the utero during Ramadan month all favor the Muslim children survival. In India, Muslims have the second lowest infant and under-five mortality rates inspite of their economically disadvantaged position (Bhat and Zavier, 2005; Sachar Report, 2006 and Deolalikar, 2008). The variations in inequality of child mortality burden was explored at district level with the census data and found that more Muslims were concentrated in developed districts during 1981 and 1991 census which contributed to the reduction in child mortality. The genetic built of Muslim women and the non-vegetarian diet and their higher concentration in developed urban areas reduces the mortality risk of their children than their Hindu counterparts (Bhalotra *et. al.*, 2010). By using three waves of NFHS, Guillot and Alendroff (2010) found that better access to piped water, sanitation and mother's place of work are helping in reducing the mortality of Muslim children than Hindus (Guillot and Alendroff, 2010).

Another study by Geruso and Spears (2015) found a strong link between sanitation and infant death. They gave econometric evidence that the externality of open defecation affects the Hindu child survival than Muslim children. Muslims concentrate more on the regions of neighborhood where there was a higher utilization of latrines. This needs to be studied further to understand what makes the Muslim children to survive better in early ages and what hindrances they face at later stages in comparison to their Hindu counterparts simultaneously by including all age specific childhood mortality rates.

With respect to caste, scheduled caste and scheduled tribes are the most socially disadvantaged sections of the society. Mostly they will be landless agricultural labourers or engaged in some traditional occupations. Subramanian et al (2006) noted a wide disparity in infant mortality between different caste groups in India, where children belonged to scheduled tribes had the greatest odds ratio of mortality (of about 1.94) when compared with other caste categories. Similarly, Dommaraju et al (2008) pointed out that caste differentials has an independent effect on child mortality even after controlling for all other environment and household characteristics. They also noted that survival chances differences between Forward Caste (FC) and Other Backward Caste (OBC) and Scheduled Caste (SC) begins at the age of five months, but between OBC and SC/ST starts at first year but it prolongs till 5 years. Again, the differences of religion and caste are also not analyzed with all age- specific mortality together to assess the variations.

*Interventions*

The mortality of the child can be controlled to a minimum extent through appropriate policy interventions even if all the above discussed factors are failed to address. There should be a mechanism to separate intervention and the delivery of health strategies to improve child survival (Bryce *et. al.*, 2003). Both at maternal level and child level, vaccination is the successful policy to control childhood mortality. Safe institutional delivery on the one hand reduces child mortality directly and also indirectly avoids mortality caused by low birth weight among children who are not born in hospitals. Infants will get easily infected when unsterilized instruments are used to cut the umbilical cord and there are high chances when the baby is born in unhealthy and unhygienic environments. Consequently tetanus is one of prime reasons for neonatal deaths (IIPS, 2000). Every pregnant mother should receive two doses of tetanus injection and the consecutive injection is highly recommended for every three years according to the National Immunization Schedule.

As per the WHO guidelines India follows the antenatal care schedule for improving mother's health during pregnancy which is a package consisting of atleast three visits to the health center, atleast one tetanus shots and consumption of iron tablets. Hence such pre and post natal inputs like tetanus shots, usage of iron folic acid supplements are given to the mother through public programs periodically to improve the survival chances of child. Das and Gupta (2000) gave a perspective on the importance of vaccination to arrest childhood mortality and undernutrition. They analyzed the pattern of the trends in vaccination where they found for BCG, the trend is decreasing and for other vaccination they observed an increasing trend during the period of 1981-1993. Mathew (2012) did a systematic review on disparities in vaccination and found higher birth order infants have low vaccination coverage. Bhargava (2003) found that tetanus shots and vaccination helps to curb the infant mortality in the primary survey conducted at Uttar Pradesh. Antenatal care variable is included in most of the studies and they find positive coefficient for higher number of visits which increases the chances of survival and also point out that those mothers who regularly visit for antenatal care are more likely to deliver the child at hospital (Bhutta *et. al.*, 2008; Mistry *et. al.*, 2009; Bhalotra., 2010; Domarajau., 2013; Adam and Akkaro, 2013; Mekonnen *et. al.*, 2013; Naseeje, 2013 and Kuntla *et. al.*, 2014). Mishra (2017) analyzed the three tribal areas of Madhya Pradesh and found access to antenatal services and institutional delivery are unsatisfactory.

The review of past literature shows that studies focus on one type of mortality and studies carried out by NFHS- 2 data. Even though the child poses unique health endowment and resides in the household unit, which in turn a unit of community, the child survival is directly or indirectly influenced by the factors at various levels within the social setup of the community. It is very clear from the literature that factors responsible for infant mortality are not same as for the neonatal mortality and so there exist non-overlapping factors for different age-specific mortality. Moreover, interventions required to address these mortality are also different. This needs a careful assessment of various factors for all age-specific mortality together in a single- equation model. Therefore this thesis for the first time is making a richer contribution by analyzing the NFHS-3 data by considering all age specific mortality and particularly bringing out the relative role of child, mother, household characteristics and the impact of utilization of specific interventions.

## OBJECTIVES

The aim is to reduce all categories of childhood mortality that could be avoided. Even though the set of determinants could be same for mortality categories, each could have a differential impact. The main objective is to carry out an empirical analysis that will allow to make a relative importance of the emphasis to be given to different age-specific mortality category vis-a vis child survival model. The other objective is to revisit some of the determinants which in earlier studies that were not given adequate attention in the Indian context or the variables were not giving the expected results. The reexamination of the determinants is carried out by restructuring the explanatory variables in an attempt to get additional insights.

The focus of the determinants is specifically on the following three aspects:

- Examine the relative role of characteristics like gender, birth order, and birth interval on childhood mortality.
- Assess the role of mother's long term, short term nutritional status and maternal dietary habits on childhood mortality categories.
- Evaluate the impact of specific interventions of mother's prenatal and postnatal inputs like antenatal check-ups, tetanus shots, iron folic acids on childhood mortality.

# METHODOLOGY

To make a comparative assessment of the different impacts of the above mentioned determinants for each category of mortality, the suitable regression technique used is (unordered) multinomial logit model. With ordered, there is ranking or preference for reducing one mortality category vis-a-vis another but the preferred model is unordered as each category of mortality is considered equally important to address as this would inform the policy process in terms of which variables have an impact on each category of mortality relative to survival.

***Estimation Approach-Multinomial Logit Model***

In this chapter of the thesis, outcome variable Y is assigned the discrete values as follows:

$Y_i$ = 1 if the $i^{th}$ child has survived the five years (59 months)
= 2 has died within the first month (first month)
= 3 has survived the first month but died within the first year (mortality in $2^{nd}$ -$12^{th}$ month)
= 4 has survived the first year but died within the next five years (mortality in $13^{th}$ – $59^{th}$ month)

These four categories are mutually exclusive and independent. It is to be noted that the first category is child's survival upto the age of five years; the second category is the neonatal mortality; the third category is part of infant mortality; the fourth category partly corresponds to under-five morality. Combining $2^{nd}$ and $3^{rd}$ is commonly defined as infant mortality and combining $2^{nd}$, $3^{rd}$ and $4^{th}$ together is defined as under-five mortality. Here they are defined to be mutually exclusive. For the statistical and econometric analysis purpose, the additional values in each category is deducted and considered only the exact change and arrived at mutually exclusive categories. Hereafter, this mutually exclusive classification will be referred as mortality categories in this chapter. Since there are four categories, the functional form for multinomial logit (MNL) is specified as:

$$pr(y_i = j \mid X_i) = \frac{\exp(X_i\beta_j)}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)} \quad for\ j>1 \tag{1a}$$

where 'i' refers to child in the sample, 'j' refers to mortality categories and 'k' implies explanatory variables.

Since $\exp(X_i\beta_1) = \exp(X_1 0) = 1$, it will be,

$$pr(y_i = 1 \mid X_i) = \frac{1}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)} \tag{1b}$$

The coefficient $\hat{\beta}$ is estimated using maximum likelihood method with the set of variables discussed above and due to the identification condition, there will be one omitted category for which the coefficients are not estimated. In this the omitted category is taken as survival of the child. The marginal effects of the independent variables can be calculated with,

$$\frac{\partial \Pr(y=m \mid X)}{\partial x_k} = \Pr(y=m \mid X)[\beta_{km} - \sum_{j=1}^{j}\beta_{kj}\Pr(y=j \mid X)] \tag{2}$$

The partial change is the slope of the curve related to each independent variable holding all other variables constant. The value of a marginal effect for a MNL model depends on the values of all the independent variables and on the coefficients for each outcome and is not a constant value as in the linear regression models. The marginal effect is not easy to interpret so the common approach used to interpret are relative risk ratios.

