Introduction

Globally, infant mortality is a major cause of concern, contributing to nearly 5 million deaths below age one every year (Debelew 2014; Conroy 2014). It is the most important health indicator reflecting the quality of life, levels of development and effectiveness of the ongoing health policies and programs of a nation. But, the most vulnerable time of child survival is the first 28 days of life i.e. the neonatal period during which majority of the infant deaths take place (Debelew 2014; Conroy 2014). High neonatal mortality indicates a country's demographic, social and economic backwardness and its inability to provide adequate health care services to its people. It contributes to about 60% of the total infant deaths in the world and more than 98% of the neonatal deaths are attributable to the low and middle income countries (Debelew 2014; Kayode 2014). Moreover, health interventions needed for the reduction of neonatal mortality are different from those of infant and child mortality which necessitates prioritization of this issue. According to WHO 2015 estimates, there is a worldwide decline in the neonatal mortality rates by 47% from 36 to 19 deaths per 1000 live births between 1990 and 2015. Although, this most sensitive indicator of health has been showing a declining trend since the past few decades, the rate of fall is low and its value still remains very high. In order to investigate the major determinants of this high infant mortality, it is necessary to focus on this most crucial part of an infant's life which resists the growth of the infants bringing lump sum of sorrows not only to the family creates an obstacle in the path of the future progress of the country itself.

India, Nigeria, Pakistan, China and Democratic Republic of Congo are the 5 leading countries accounting for more than half of the newborn deaths in the world of which India has the largest share. Nearly one-fourth of the global neonatal deaths are attributable to that of India. It also accounts for about two-third of all infant deaths in India. It is that part of human life in which there is a high chance of vulnerability due to various individual, household and community level factors. It has decreased considerably from 48.6 per 1000 live births in National Family Health Survey (NFHS) (1992-93) to 39 per 1000 live births in NFHS (2005-06). As per Sample Registration System (SRS) 2014, infant mortality rate in India was 39 per 1000 live births whereas neonatal mortality rate was 26 per 1000 live births. But to achieve the target of the Millennium Development Goal, India needs to go far.

Neonatal mortality is alarmingly high in almost all the states of India. But there remain large inter-state as well as intra-state disparities due to the prevalence of wealth quintile and type of residence and presence of gender inequality (Sankar et al 2016). The states of Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar contribute to more than half of newborn and under-five deaths in India (UNICEF India 2016). It is much higher among the rural communities, scheduled castes, scheduled tribes and other groups belonging to the lower strata as compared to that in urban areas due to socioeconomic deprivations and inadequate accessibility of health care services. As per SRS 2015, Kerala records the least neonatal mortality rate of 6 per 1000 live births which is equal to that of the United States of America, whereas Madhya Pradesh and

Odisha represent Nigeria with very high NMR of 35 and Haryana resembles Kiribati with NMR of 24. This gives a clear indication that within India, there are many different countries (representing the states) with different values of neonatal mortality rate and these are run by their corresponding governance other than the central control. It is observed that although they are similar in terms of the socioeconomic and demographic characteristics, yet the levels of NMR are different.

Review of Literature: Need for the Study

A plenty of research work is done all over the world focusing on various dimensions of neonatal mortality. These mainly include epidemiological and demographic studies which are concerned in the investigation of the different factors responsible for high neonatal deaths in a region and finding probable solutions for its reduction. The main reasons for most of the neonatal deaths are found to be premature birth, asphyxia, sepsis, pneumonia, congenital anomalies and diarrheal diseases (Rammohan et al 2013, Sankar et al 2016) which cannot be treated or prevented due to inadequate nutrition and poor accessibility of the health care centers. It is estimated that nearly 78% of the neonatal deaths in India are due to premature birth, low birth weight, birth asphyxia, birth trauma and neonatal infections whereas pneumonia and diarrheal diseases contribute to nearly 50% of the deaths (*Bassani et al 2016*). In view of all these, the socio-economic factors viz. parental education, age of the mother, sex of the child, economic condition, place of residence, birth order, preceding birth interval, antenatal care, post natal care, health care utilization, religion and caste play an important role in creating such vulnerable situation (Usha rani 2014; Fadel, Ram et al 2015; Gupta et al 2015; Singh et al 2012) and are the crucial determinants of both infant and neonatal mortality. In addition, the contribution of household headship in infant mortality is prevalent in the sense that female headed households experience lower infant deaths as compared to male headed households (Gupta et al 2015) irrespective of place of residence and sex of the child.

The effect of unintended pregnancy on neonatal mortality is also observed in the less developed countries like India (Singh et al 2012). Unwanted and mistimed pregnancy can lead to unsupervised delivery, partial or no vaccination to the newborn and stunting growth due to malnutrition which are positively correlated with neonatal mortality. Moreover, the pregnancy intentions vary according to the different individual, household and community level factors. The estimates show that in India, unwanted births have respectively 1.17 times, 1.27 times and 1.13 times higher odds of being delivered by unskilled attendance, receiving no or incomplete immunization and having stunted growth than those of wanted children (Singh et al).

A Geospatial analysis of infant and child mortality in India put emphasis on the independent effect of geographical space on infant and child deaths using the data of 76 natural regions of India (Singh, Pathak et al 2011). The regional differences play an important role in influencing the individual and household level factors which in turn determine the infant and child mortality (outcome variables). The findings of this study suggest that the regions which are underprivileged in terms of poverty, child nutrition and female literacy, report higher levels of infant and child deaths in comparison to others. Moreover, it reveals that there are several regions which show inconsistent relationship between poverty and mortality. The differences in the socio-economic condition, culture and norms in different states in India are responsible for difference in the attitude towards female children, female education, female work force participation and other factors affecting infant mortality rate to a great extent (Kapoor 2010).

But, a multilevel analysis of neonatal mortality in Ghana brings out a clear picture of the role of individual and community level factors on neonatal mortality using hierarchical nature (Kayode, Ansha et al 2014). Socioeconomic disadvantaged communities serve as the community level determinants for this analysis. Taking into consideration of both the above factors, it is observed that infants with multiple gestations have 5 times higher likelihood of dying in the neonatal phase in Ghana. There is a 2-fold increase in the likelihood of dying of neonates with low birth weight, a 3.5 fold increase if preceding birth interval is less than 18 months as compared to those above 36 months. Early breast feeding and better utilization of health care resources reduces the risk of neonatal deaths. Moreover, negative association is visible between residence in socioeconomic deprived communities and neonatal survival. The disparities in per capita GDP, proportion of female literates, scheduled caste, scheduled tribe and marginalized population, gender inequalities and geographical variations among the states play a significant role in creating a susceptible situation to neonatal deaths (Sankar et al 2016, Kapoor 2010, Gupta et al 2016). Maternal and child health related factors like proportion of currently married women practicing modern contraception, aware of ORS rehydration solution, proportion of children fully vaccinated and percentage of Caesarian birth in the community are important in the study of Infant mortality (Saikia, Singh et al 2013).

Although a large number studies are done globally related to neonatal mortality, the work is limited in case of the less developed countries like India. Neonatal period is the most crucial time of life that needs more attention. The available studies mainly deal with the determinants of neonatal mortality in India focusing on the association between individual, household and community level factors separately with neonatal mortality. These fail to disentangle the combined effect of all these factors considering their hierarchical structure based on the concept that people residing in the same region or community are exposed to the similar types of risks and therefore have similar health outcomes than those residing in other regions. In other words, those having similar individual and household level characteristics but living in different communities can have different health outcomes.

This paper makes an attempt to fill this important gap in Indian literature by examining neonatal mortality using hierarchical model which can assess both fixed effect and random effect in one model and see whether there is any association between the state level factors and neonatal mortality regardless of the individual and household level factors or whether there is a role of the individual and household characteristics in determining the inter-community variation in neonatal mortality.

Objectives of the Study

- To study the trends of neonatal mortality rates in India
- To investigate the individual, household and community level determinants of neonatal mortality
- To examine the contribution of individual, household and community level factors to neonatal mortality

Data and Methods

We have used the data from the Sample Registration System (SRS) to study the trends of neonatal mortality rates in India and within its states. Moreover, Indian National Family Health Survey (NFHS) 3, Indian Census 2001 data and 2005-06 data from the Ministry of Statistics and Programme Implementation are used to determine and examine the effects of different individual, household and state level factors on neonatal mortality in India.