More commonly, the results of the MNL model are presented as relative risk ratios ($\Omega$) as follows:

$$\Omega_{j;n}(X_i) = \frac{pr(y_i = j \mid X_i)}{pr(y_i = n \mid X_i)} = \frac{\dfrac{\exp(X_i\beta_j)}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)}}{\dfrac{\exp(X_i\beta_n)}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)}} = \frac{\exp(X_i\beta_j)}{\exp(X_i\beta_n)} = \exp(X(\beta_j - \beta_n)) \qquad \text{(3a)}$$

So, $\Omega_{j;1}(X_i) = \exp(X_i\beta_j)$ which implies $\beta_n = 0$, where n=omitted category. (3b)

The relative risk ratios are the ratios of two probabilities. The interpretation of the relative risk ratios is for a unit change in the predictor variable, the relative risk ratio of outcome 'j' relative to the referent group is expected to change by a factor of the respective parameter estimate given the variables are held constant. The results are expressed in relative risk ratios in Table 7 and the corresponding coefficients of (equation 1a) are given in the 8.

***Tests of hypothesis***

After estimating the coefficients, the following two tests are performed: a) Hausman (1978) test for Independence of Irrelevant Alternatives (IIA)[1] and b) test for combining two or more categories.[2] The results of these two tests are discussed in the results section.

## DATA

The thesis uses the third round of the National Family Health Survey (IIPS, 2005) data on children aged 0-59 months in the year 2005-06. The mortality data is collected for the last five years and nearly 51555 live births were recorded since January 2000. Out of the total women 124385

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[1] IIA is usually tested if two alternatives are independent in a choice model. The rejection of null implies that instead of MNL, either the conditional logit, multinomial probit or nested logit models are to be estimated.

[2] In this test the null hypothesis is that the coefficients of the explanatory variables have same estimated values for any two chosen categories and if the null is accepted then the two categories are combined. So the test is performed sequentially taking two categories at a time.

in the age group of 15-49 interviewed, 68.5% of the women reported at least 1 live birth during the interview period. Nutritional status of mothers aged 15-49 years is available for all the children while a similar detail is available for the fathers for a smaller subsample (45%) of children. Household characteristics including possession of durable goods that proxy for economic status, feeding and care practices, access to health facilities, social infrastructure and factors relating to gender empowerment are the other set of information collected in this survey. It is to be noted that only 45% of children have information of father's anthropometry so our analysis on the smaller sample with paternal characteristics is carried out mainly to understand the relative contribution of maternal and paternal intergenerational transmission. Otherwise, most of the analysis is carried out on a larger sample thereby excluding the father's intergenerational characteristics.

Table 2 shows the brief description of the variables that are used in the regression estimation of childhood mortality. The total live births after controlling for all the other factor variables by eliminating the extreme outliers, 48519 is included in the regression model. Out of this, 52% are boys and 48% are girls. Higher birth order children are around 43% and around 78% of the children are born with birth interval greater than 24 months. Amongst child level variables, the focus is on gender, where the gender variable is interacted with the birth order to understand the pattern of mortality in the index of child birth as done in Jayachandran and Pande (2015). We anticipate that this interaction term would give inverted u-shape curve with the respective positive and negative coefficients at lower and higher birth order of the children.

Maternal height which is available as a continuous variable has been grouped into quintiles (five groups) to be considered as an ordered categorical variable. Such a grouping enables a relative comparison of moving from a lower height group to a higher height group. We would expect the coefficient to be increasingly negative across the increasing height quintiles and would also be interested in knowing among which categories of height the gaps or differences are large. Another aspect of interest would be to ascertain if paternal characteristics are as relevant as maternal characteristic in improving child mortality as mentioned in the previous section.

As mentioned in literature review section, mother's reproductive role would probably have a dominant effect on child's health and therefore when both maternal (mother) and paternal (father) variables are included in the model that only maternal coefficients are statistically significant. Further, due to assortative mating if the paternal height also contains similar information as maternal height then excluding maternal height from the dataset should make paternal height variables to be statistically significant. In the absence of assortative mating and only mother's reproductive role the paternal height may not be significant at all. Hence as mentioned in objective 2, this modeling framework will help us to understand if the focus has to be largely on improving women's nutritional status rather than on both the parents. Furthermore due to intergenerational transmission of nutritional status a taller mother would have healthier offspring irrespective of the sex of the child so that in the next generation the gap in the height between male and female adults would automatically be reduced. The corresponding results are discussed in the results section.

For this, the attempt is first made to compare if father's height is as relevant or is less relevant than the mother's height for the smaller subsample of children. This comparison is then extended to other variables like age at first birth, and education for each parent separately. For large sample, father's height turned out to be insignificant once maternal characteristics are controlled.

BMI variable is grouped into three categories as less than 18.5, 18.5-24.9 and greater than 25 which is the classification given by WHO

(2006) defining undernourished, normal, and obese women respectively. Most studies would use a categorical variable as undernourished mother or not (BMI <18.5) category (Bhalotra, 2006 and Mekonnen *et. al.*, 2013). In this study, we grouped into three categories to know the difference of the women in which BMI specific range tend to lose their child more in all age-specific childhood mortality outcomes. Apriori information from the literature says that risk ratios will be greater than one for undernourished mothers and the magnitude difference between a mother who is in a normal BMI range and undernourished will be more. Table 2 show about 40% and 53% are in the undernourished and normal category respectively and remaining are in obese category.

Mother's age at first birth variable is grouped into three age categories as <20years, 20-34 years and >34 years. Among these the first category is below legally permissible age of marriage which on the one hand violates the law also on the other hand detrimental to mother and child's survival. In the Indian context (and as also observed from the dataset) there would rarely be reported child birth before marriage. As per the Census (2011) data, 27% of women consequently postponing child birth to post teenagers is an important feature to reduce child mortality as has been observed in Sinha *et. al.* (2017). Similarly, older age mothers (above 30 years) are also at the risk of losing more children at birth due to pregnancy complications. Therefore we expect mother's age at first birth to contribute negatively towards mortality for the normal age groups when compared with teen age mothers. From the descriptive Table 2.2, about 60% of mothers had their first birth below 20 years.

Breastfeeding initiation variable could be considered both at child level and maternal level. Since mother is the decision maker of all food habits given to child, we are taking this variable at maternal level, where only 35% of the mothers started the initiation within 1 hour of birth of the child. In the study by Mittal *et. al.* (2007) the feeding practices are highly influenced by the elderly persons in the household where they insist for prolonged breastfeeding. In the modern era, sedentary lifestyle brought changes in the food habits which add more complications for the birth of the child where the dietary diversity of the mother is equally important. Data on whether the mother consumes fruits, milk, pulses, vegetables, meat, fish and egg were given. These number of food items are regrouped into three tercile as consumed in Menon *et. al.* (2015) and the lowest category is considered as a reference category. The terciles represents an aspect of dietary diversity in terms of access and affordability. But, whether the intake leads to appropriate dietary requirements for gaining proper weight and height and minimum nutrition cannot be assessed.

It is necessary to ascertain the mother's empowerment and her autonomy in household decisions. Mother's education variable is classified into illiterate, primary, secondary and higher categories where illiterate category is considered as reference category and expects a negative coefficient for highly educated mother that signifies lower risk of mortality of the child. More than half of the sample around 52% of the mothers are illiterate (Table 2).

As described in previous section, domestic violence brings physical and mental stress for women and hinders her autonomy in household and day-to-day activities. The data collects information on beating, pushing, physical torture and usage of abuse words by a husband upon wife and this variable is grouped as degree of violence such as less, severe and no violence and anticipating negative coefficient where severe violence increases child mortality.

Economic status is captured through a categorical variable with five categories as NFHS 3 does not collect income or consumer expenditure. This categorical variable is constructed based on the possession (or not) of several consumers durable goods (21 variables) combined into a wealth index using Principal Component Analysis (Filmer and Pritchett, 2001). The first principal component is then ranked in an increasing order and households with the bottom 20% values are considered as 'poorest', the next 20% values are 'poor; and so on with the top 20% values as the 'richest' household.

Other variables like caste (SC, ST, OBC and others), religion (Hindu, Muslim and Christian), safe drinking water (treated or untreated), sanitation practices (open defecation at PSU level), usage of fuel (dirty or clean, place of residence are all used with the classification as widely noted in the literature. State dummies grouped as regions of Southern (Andhra Pradesh, Karnataka, Kerala and Tamil Nadu), Northern (Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Haryana, Delhi and Rajasthan), Centre (Uttar Pradesh, Chandigarh and Madhya Pradesh), Western (Goa, Gujarat and Maharashtra), North- Eastern (Sikkim, Arunachal Pradesh, Nagaland, Sikkim, Mizoram, Manipur, Tripura and Meghalaya) and Eastern(Bihar, Odisha and West Bengal) states are included to control for state fixed effects.

Interventions at mother level are very useful in analyzing the child health indicators. It is not only serves as a barometer to measure the awareness but also an indicator of successful implementation. For antenatal visits, number of visits is grouped as 0 and greater than 1, where 54% of women went to the hospital during pregnancy for antenatal visits. Other interventions variable tetanus shots and iron supplements are grouped as a binary variable of yes and no category, where no category being the reference.