SRS is a dual record system which provides demographic statistics for India on a regular basis. It collects data on registration of births and deaths and verifies it through periodic retrospective sample surveys. It is a very reliable source for providing the levels of neonatal and infant mortality for India and its states classified by place of residence and sex. NFHS is a large-scale, multi-round survey conducted in a representative sample of households throughout India under Ministry of Health and Family Welfare with International Institute for Population Sciences (IIPS), Mumbai as the nodal agency. Its first two rounds NFHS-1 and NFHS-2 were conducted in 1992-93 and 1998-99 respectively. The third round NFHS-3 was conducted in 2005-06 in 29 states of India in which 124,385 women living in 109,041 households were interviewed. It provides consistent and reliable estimates of fertility, mortality, family planning, utilization of maternal and child health care services and other related indicators at the national, state and regional levels. Census of India is conducted in every ten years by the Registrar General and Census Commissioner of India under the Ministry of Home Affairs, Government of India. Its data are based on complete enumeration. Ministry of Statistics and Programme Implementation of India provides data on national accounts and macroeconomic aggregates at current prices (per capita NSDP etc.).

In this paper, firstly, we have studied the trends in the neonatal and infant mortality in India and comparisons are made among the different states using SRS data. The trends of neonatal mortality across states are analyzed using SRS mortality data for the last 45 years from 1971 to 2015. Next, the analysis is done based on the total births reported in the last five years preceding the date of the NFHS-3 survey after subtracting those who born in the last one month prior to the date of interview. The motive is to eliminate all those births whose survival status for neonatal mortality is not known. The missing cases are also removed to obtain the ultimate sample for the study. The total analytical sample size for this study is 50141 live births after removing all the censored births and missing cases in the last five years prior to the survey date of which 1594 were the neonatal deaths. The outcome variable taken for the analysis is neonatal death which is coded as 0 (no) and 1 (yes) whereas the exposure variables used in it are categorized as follows:

Individual level determinants:

These determinants generally include the mother and child related factors. The maternal factors comprises of pregnancy intention, mother's age in completed years at the time of birth of the index child, mother's education (no schooling, primary, secondary and higher) and mother's media exposure whereas the neonatal factors include the sex of the child, birth order and preceding birth interval and birth size . At the time of interview, question were asked for every birth in the last five years to the mother whether the pregnancy was wanted then, wanted later or not wanted at all at the time of conception. This constitutes the pregnancy intension variable categorized as wanted, unwanted and mistimed. Mother's media exposure variable is formed on the basis of information on exposure to radio, television and newspaper into no exposure, partial and full exposure. Birth size is based on the question asked to the respondents about the size of the child being very large, larger than average, average, smaller than average or small. First and last two categories are clubbed to obtain three categories of birth size viz. large, average and small.

Household level determinants:

Types of place of residence (urban/rural), religion (Hindu, Muslim and others), caste (scheduled caste/tribe, other backward class and other socioeconomically progressive class) and wealth quintile are used as household level control variables. The wealth quintile index is formed by combining information on household assets and housing features into five categories viz. poorest, poorer, middle, richer and richest.

Community level determinants:

The community level is classified into two levels which include the PSU (Primary Sampling Unit) level nested within the State level. PSU level factors include modern contraceptive prevalence rate, percentage of women aware of ORS rehydration solution, percentage of births attended by skilled birth attendant and percentage of caesarian birth whereas per capita Net State Domestic Product (NSDP) 2005-06, obtained from Ministry of Statistics and Programme Implementation along with female literacy rate, percentage of male in non-agricultural sector, poverty ratio, and percent urban obtained from Census 2001 are used as the State level factors.

Statistical Analysis:

Descriptive analyses:

In this section, we have described the characteristics of the analytical sample used in this study. Percentage of neonatal deaths occurred from each of the population sub-groups are described here. This often helps the readers to understand the study population and also helps us to understand how neonatal deaths are concentrated among various population groups. We have reported the Chi-square value for each of the controlling factors, showing the significance of their association with neonatal death. Beside the bivariate analysis described above, we have used multilevel hierarchical model to understand the adjusted level of predictability of each set of independent variable and disentangle the contribution of each level (individual and community) of hierarchy to explain the total variation in neonatal death. The detailed description of the model is given below.

Model:

The analysis is done using National Family Health Survey 2005-06 data. Considering the hierarchical nature of the NFHS data in which all the individual and household level factors are nested within the PSU level determinants which are further nested within the state level factors, we have used multilevel hierarchical model. The simple binary logistic model is not sufficient to bring out the heterogeneity and decompose the variations between the different levels as it necessitates the assumption of independence of observations. This assumption is violated in multilevel models. Thus, we have used three level multilevel logistic regressions for the analysis considering level 1 as the individual and household level factors whereas PSUs and States represented level 2 and level 3 respectively. Four models are fitted in this analysis of which model 1 is a null model with no determinants, model 2 shows the association of individual and household level factors with neonatal deaths, model 3 consists of all individual, household and PSU level factors whereas all determinants including the state level factors were included in model 4. In this analysis all the community level variables are used as continuous variables. The association of the all the covariates with the outcome variable is checked for their significance using Chi2 test at 5% level of significance.