**Table 2: Descriptive Statistics of the Variables in the Data**

| Variables | Mean | Std.dev | Variables | Mean | Std.dev |
|---|---|---|---|---|---|
| *Gender of the child:* Male | 0.521 | 0.500 | Wage labour in non-agri | 0.298 | 0.458 |
| Female | 0.479 | 0.500 | Professional & others | 0.253 | 0.435 |
| *Birth order:* First child | 0.299 | 0.579 | *Wealth*: poorest | 0.260 | 0.439 |
| Second child | 0.271 | 0.444 | Poor | 0.227 | 0.419 |
| Three and >3 child | 0.430 | 0.562 | Middle | 0.200 | 0.400 |
| *Birth Size:* Very large | 0.043 | 0.203 | Richer | 0.177 | 0.382 |
| Avg and larger than avg | 0.747 | 0.435 | Richest | 0.137 | 0.343 |
| Small and smaller than avg | 0.210 | 0.407 | *Caste:* SC | 0.209 | 0.407 |
| *Birth interval:* Greater than 24 months | 0.776 | 0.417 | ST | 0.098 | 0.297 |
| Lesser than 24 months | 0.224 | 0.417 | OBC | 0.408 | 0.491 |
| *Mother's height*: Height Quintile 1 | 0.202 | 0.402 | Others | 0.285 | 0.452 |
| Height Quintile 2 | 0.207 | 0.405 | *Religion:* Hindu | 0.788 | 0.409 |
| Height Quintile 3 | 0.198 | 0.399 | Muslim | 0.165 | 0.372 |
| Height Quintile 4 | 0.196 | 0.397 | Christian | 0.046 | 0.210 |
| Height Quintile 5 | 0.197 | 0.398 | *Cooking Fuel:* Dirty Fuel | 0.815 | 0.388 |
| *Mother's BMI:* Mbmi <18.5 | 0.389 | 0.518 | Clean Fuel | 0.185 | 0.388 |
| 18.5-24.9 | 0.539 | 0.499 | *Drinking water:* untreated | 0.714 | 0.452 |
| Above 25 | 0.073 | 0.261 | Treated | 0.286 | 0.452 |
| *Mother's age at first birth*: >20 years | 0.597 | 0.491 | PSU open defecation | 0.640 | 0.376 |
| 20-34 years | 0.402 | 0.490 | *Tetanus shots*: yes | 0.457 | 0.498 |
| >=35 years | 0.002 | 0.042 | No | 0.543 | 0.498 |
| *Mother's education:* Illiterate | 0.514 | 0.500 | *Iron tablets:* yes | 0.541 | 0.498 |
| Primary | 0.139 | 0.346 | No | 0.459 | 0.498 |
| Secondary | 0.300 | 0.458 | Antenatal Visits | 0.543 | 0.498 |

(*Contd Table …*)

(*Contd Table ...*)

| Variables | Mean | Std.dev | Variables | Mean | Std.dev |
|---|---|---|---|---|---|
| Higher | 0.047 | 0.211 | *Place of delivery:* Home | 0.615 | 0.486 |
| *Initiation of breastfeeding:* Later 1 hour | 0.656 | 0.475 | Public | 0.181 | 0.385 |
| Within 1 hour | 0.344 | 0.475 | Private | 0.204 | 0.403 |
| *Mother's Dietary Diversity:* Low diversity in food habits | 0.340 | 0.474 | *Residence:* Urban | 0.242 | 0.428 |
| Middle diversity in food habits | 0.376 | 0.484 | Rural | 0.758 | 0.428 |
| High diversity in food habits | 0.284 | 0.451 | *Region:*South | 0.159 | 0.365 |
| *Domestic violence:* No violence | 0.685 | 0.465 | North | 0.132 | 0.338 |
| Severe violence | 0.214 | 0.410 | Centre | 0.291 | 0.454 |
| Less violence | 0.101 | 0.301 | West | 0.120 | 0.325 |
| *Father's occupation*: Self Employed in Agriculture | 0.149 | 0.356 | North-East | 0.038 | 0.197 |
| Self-Employed in non-agri | 0.123 | 0.329 | East | 0.260 | 0.439 |
| Wage labour in agri | 0.167 | 0.373 | | | |

**Source:** Calculated by using National Family Health Survey (NFHS-3), 2005-06.

**Note:** Sample Size- number of observations, Mean- Mean Value of the variables, Std.dev Standard deviation of the variables.

## RESULTS

This section gives the discussion on the estimated relative risk ratios from multinomial logit model. Table 3 gives the results of the tests of hypothesis for IIA and as the Chi-square test value is not statistically significant at 5% level of significance (p-values are greater than 0.05), so we accept that null model as MNL.

**Table 3: Hausman Tests for Independence of Irrelevant Alternatives**

| Categories | Chi- Square | Degrees of Freedom | P- Value |
|---|---|---|---|
| C1 | 0.00 | 1 | 1.00 |
| C2 | 0.00 | 1 | 1.00 |
| C3 | 1.087 | 92 | 1.00 |

**Source:** Calculated from National Family Health Survey (NFHS-3), 2005-06.

**Note:** Null hypothesis is Odds(of any two outcomes) are independent of other alternatives, outcomes are the categories of mortality. C1- neonatal mortality, C2- Infant Mortality, C3- Under-five mortality.

The next test of hypothesis is to combine any two outcomes and as the null hypothesis of equality of all the estimated coefficients for any two chosen category is rejected at 5% level of significance (p-value less than 0.01 for the chi-square statistic), This justifies that a multinomial logit model lowing for separate mutually exclusive categories for mortality is statistically valid.

**Table 4: Wald Test Results for Combining Outcomes**

| Alternatives Combined | Chi- Square Statistic | P- Value |
|---|---|---|
| C1 & C2 | 212.9*** | 0.00 |
| C1 & C3 | 142.7*** | 0.00 |
| C1 & C0 | 1226.5*** | 0.00 |
| C2 & C3 | 79.4*** | 0.007 |
| C2 & C0 | 711.0*** | 0.00 |
| C3 & C0 | 212.8*** | 0.00 |

**Source:** Calculated from National Family Health Survey (NFHS-3), 2005-06.

**Note:** Null hypothesis is if any two alternatives can be combined. Significance of the test statistic shows that the null is rejected, at 51 degrees of freedom. C0- if child survives beyond 59 months, C1- if child survives beyond 59 months, C1- if mortality is within 0-28 days (infant mortality), C2- if mortality is between $2^{nd}$-$12^{th}$ month(covers part of infant mortality), and C3: if mortality is between $13^{th}$-$59^{th}$ month (covers part of under-five mortality).

Table 5 reports the summary statistics of the independent variables used in the model across each mortality category. The mean distribution and standard deviation of the independent variables are given for all the childhood mortality categories. This table shows that in the sample there are 1622 neonatal deaths, 921 infant deaths and 172 children died before reaching age 5. This summary statistics table gives a clear picture that how different determinants impacts mortality at different ages.

Table 5 show that male deaths are more in the neonatal category, whereas female deaths (58%) are more in case of infant and under-five mortality. Similarly, children of birth order 1 deaths are high (37%) in case of neonates whereas at higher age groups, children of high birth order (60%) are more at the risk of dying. Around 30% of the children who are smaller than average have died within 28 days and 78% of the children survived who are born with the birth interval greater than 24 months from Table 5. 84.3% of under-five deaths are occurred for the mothers who are illiterate.

**Table 5: Summary Statistics of Independent Variables across Each Categories of Mortality**

| Variables | Neonatal Mortality | | Infant Mortality | | Under-five Mortality | | Survival | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Sd | Mean | Sd | Mean | Sd | Mean | Sd |
| Gender - Male | 0.546 | 0.498 | 0.425 | 0.495 | 0.417 | 0.495 | 0.523 | 0.499 |
| Female | 0.454 | 0.498 | 0.575 | 0.495 | 0.583 | 0.495 | 0.477 | 0.499 |
| Birth Order - First child | 0.373 | 0.484 | 0.261 | 0.439 | 0.193 | 0.396 | 0.297 | 0.586 |
| Second child | 0.221 | 0.415 | 0.211 | 0.409 | 0.211 | 0.409 | 0.275 | 0.446 |
| Three and >3 child | 0.405 | 0.491 | 0.527 | 0.500 | 0.596 | 0.492 | 0.428 | 0.566 |
| Birth Size- Very large | 0.056 | 0.231 | 0.037 | 0.188 | 0.075 | 0.264 | 0.043 | 0.202 |
| Avg and larger than avg | 0.644 | 0.479 | 0.687 | 0.464 | 0.707 | 0.456 | 0.753 | 0.431 |
| Small and smaller than avg | 0.300 | 0.458 | 0.276 | 0.447 | 0.218 | 0.414 | 0.204 | 0.403 |
| Birth Interval- Greater than 24 months | 0.682 | 0.466 | 0.664 | 0.473 | 0.647 | 0.479 | 0.783 | 0.412 |
| Lesser than 24 months | 0.318 | 0.466 | 0.336 | 0.473 | 0.353 | 0.479 | 0.217 | 0.412 |
| Maternal Height Quintile 1 | 0.249 | 0.433 | 0.313 | 0.464 | 0.224 | 0.418 | 0.198 | 0.398 |
| Height Quintile 2 | 0.197 | 0.398 | 0.180 | 0.384 | 0.260 | 0.440 | 0.208 | 0.406 |
| Height Quintile 3 | 0.197 | 0.398 | 0.167 | 0.373 | 0.198 | 0.400 | 0.199 | 0.399 |
| Height Quintile 4 | 0.184 | 0.387 | 0.183 | 0.387 | 0.182 | 0.387 | 0.197 | 0.397 |
| Height Quintile 5 | 0.174 | 0.379 | 0.157 | 0.364 | 0.136 | 0.344 | 0.199 | 0.399 |
| BMI - <18.5 | 0.417 | 0.493 | 0.421 | 0.494 | 0.457 | 0.500 | 0.386 | 0.520 |
| 18.5-24.9 | 0.514 | 0.500 | 0.530 | 0.499 | 0.519 | 0.501 | 0.540 | 0.498 |
| 25-29.9 | 0.058 | 0.235 | 0.040 | 0.196 | 0.024 | 0.153 | 0.056 | 0.435 |
| Above 30 | 0.011 | 0.105 | 0.009 | 0.096 | 0.000 | 0.000 | 0.017 | 0.131 |
| Age at first birth - >20 years | 0.643 | 0.479 | 0.683 | 0.465 | 0.719 | 0.451 | 0.592 | 0.491 |
| 20-34 years | 0.357 | 0.479 | 0.316 | 0.465 | 0.281 | 0.451 | 0.406 | 0.491 |
| >=35 years | 0.000 | 0.008 | 0.001 | 0.029 | 0.000 | 0.000 | 0.002 | 0.043 |
| Mother Education- Illiterate | 0.715 | 0.452 | 0.797 | 0.403 | 0.843 | 0.365 | 0.498 | 0.500 |
| Primary | 0.108 | 0.311 | 0.082 | 0.275 | 0.083 | 0.276 | 0.141 | 0.348 |
| Secondary | 0.164 | 0.370 | 0.110 | 0.313 | 0.062 | 0.243 | 0.311 | 0.463 |
| Higher | 0.014 | 0.116 | 0.011 | 0.103 | 0.012 | 0.108 | 0.049 | 0.216 |
| Breastfeeding- Later 1 hour initiation | 0.770 | 0.421 | 0.741 | 0.438 | 0.735 | 0.443 | 0.649 | 0.477 |
| Within 1 hour initiation | 0.230 | 0.421 | 0.259 | 0.438 | 0.265 | 0.443 | 0.351 | 0.477 |
| Domestic Violence - No violence | 0.669 | 0.471 | 0.569 | 0.496 | 0.547 | 0.499 | 0.689 | 0.463 |

(*Contd Table ...*)

(*Contd Table ...*)

| Variables | Neonatal Mortality | | Infant Mortality | | Under-five Mortality | | Survival | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Sd | Mean | Sd | Mean | Sd | Mean | Sd |
| Severe violence | 0.220 | 0.415 | 0.294 | 0.456 | 0.265 | 0.443 | 0.212 | 0.409 |
| Less violence | 0.111 | 0.314 | 0.137 | 0.344 | 0.188 | 0.392 | 0.099 | 0.299 |
| Father Occupation- Self Employed in Agriculture | 0.151 | 0.358 | 0.161 | 0.368 | 0.196 | 0.398 | 0.149 | 0.356 |
| Self-Employed in non-agriculture | 0.132 | 0.338 | 0.135 | 0.341 | 0.100 | 0.301 | 0.123 | 0.328 |
| Wage labour in agriculture | 0.196 | 0.397 | 0.192 | 0.394 | 0.207 | 0.406 | 0.165 | 0.371 |
| Wage labour in non-agriculture | 0.309 | 0.462 | 0.329 | 0.470 | 0.286 | 0.453 | 0.297 | 0.457 |
| Professional & others | 0.206 | 0.404 | 0.176 | 0.381 | 0.191 | 0.394 | 0.257 | 0.437 |
| Mother Diet : Higher | 0.367 | 0.482 | 0.333 | 0.472 | 0.333 | 0.473 | 0.339 | 0.473 |
| Middle | 0.358 | 0.480 | 0.333 | 0.471 | 0.419 | 0.495 | 0.378 | 0.485 |
| Low | 0.275 | 0.447 | 0.334 | 0.472 | 0.248 | 0.433 | 0.283 | 0.451 |
| Tetanus No | 0.705 | 0.456 | 0.723 | 0.448 | 0.770 | 0.422 | 0.440 | 0.496 |
| Yes | 0.295 | 0.456 | 0.277 | 0.448 | 0.230 | 0.422 | 0.560 | 0.496 |
| Iron tablets- No | 0.737 | 0.440 | 0.770 | 0.421 | 0.835 | 0.372 | 0.527 | 0.499 |
| Yes | 0.263 | 0.440 | 0.230 | 0.421 | 0.165 | 0.372 | 0.473 | 0.499 |
| Antenatal Visits - No | 0.683 | 0.465 | 0.701 | 0.459 | 0.775 | 0.419 | 0.441 | 0.496 |
| Yes | 0.317 | 0.465 | 0.300 | 0.459 | 0.225 | 0.419 | 0.559 | 0.497 |
| Place of Delivery- Home | 0.635 | 0.482 | 0.780 | 0.414 | 0.857 | 0.351 | 0.610 | 0.488 |
| Public | 0.159 | 0.366 | 0.092 | 0.289 | 0.044 | 0.206 | 0.184 | 0.387 |
| Private | 0.206 | 0.405 | 0.128 | 0.334 | 0.099 | 0.300 | 0.206 | 0.405 |
| Wealth - poorest | 0.320 | 0.467 | 0.348 | 0.477 | 0.403 | 0.492 | 0.255 | 0.436 |
| Poor | 0.255 | 0.436 | 0.305 | 0.461 | 0.325 | 0.470 | 0.224 | 0.417 |
| Middle | 0.202 | 0.402 | 0.184 | 0.388 | 0.168 | 0.375 | 0.200 | 0.400 |
| Richer | 0.149 | 0.356 | 0.109 | 0.312 | 0.086 | 0.281 | 0.180 | 0.384 |
| Richest | 0.074 | 0.262 | 0.054 | 0.227 | 0.018 | 0.134 | 0.141 | 0.348 |
| Caste- SC | 0.230 | 0.421 | 0.247 | 0.431 | 0.291 | 0.456 | 0.207 | 0.405 |
| ST | 0.106 | 0.308 | 0.141 | 0.348 | 0.212 | 0.410 | 0.096 | 0.295 |
| OBC | 0.400 | 0.490 | 0.379 | 0.485 | 0.372 | 0.485 | 0.409 | 0.492 |
| Others | 0.264 | 0.441 | 0.233 | 0.423 | 0.124 | 0.330 | 0.288 | 0.453 |
| Religion – Hindu | 0.817 | 0.387 | 0.797 | 0.403 | 0.817 | 0.388 | 0.787 | 0.410 |
| Muslim | 0.145 | 0.352 | 0.166 | 0.372 | 0.133 | 0.341 | 0.166 | 0.373 |
| Christian | 0.038 | 0.192 | 0.037 | 0.189 | 0.050 | 0.219 | 0.047 | 0.212 |
| Dirty Fuel | 0.888 | 0.316 | 0.918 | 0.275 | 0.965 | 0.185 | 0.809 | 0.393 |
| Clean Fuel | 0.112 | 0.316 | 0.082 | 0.275 | 0.035 | 0.185 | 0.191 | 0.393 |
| Drinking water-untreated | 0.752 | 0.432 | 0.799 | 0.401 | 0.754 | 0.432 | 0.710 | 0.454 |



(*Contd Table ...*)

(*Contd Table ...*)

| Variables | Neonatal Mortality | | Infant Mortality | | Under-five Mortality | | Survival | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Sd | Mean | Sd | Mean | Sd | Mean | Sd |
| Treated | 0.248 | 0.432 | 0.201 | 0.401 | 0.246 | 0.432 | 0.290 | 0.454 |
| PSU open defecation | 0.714 | 0.347 | 0.720 | 0.335 | 0.783 | 0.300 | 0.634 | 0.377 |
| Residence- Urban | 0.175 | 0.380 | 0.170 | 0.376 | 0.105 | 0.308 | 0.247 | 0.431 |
| Rural | 0.825 | 0.380 | 0.830 | 0.376 | 0.895 | 0.308 | 0.753 | 0.431 |
| Region- South | 0.118 | 0.323 | 0.097 | 0.297 | 0.120 | 0.326 | 0.162 | 0.368 |
| North | 0.121 | 0.326 | 0.135 | 0.341 | 0.132 | 0.340 | 0.132 | 0.339 |
| Centre | 0.351 | 0.477 | 0.408 | 0.492 | 0.376 | 0.486 | 0.286 | 0.452 |
| West | 0.095 | 0.293 | 0.070 | 0.256 | 0.092 | 0.291 | 0.122 | 0.327 |
| North-East | 0.039 | 0.194 | 0.041 | 0.198 | 0.051 | 0.220 | 0.038 | 0.197 |
| East | 0.276 | 0.447 | 0.249 | 0.432 | 0.229 | 0.421 | 0.260 | 0.439 |

**Source:** Calculated from, National Family Health Survey (NFHS-3), 2005-06.

**Note:** Category 1- Neonatal Mortality, Category 2- Infant Mortality, Category 3 – Under-five Mortality, Category 0- Survival is the omitted category of the regression model.

We initially present results to ascertain how the magnitude of the mother's height (an important variable capturing inter-generational transmission) changes in magnitude once other factors capturing intra-generation features are introduced. Table 5 shows the results for this analysis. This is followed by a detailed discussion of the differences in estimated coefficients across different categories of mortality and the results are presented in Table 6.

*Relevance of Maternal Height*

As mentioned in the objectives, the results are presented for the impact of mother's height (intergenerational transmission) as following a). Unadjusted for other covariates b). Adjusted for father's height but based on smaller sample c). Adjusted for BMI to account for small but healthy hypothesis, d) also adjusted for child level and maternal level characteristics e) adjusted for housing environment f) also adjusted for intervention variables. The results confirm the importance of stronger influence of maternal height on childhood mortality and it corroborates with the findings of Venkatramani, (2011), Subramanian *et. al.* (2011), Mekonnen *et. al.* (2013). Even after controlling the potential confounders, maternal height retains its significance with large impact in reducing the childhood mortality.

For a child to survive the first month and live beyond five years, the odds of mortality to survival as shown in Table 6 declines from 0.75 to 0.69 that is, the odds of survival increases with mother's height quintile category. The odds of mortality when compared to survival beyond 28 days to 1 year decreases from 0.54 to 0.49 moving from the lower to highest height quintile. For the third category of mortality as the events are very less, the top most height quintile category alone contributes to lower mortality risk. Overall it is observed that for early mortality maternal characteristics are more important which is consistent with the findings of Coffey (2013) where 20 neonatal deaths per 1000 births are averted with an increase in the mean height of the mother by 0.8cm and other factors play a larger role in avoidable mortality for later age.

In order to ascertain if maternal height and paternal height play the same role or the former is more important; father's height quintile categories are also used as control variables along with mother's height categories and reported in column 2 of Table 6 but is based on a smaller sample as mentioned earlier.

Firstly, when father's height alone is included then the magnitudes of the estimated coefficients are of lower magnitude which implies that the odds of survival are lower than that for maternal height and could also be because of the smaller sample size. When maternal height is also included the paternal height becomes insignificant and one observes that the maternal height has a dominant impact. Thus the results in this study show that intergenerational impact captured through mother's height is larger than for father's height showing that maternal characteristics are more important than father's and is at variance with the findings in Subramanian *et. al.* (2016). They do not find any difference in the impact between father's and mother's age at first birth thereby concluding that both have a similar impact.

*Small is healthy hypothesis*

Even if mothers are undernourished in terms of their heights if they are not undernourished in terms of the BMI then that accounts for 'small is healthy' hypothesis. To assess the impact of this, a well-nourished mother captured by BMI being above 18.5 (or not) is used to control for this. The results in column 3 of Table 6 show that 'small is healthy' hypothesis (Sukathme, 1982 and Seckler, 1982) does play some role as the adjusted rr coefficients for height quintiles changes but does not become insignificant. More importantly, we find that for the earliest mortality the magnitude declines while for later mortality the magnitude increases a bit indicating that avoidable mortality can be addressed through improvements in short-term nutritional status of the mother. In the case of mortality between 12-59 months it is observed that both long term and short term nutritional status of the mother does not make a huge impact but interestingly, mother's education turns out to be more significant which signifies that if the mother is educated and aware of access to pre and post natal inputs, avoidable mortality could be minimized for this category.

The next column 4 of Table 6 reports the results for maternal height after adjusting for maternal characteristics like mother's diet and interventions like antenatal care, tetanus shots and iron suuplements, in case of mortality category 1, likelihood of mortality compared to survival now is lower as contributed from mother's height. This implies that once other factors are controlled for, they bring down the mortality chances for each category of mortality but also reduce the impact of intergenerational factors. This means that though a child may have certain inherited disadvantages but if the factors like dietary diversity, tetanus shots, proper health visits for antenatal care and iron supplements are available and administered then the mortality chances decline. It is also observed that now the impact of inter-generational variables is lesser for the earliest mortality category compared to the infant mortality.

**Table 6: Relative Risk Ratios for 3 Categories of Childhood Mortality: Relevance of Maternal Height**

| **Mortality Categories** | **Estimated Relative Risk Ratios from a Multinomial Logit Model** | | | | | |
|---|---|---|---|---|---|---|
| **Category 1 (nnm=1)** | **Unadjusted[1]** | **Adjusted for father's height[2]** | **Adjusted for BMI[3]** | **Adjusted for child and maternal characteristic[4]** | **Adjusted for Housing environment[5]** | **Adjusted for all variables[6]** |
| Height Quintile 2[€] | 0.755*** | 0.697*** | 0.752*** | 0.784*** | 0.783*** | 0.777***(0.056)[a] |
| Height Quintile 3 | 0.784*** | 0.662*** | 0.787*** | 0.841*** | 0.840*** | 0.861***(0.063) |
| Height Quintile 4 | 0.746*** | 0.663*** | 0.742*** | 0.814*** | 0.818*** | 0.823***(0.062) |
| Height Quintile 5 | 0.691*** | 0.542*** | 0.693*** | 0.780*** | 0.780*** | 0.818***(0.064) |
| Constant | 0.052*** | | | | | |
| **Category 2 (Im= 1)** | | | | | | |
| Height Quintile 2[€] | 0.545*** | 0.571*** | 0.548*** | 0.560*** | 0.560*** | 0.556***(0.053) |
| Height Quintile 3 | 0.528*** | 0.534*** | 0.534*** | 0.585*** | 0.581*** | 0.578***(0.059) |
| Height Quintile 4 | 0.585*** | 0.581*** | 0.591*** | 0.670*** | 0.674*** | 0.655***(0.063) |
| Height Quintile 5 | 0.494*** | 0.517*** | 0.501*** | 0.592*** | 0.600*** | 0.590***(0.060) |
| Constant | 0.035*** | | | | | |
| **Category 3 (U5M=1)** | | | | | | |
| Height Quintile 2[€] | 1.062 | 1.606 | 1.109 | 1.131 | 1.112 | 1.088(0.224) |
| Height Quintile 3 | 0.843 | 0.569 | 0.892 | .978 | 0.968 | 0.937(0.207) |
| Height Quintile 4 | 0.787 | 0.693 | 0.829 | 0.927 | 0.941 | 0.888(0.201) |
| Height Quintile 5 | 0.579** | 0.612 | 0.615** | 0.724 | 0.745 | 0.713(0.178) |
| Constant | 0.005*** | | | | | |
| *Pseudo R-Square* | 0.0044 | 0.0082 | 0.0062 | 0.0585 | 0.0616 | 0.168 |



*(Contd Table …)*

(*Contd Table ...*)

| Mortality Categories | Estimated Relative Risk Ratios from a Multinomial Logit Model | | | | | |
|---|---|---|---|---|---|---|
| **Category 1 (nnm=1)** | **Unadjusted[1]** | **Adjusted for father's height[2]** | **Adjusted for BMI[3]** | **Adjusted for child and maternal characteristic[4]** | **Adjusted for Housing environment[5]** | **Adjusted for all variables[6]** |
| **All category (Mortality= 1)** | ***Estimated Odds Ratios from a Binary Logit Model*** | | | | | |
| Height Quintile 2[€] | 0.692*** | 0.695*** | 0.693*** | 0.717*** | 0.715*** | 0.768***(0.047) |
| Height Quintile 3 | 0.689*** | 0.602*** | 0.696*** | 0.751*** | 0.748*** | 0.765***(0.048) |
| Height Quintile 4 | 0.687*** | 0.634*** | 0.689*** | 0.765*** | 0.768*** | 0.756***(0.049) |
| Height Quintile 5 | 0.610*** | 0.536*** | 0.616*** | 0.705*** | 0.710*** | 0.710***(0.047) |
| Constant | 0.092*** | | | | | |

**Source:** Calculated from National Family Health Survey (NFHS-3), 2005-06.

**Note**: Base Outcome: Survival beyond 5 years. Relative Risk Ratios are estimated using equation (3b).

€- Height Quintile 1 is the reference category- mother height converted into quintiles with 20% of population in each quintile for the purpose of analysis. Q1(<143cm) Q2(146-149cm), Q3(150-153cm), Q4(153-156cm), Q5(156-160cm).

Nnm- neonatal mortality, Im- Infant mortality, U5M- Under-five mortality.

1- Model included only mother's height

2 - Model controlled for both mother's and father's height where the sample size is different because father's anthropometry reported in NFHS- 3 are less in number.

3 - Model included maternal height and BMI.

4 - Model controlled for mother's height, BMI, age at first birth, education, gender, birth order and birth size.

5- Model controlled for height, BMI, age at first birth, education, gender, birth order, birth size, caste, religion, wealth and mother diet.

6 - Model controlled for gender, birth order, birth size, place of residence, wealth, caste, religion, fuel, water, sanitation, mother's age at first birth and education, tetanus shots, iron tablets, antenatal care, mother's diet, place of delivery, initiation of breastfeeding, domestic violence, state group dummies, father education.

A – Values in brackets represent standard errors; *** (p<0.001)1% significance level, **(p<0.05) 5% significance level.

If we look row-wise, the pace of decline towards the top quintile of the mother (0.77 to 0.82) is small thereby suggesting that other variables do play a role in reducing the mortality but not with large magnitude as maternal height, for the short term survival. But for the infant mortality the magnitudes are more or less same (0.55 to 0.59) except for the top quintile of the mother. So for longer term survival even if the mother is tall enough, along with maternal height other factors like education, occupation do play a bigger role in avoiding under-five and infant mortality. This result not only signifies the dominant role of maternal height but also other factors like diet, education, usage of treated water, BMI, interventions like antenatal care, iron tablets, tetanus shots, institutional delivery gives an added advantage for the reduction of child mortality.

Another interesting result is to note that for the infant mortality we can witness the pattern is more or less same when other factors are included. This is because category 2 relates to more long period of survival and other factors like interventions seem to play a major role and reduces the mortality risk. Maternal height is not significant for under-five mortality but other factors like mother's education and antenatal visits are highly significant since in the longer duration mortality can be arrested through awareness and the proper usage of interventions. When we include all the variables the pseudo R-square increases but the contribution of both variables retain its significance with respect to mother's diet and interventions.

In case of combining all the childhood mortality categories last panel in Table 6, the odds ratio estimates of the logit model reduces thereby increasing the likelihood of the child to survive. When other control variables are added, thepattern is more or less same as for category 1 mortality, and this clearly shows that we would not have got additional insight from analyzing the age-specific results for each category and the conclusions could be limited. These results are included to depict the importance of undertaking the age specific childhood mortality outcomes to get a clear understanding while devising policies.

**Table 7: Estimates of Relative Risk Ratios for Age- Specific Mortality Rates from Multinomial Logistic Regression**

| VARIABLES | Category 1 | Category 2 | Category 3 |
|---|---|---|---|
| | odds ratio | odds ratio | odds ratio |
| *Gender*Birth Order: (1st child *Male= Ref)* | | | |
| Male * $2^{nd}$ order | 0.496*** | 0.538*** | 0.638 |
| | (0.0457) | (0.0792) | (0.215) |
| Male *≥ $3^{rd}$ order | 0.378*** | 0.554*** | 0.671 |
| | (0.0317) | (0.0679) | (0.189) |
| Female * $1^{st}$ order | 0.745*** | 1.030 | 0.795 |
| | (0.0599) | (0.130) | (0.259) |
| Female* $2^{nd}$ order | 0.389*** | 0.831 | 1.006 |
| | (0.0384) | (0.110) | (0.308) |
| Female * ≥ $3^{rd}$ order | 0.381*** | 0.869 | 1.147 |
| | (0.0322) | (0.100) | (0.304) |
| *Birth Size:(Small and smaller than average=Ref)* | | | |
| Verylarge | 0.966 | 0.737* | 1.923** |
| | (0.109) | (0.133) | (0.590) |
| Average and larger than average | 0.623*** | 0.723*** | 0.963 |
| | (0.0336) | (0.0529) | (0.169) |
| *Birth Interval : (<24 months =Ref)* | | | |
| Greater than 24mths | 0.467*** | 0.576*** | 0.627*** |
| | (0.0285) | (0.0437) | (0.101) |
| *Mother Height: (Quintile 1; Shortest =Ref)* | | | |
| Quintile 2 | 0.777*** | 0.556*** | 1.088 |
| | (0.0566) | (0.0532) | (0.224) |
| Quintile 3 | 0.861** | 0.578*** | 0.937 |
| | (0.0632) | (0.0568) | (0.207) |
| Quintile 4 | 0.823*** | 0.655*** | 0.888 |
| | (0.0617) | (0.0629) | (0.201) |
| Quintile 5(Tallest group) | 0.818*** | 0.590*** | 0.713 |
| | (0.0636) | (0.0608) | (0.178) |
| *Mother BMI: (<18.5=Ref)* | | | |
| 18.5-24.9 | 0.953 | 0.998 | 0.933 |
| | (0.0484) | (0.0672) | (0.137) |



(*Contd Table ...*)

(*Contd Table ...*)

| VARIABLES | Category 1 | Category 2 | Category 3 |
|---|---|---|---|
| | **odds ratio** | **odds ratio** | **odds ratio** |
| Above 25 | 1.419*** | 1.249 | 0.734 |
| | (0.151) | (0.202) | (0.357) |
| *Mother's age at first birth: (<20 yrs =Ref)* | | | |
| 20-34 yrs | 0.996 | 0.985 | 0.938 |
| | (0.0532) | (0.0716) | (0.154) |
| >34yrs | 0.0586 | 1.026 | 2.550 |
| | (0.161) | (1.123) | (0.0151) |
| *Mother Education: (Illiterate =Ref)* | | | |
| Primary | 0.501*** | 0.413*** | 0.453*** |
| | (0.0406) | (0.0498) | (0.120) |
| Secondary | 0.311*** | 0.286*** | 0.220*** |
| | (0.0247) | (0.0343) | (0.0711) |
| Higher | 0.151*** | 0.202*** | 0.617 |
| | (0.0339) | (0.0690) | (0.467) |
| *Initiation of breastfeeding: (Later 1 hr = Ref)* | | | |
| Within 1 hr | 0.669*** | 0.959 | 0.967 |
| | (0.0403) | (0.0755) | (0.168) |
| *Mother Diet: (Low = Ref)* | | | |
| Middle | 0.918 | 0.959 | 1.160 |
| | (0.0580) | (0.0841) | (0.215) |
| High | 0.770*** | 0.901 | 0.600** |
| | (0.0521) | (0.0794) | (0.124) |
| *Domestic Violence: (No violence = Ref)* | | | |
| Severe violence | 1.078 | 0.756*** | 0.843 |
| | (0.0654) | (0.0569) | (0.145) |
| less violence | 1.028 | 0.923 | 1.401 |
| | (0.0916) | (0.0980) | (0.303) |
| *Father Occupation: (Professional = Ref)* | | | |
| Selfemployed in agri | 0.920 | 1.016 | 0.698 |
| | (0.0801) | (0.120) | (0.169) |
| Selfemployed in nonagri | 1.086 | 1.108 | 0.593* |
| | (0.0946) | (0.131) | (0.165) |



(*Contd Table ...*)

(*Contd Table ...*)

| VARIABLES | Category 1 | Category 2 | Category 3 |
|---|---|---|---|
| | odds ratio | odds ratio | odds ratio |
| Wagelabour in agri | 0.990 | 0.911 | 0.624** |
| | (0.0815) | (0.103) | (0.147) |
| Wagelabour in nonagri | 0.998 | 0.989 | 0.597** |
| | (0.0716) | (0.0976) | (0.127) |
| *Wealth: (Poorest = Ref)* | | | |
| Poorer | 1.008 | 1.247*** | 1.188 |
| | (0.0670) | (0.104) | (0.209) |
| Middle | 1.069 | 1.094 | 0.950 |
| | (0.0812) | (0.112) | (0.215) |
| Richer | 1.125 | 1.013 | 0.941 |
| | (0.109) | (0.141) | (0.305) |
| Richest | 0.985 | 1.077 | 0.508 |
| | (0.146) | (0.235) | (0.354) |
| *Caste: (SC = Ref)* | | | |
| | (0.0888) | (0.138) | (0.285) |
| OBC | 0.905 | 0.855* | 0.673** |
| | (0.0597) | (0.0749) | (0.126) |
| Others | 1.209** | 1.147 | 0.485*** |
| | (0.0951) | (0.125) | (0.136) |
| *Religion:( Others = Ref)* | | | |
| Hindus | 1.077 | 1.106 | 0.991 |
| | (0.143) | (0.202) | (0.361) |
| Muslims | 0.775* | 0.883 | 0.994 |
| | (0.116) | (0.180) | (0.427) |
| *Fuel: (Dirty fuel = Ref)* | | | |
| Cleanfuel | 0.946 | 0.881 | 0.610 |
| | (0.106) | (0.148) | (0.301) |
| *Drinking Water : (Untreated = Ref)* | | | |
| Treated water | 1.192*** | 0.996 | 1.288 |
| | (0.0765) | (0.0901) | (0.240) |
| PSU open defecation | 1.116 | 0.825 | 0.890 |
| | (0.118) | (0.120) | (0.300) |
| *Place of Residence: (Rural = Ref)* | | | |



(*Contd Table ...*)

(*Contd Table …*)

| VARIABLES | Category 1 | Category 2 | Category 3 |
|---|---|---|---|
| | **odds ratio** | **odds ratio** | **odds ratio** |
| Urban | 0.882 | 0.992 | 0.768 |
| | (0.0766) | (0.117) | (0.222) |
| Tetanus Shots: *(None = Ref)* | | | |
| Yes | 0.471*** | 0.534*** | 0.677 |
| | (0.0388) | (0.0582) | (0.167) |
| Iron Tablets: *(None = Ref)* | | | |
| Yes | 0.948 | 0.790** | 0.569** |
| | (0.0801) | (0.0879) | (0.151) |
| *Antenatal visits: (None = Ref)* | | | |
| Yes | 0.777*** | 0.855 | 0.624* |
| | (0.0691) | (0.0975) | (0.162) |
| *Place of delivery:( Home = Ref)* | | | |
| Public | 1.491*** | 0.754** | 0.394*** |
| | (0.112) | (0.0913) | (0.142) |
| Private | 1.894*** | 1.097 | 1.028 |
| | (0.138) | (0.123) | (0.275) |
| *Region: (Centre = Ref)* | | | |
| South | 0.797** | 0.853 | 1.367 |
| | (0.0726) | (0.110) | (0.366) |
| North | 0.701*** | 0.825* | 0.920 |
| | (0.0603) | (0.0906) | (0.225) |
| West | 0.754*** | 0.674*** | 1.023 |
| | (0.0748) | (0.0981) | (0.296) |
| North-East | 1.295** | 0.883 | 1.281 |
| | (0.160) | (0.175) | (0.535) |
| East | 0.954 | 0.728*** | 0.702* |
| | (0.0627) | (0.0645) | (0.143) |
| Intercept | 0.500*** | 0.280*** | 0.0518*** |
| | (0.110) | (0.0842) | (0.0336) |

**Source:** Calculated from National Family Health Survey (NFHS-3), 2005-06.

**Note:** p-values significance *** p<0.01, ** p<0.05, * p<0. Standard errors are in parenthesis. Pseudo R-square =0.168, N= 48250.

Based on the results of the MNL regression model, if the relative risk ratio of (equation 3b) is greater than 1 (Table 7) implies positive coefficients (See Table 8) and the odds of risk of mortality will be higher, whereas if the ratio is less than 1 (Table 7) that signifies the negative coefficients (See Table 8) and odds of mortality is lesser.

Table 7 shows that risk of neonatal mortality is lower for the higher order births for both males and females. If the child is of first order and happens to be a female, the odds of mortality (neonatal) is lesser when compared to other categories of mortality; the magnitudes are all less than one and the coefficient for higher order birth are lower for both male and female children. Between male and female child, the coefficient of female first child is less than 1 and significant. A female child has an advantage of survival than males during their first month of childhood. In case of infant mortality, risk is higher for males at higher order births. As discussed in the literature, to some extent the interaction term gives us the better picture that which child (male or female) has a larger probability at higher birth order.

The effects of birth spacing on mortality are studied more often (Bhalotra and Soest, 2008; Davanzo, 2004 and Kozuki, 2013). Shorter birth intervals will increase the risk of death of the child and the odds are greater than one, throughout. Bhalotra and Arulamplam (2006) argue that death clustering in the Indian households is occurring because of shorter birth intervals. Shorter birth intervals also leads to competition for household resources including the fact that with more children in the similar ages would lead to higher risk of infectious diseases. Another major determinant of survival chances of infancy is size of child at birth. 48% of the sample children born at home that are in non-institutional setting, so birth weight was not assessed properly. It is purely mother's assessment of the child size. Children who are larger and average in size have lower risk of mortality which is shown by the negatively significant coefficient and it is comparatively higher for infant and neonatal mortality. The positive coefficient implies that if the child is smaller than average, odds of deaths is greater and higher for infant mortality. One interesting result to note is if the child is small and able to survive upto 5 years perhaps due to post-natal inputs, their relative risk to die is low which is indicated by negative coefficient (See Table 8).

Education of the mother is the most widely used variable in the literature and the results are not different from the earlier studies as educated mothers have lower risk of mortality. Mother's education is bringing a higher impact as the magnitudes are much lesser (0.15 for category 1; and 0.20 for category 2) for higher education compared to all the other variables used in the model (Table 7). Since literate mothers are likely to be more aware, this reduces the risk of mortality of the child. Initiation of breastfeeding reduces the risk of neonatal mortality by 0.67 times which is consistent with the Gupta *et. al.* (2010) where the delay in breastfeeding even for 1 hour increases the risk to two-fold times. Mother's dietary intake is making a big difference for the mothers who consume more diversified food groups, their children have around one-fold lesser risk of neonatal mortality and the magnitude is higher for under-five mortality but when maternal height is included, mother's diet contribution becomes smaller for both neonatal and infant mortality.

As discussed in the literature review section, not many studies have documented the role of domestic violence and dietary practices on mortality. The behavior of the father like beating, scolding the wife will increase the stress on the mother especially during pregnancy which would lead to complications in birth and the growth of the child. It is obvious from the result from Table 7 that severe violence increases the odds ratio of infant mortality of the child. The same result was observed by Koenig *et. al.* (2010) for neonatal mortality among rural Indian children.

Factors like caste, religion, income are associated with socio-economic differentials on age specific mortality. The wealth quintiles variable shows that the richer children are at lower risk of mortality (Table 7) than their poorest counterparts which is indicated by negative coefficients for under-five and neonatal mortality (See Table 8) This variable lost its significance in the full model after the introduction of mother's education and father's occupation into it. Compared to the fathers who are not in agriculture, the child born in the family whose fathers are wage labourers, they are able to survive and it is significant for under-five mortality.

The caste variable gives the mixed pattern when compared with scheduled caste, for the categories 2 and 3 ( infant and under-five), scheduled tribe infants are at higher risk but in neonatal their risk is lower. For OBC, their risk is lower in the case of neonatal and infant mortality but for the under -five mortality when compared with others their odds of likely to survive declined. We did not find any significant differences between SC/ST and OBC as analogous to the findings of the study by Domararaju *et. al.* (2008) which could be because of the social and the economic class occupied by these groups. Religion variable gives us the interesting results where in neonates, the coefficient is significant and positive for Hindus which reflects risk for mortality when compared to other religion and Muslims have lesser risk throughout and their odds of likelihood to survive is more. This result in Table 7 once again finds support from the literature on Muslim survival advantage (Bhalotra *et. al.*, 2010 and Brainerd and Menon, 2015).

## Table 8: Estimated Regression Coefficients from Multinomial Logit Model

| VARIABLES | NMR | IMR | U5MR |
|---|---|---|---|
| *Gender*Birth Order (1st child Male= Ref)* | | | |
| Male * 2 child | -0.701*** | -0.620*** | -0.449 |
| | (0.0920) | (0.147) | (0.337) |
| Male* More than 3 child | -0.974*** | -0.591*** | -0.398 |
| | (0.0838) | (0.122) | (0.281) |
| Female * 1 child | -0.294*** | 0.0295 | -0.229 |
| | (0.0804) | (0.126) | (0.325) |
| Female* 2 child | -0.944*** | -0.185 | 0.00583 |
| | (0.0986) | (0.133) | (0.306) |
| Female *More than child | -0.964*** | -0.140 | 0.137 |
| | (0.0844) | (0.116) | (0.265) |
| *Birth Size(Small and smaller than average= Ref)* | | | |
| verylarge | -0.0343 | -0.304* | 0.654** |
| | (0.113) | (0.180) | (0.307) |
| Average and larger than average | -0.473*** | -0.325*** | -0.0378 |
| | (0.0540) | (0.0733) | (0.175) |
| Birth Interval (<24 months= *Ref*) | | | |
| Greater than 24mths | -0.760*** | -0.552*** | -0.467*** |
| | (0.0609) | (0.0759) | (0.161) |
| Mother Height( Quintile 1= *Ref*) | | | |
| Quintile 2 | -0.253*** | -0.586*** | 0.0847 |
| | (0.0728) | (0.0956) | (0.206) |
| Quintile 3 | -0.150** | -0.549*** | -0.0651 |
| | (0.0734) | (0.0983) | (0.221) |
| Quintile 4 | -0.195*** | -0.423*** | -0.119 |
| | (0.0749) | (0.0961) | (0.227) |
| Quintile 5 | -0.200*** | -0.527*** | -0.338 |
| | (0.0777) | (0.103) | (0.250) |
| Mother BMI( <18.5= *Ref*) | | | |
| 18.5-24.9 | -0.0483 | -0.00157 | -0.0692 |
| | (0.0508) | (0.0673) | (0.147) |



(*Contd Table ...*)

(*Contd Table ...*)

| VARIABLES | NMR | IMR | U5MR |
|---|---|---|---|
| Above 25 | 0.350*** | 0.222 | -0.309 |
| | (0.106) | (0.162) | (0.487) |
| Mother's age at first birth(<20 yrs= *Ref*) | | | |
| 20-34 yrs | -0.00440 | -0.0148 | -0.0645 |
| | (0.0535) | (0.0727) | (0.164) |
| >34yrs | -2.837 | 0.0255 | -10.58 |
| | (2.754) | (1.094) | (593.9) |
| Mother Education( Illiterate= *Ref*) | | | |
| Primary | -0.690*** | -0.883*** | -0.792*** |
| | (0.0809) | (0.120) | (0.266) |
| Secondary | -1.169*** | -1.252*** | -1.514*** |
| | (0.0794) | (0.120) | (0.323) |
| Higher | -1.892*** | -1.601*** | -0.484 |
| | (0.225) | (0.342) | (0.757) |
| Initiation of breastfeeding( Later 1 hr= *Ref*) | | | |
| Within 1 hr | -0.402*** | -0.0421 | -0.0335 |
| | (0.0602) | (0.0787) | (0.174) |
| Mother Diet( Low= *Ref*) | | | |
| Middle | -0.0852 | -0.0422 | 0.148 |
| | (0.0632) | (0.0877) | (0.185) |
| High | -0.261*** | -0.105 | -0.511** |
| | (0.0676) | (0.0882) | (0.207) |
| Domestic Violence(No violence= *Ref*) | | | |
| Severe violence | -0.0752 | 0.279*** | 0.171 |
| | (0.0606) | (0.0752) | (0.172) |
| less violence | -0.0473 | 0.199** | 0.509*** |
| | (0.0802) | (0.0994) | (0.195) |
| Father Occupation(Professional= *Ref*) | | | |
| Selfemployed in agri | -0.0832 | 0.0163 | -0.359 |
| | (0.0871) | (0.118) | (0.241) |
| Selfemployed in nonagri | 0.0823 | 0.102 | -0.523* |
| | (0.0871) | (0.118) | (0.278) |
| Wagelabour in agri | -0.0101 | -0.0931 | -0.471** |
| | (0.0824) | (0.113) | (0.236) |

(*Contd Table ...*)

(*Contd Table ...*)

| VARIABLES | NMR | IMR | U5MR |
|---|---|---|---|
| Wagelabour in nonagri | -0.00203 | -0.0115 | -0.516** |
| | (0.0718) | (0.0988) | (0.214) |
| Tetanus Shots(None= *Ref*) | | | |
| Yes | -0.752*** | -0.627*** | -0.390 |
| | (0.0823) | (0.109) | (0.247) |
| Iron Tablets( None= *Ref*) | | | |
| Yes | -0.0535 | -0.236** | -0.565** |
| | (0.0845) | (0.111) | (0.265) |
| Antenatal visits( None= *Ref*) | | | |
| Yes | -0.252*** | -0.156 | -0.472* |
| | (0.0889) | (0.114) | (0.260) |
| Place of Delivery( Home= *Ref*) | | | |
| Public | 0.399*** | -0.283** | -0.933*** |
| | (0.0752) | (0.121) | (0.361) |
| Private | 0.639*** | 0.0925 | 0.0272 |
| | (0.0728) | (0.112) | (0.268) |
| Wealth(Poorest= *Ref*) | | | |
| Poorer | 0.00806 | 0.221*** | 0.172 |
| | (0.0665) | (0.0835) | (0.176) |
| Middle | 0.0664 | 0.0899 | -0.0513 |
| | (0.0760) | (0.103) | (0.227) |
| Richer | 0.118 | 0.0134 | -0.0611 |
| | (0.0966) | (0.139) | (0.324) |
| Richest | -0.0150 | 0.0742 | -0.677 |
| | (0.148) | (0.219) | (0.696) |
| Caste(SC= *Ref*) | | | |
| ST | -0.0548 | 0.187 | 0.255 |
| | (0.0938) | (0.115) | (0.220) |
| OBC | -0.100 | -0.156* | -0.396** |
| | (0.0660) | (0.0876) | (0.187) |
| Others | 0.189** | 0.137 | -0.724*** |
| | (0.0787) | (0.109) | (0.281) |
| Religion(Others= *Ref*) | | | |



(*Contd Table ...*)

(*Contd Table ...*)

| VARIABLES | NMR | IMR | U5MR |
|---|---|---|---|
| Hindu | 0.0739 | 0.101 | -0.00951 |
| | (0.132) | (0.182) | (0.364) |
| Muslim | -0.255* | -0.125 | -0.00563 |
| | (0.150) | (0.204) | (0.429) |
| Fuel(Dirty = *Ref*) | | | |
| cleanfuel | -0.0560 | -0.127 | -0.494 |
| | (0.112) | (0.168) | (0.492) |
| Drinking Water ( Untreated = *Ref*) | | | |
| Treated water | 0.176*** | -0.00414 | 0.253 |
| | (0.0642) | (0.0905) | (0.187) |
| PSU open defecation | 0.109 | -0.193 | -0.117 |
| | (0.106) | (0.145) | (0.337) |
| Place of residence(Rural = *Ref*) | | | |
| Urban | -0.126 | -0.00758 | -0.264 |
| | (0.0869) | (0.118) | (0.289) |
| Region(Centre = *Ref*) | | | |
| South | -0.227** | -0.159 | 0.313 |
| | (0.0911) | (0.129) | (0.267) |
| North | -0.355*** | -0.193* | -0.0834 |
| | (0.0859) | (0.110) | (0.244) |
| West | -0.282*** | -0.394*** | 0.0230 |
| | (0.0991) | (0.145) | (0.289) |
| North-East | 0.259** | -0.124 | 0.247 |
| | (0.124) | (0.198) | (0.418) |
| East | -0.0471 | -0.317*** | -0.353* |
| | (0.0657) | (0.0885) | (0.203) |
| Constant | -0.618*** | -1.551*** | -3.132*** |
| | (0.216) | (0.297) | (0.639) |
| Observations | 48,250 | 48,250 | 48,250 |

**Source:** Calculated from National Family Health Survey (NFHS-3), 2005-06.

**Note**: *** p<0.01, ** p<0.05, * p<0.1 Standard errors in parentheses

Among the household infrastructure variables, access to safe drinking water helps in reducing the neonatal mortality and open defecation variable and fuel reduces its significance, once other variables are controlled in the model. Notable regional differences are also witnessed in the model where the risk is lesser in southern region compared to other regions. Among the intervention variable, iron tablets are helping in reducing more neonatal mortality of about 0.47 times to a larger extent even after introducing all variables in the model. Antenatal visit variable are also significant and the results are consistent with the existing literature as discussed in the literature review section. These variables are highly significant for the chances of survival within the first month in comparison with the other two categories. In case of institutional delivery, compared to home delivery, institutional delivery increases the risk of mortality. For neonates, delivery at the public hospitals is turning out to be significant whereas for infant and under-five mortality private hospitals reduces their risk of mortality. This contradictory result may be due to the underreporting cases of home delivery deaths.

## KEY FINDINGS

This chapter examined the determinants of childhood mortality in India for children aged 0-5 years using a multinomial logit model. The magnitudes of the coefficients are varying across the different categories of the mortality, clearly substantiating the need for this modelling framework used in this chapter.

The main empirical findings are summarized below;

- Mother's long term nutritional status reduces the risk to mortality for category 1(earlier days of mortality) to a larger extent compared to other two categories. Compared to mother's height, father's height has lower magnitude in all the outcomes and if both the variables are included, then father's height is not statistically significant, highlighting the larger role played by the mother's nutritional status in intergenerational transmission. Mother's short term nutritonal status that is BMI (<18.5kg/$m^2$) adversely impacts category 2 (infant) mortality more than neonatal thereby indicating that maintenance of normal BMI can be addressed through focusing on undernourished mothers.

- Initiation of breastfeeding within 1 hour influences neonatal survival alone while the high quality dietary diversity influences both neonatal and under-five mortality.
- With respect to the objective of assessing the relative role of child characteristics, the interaction term of gender and birth order shows some significant results that in neonates, male children are survive more at higher order births compared to females. The odds of survival is likely to be very low for neonates if the child is born within a short birth interval and smaller in size; after controlling for other factors.
- Other control variables used in the model are wealth status of the household, father's education and occupation, rural/urban residence lost its significance once other variables are controlled for.
- Once mother's education was controlled for, her employment and occupation status did not influence childhood mortality and hence was excluded from the analysis. It was also found that once economic status is controlled, father's occupation is still statistically significant for category 3 mortality. This could also be because this mortality rates have far lower incidence in the dataset compared to undernutrition.
- The intervention variables like antenatal care, tetanus shots, and iron supplements help to curb the mortality. In this, tetanus shots increases the odds of neonatal survival by 0.53 times and increases the infant survival by 0.47 times.

As mentioned in the objective of this chapter separating age-specific categories of mortality and estimating a multinomial logit model has given useful insights on mortality reduction among very young children in India. The results are largely as expected and align with earlier studies. Our attempt to restructure or respecify some of the explanatory variables related to mother's anthropometry, feeding and care practices, gender and birth order and health seeking behavior of the mother has given a finer understanding of these determinants and adds to the existing empirical literature. The major limitations are discussed in the last chapter.

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