The fixed effects of all the determinants are expressed in the form of odd ratios with p values and 95% confidence interval. The random effects are shown using the intra-class correlation coefficients (ICC) expressed as the ratio of the random intercept of the given level to the sum of the random intercepts of all the levels. In this model the random intercept of level 1 is $\pi^2/3$. The contribution of the various level factors explaining the i^{th} level variance is calculated by the formula:

$$R_i^2=(\sigma_{u/b}^2 - \sigma_{u/m}^2)/ \sigma_{u/b}^2$$

Where $\sigma_{u/b}^2$ is the i^{th}-level residual variance for the baseline model, which is the intercept-only model and $\sigma_{u/m}^2$ is the i^{th} -level residual variance for the comparison model.

We have run multilevel logistic regressions in the statistical software package STATA 13 using 6 integration points in xtmelogit command after checking the log likelihood estimates.

Trends in Neonatal Mortality Rates in India

It is discussed earlier that infant and neonatal mortality rates in India are continuously declining but not at equal pace (Figure 1). The large inter-state disparities in NMR are clearly visible from Figure 3 and 4. In Figure 1, we can observe that both IMR and NMR have declined significantly over time but the reduction in IMR was much faster than NMR. This led to an increase in the percentage share of NMR in IMR from 58.3% in 1971 to 67.6% in 2015 (Figure 2). At present NMR contributes nearly two-third of all infant deaths in India.

[Insert Figure 1 here]

This type of trend is not only seen in India but also in its different states but there are differences in the levels and pattern of decline of NMR both in the rural and urban areas. As per SRS 2015, among the Indian states, Kerala ranks first in having the lowest neonatal mortality rate followed by Tamil Nadu, Maharashtra and Telengana whereas Odisha shows the highest value of NMR preceding Madhya Pradesh (MP) and Chhattisgarh. Moreover, there are certain striking features regarding the situations of some of the Indian states which are discussed in this paper in the following two figures.

[Insert Figure 2 here]

Is neonatal mortality converging across states?

Figure 3 provides information on the past and present situations of NMR in four states of India viz. Kerala, Odisha, Madhya Pradesh and Haryana. It reveals that Madhya Pradesh has reached the same position in 2015 as that of Kerala 40 years back in 1975. This is identified with a dotted line drawn from the starting point of Kerala in 1975 and the ending point of MP in 2015. Again, MP and Odisha started almost at the same point in 1971 and have attained nearly the same figure in 2015 each accounting for approximately 51% decline whereas it is not the case in case of Kerala and Haryana. Although their levels were similar in 1971, they did not follow the same pattern afterwards. At one hand, Kerala shows a fast decline of 66% in neonatal mortality rates from 1971 till 1990, the pace of which slows down a little afterwards till it achieves the level of neonatal mortality rate of more developed countries similar to that of United States of America in 2015. On the contrary, the performance of Haryana is very poor during the 45 years period. Haryana has experienced a considerable increase in NMR from 35.3 in1971 to 68.7 in 1975 after which it starts declining and reaches the level of 24 in 2015 which is very high as compared to that of Kerala. The overall decline in Haryana is 32% during the last 45 years. It is also noticeable that even the literacy condition of Odisha is better than that of many other states yet it experiences the highest level of NMR in 2015.

[Insert Figure 3 here]

Figure 4 shows the comparison between the neonatal mortality rates of the rural and urban areas of Kerala and that of urban areas of three Indian states viz. Uttar Pradesh (UP), Odisha and Tamil Nadu. Rural Kerala has experienced a faster decline (in NMR than urban Kerala and reached similar levels in 1985 after which both started following the same pattern till 2005. Beyond 2005, the curve of urban Kerala is more downward sloping than its rural counterpart. The most striking feature revealed from this graph is the high levels of neonatal mortality rates in the urban areas of Uttar Pradesh (UP) and Odisha as compared to that of rural Kerala indicating that place of residence solely cannot determine the mortality situation; there are certain characteristics of the states which play a significant role in bringing down the level of NMR. Although urban Odisha started at a lower level than urban Tamil Nadu in 1971, it experienced lots of ups and downs and finally reached a level of NMR which is much higher than that of Tamil Nadu in 2015. Even, the very high starting value of NMR in urban Uttar Pradesh in 1971 came down below that of Odisha in 2015. The urban regions of Tamil Nadu are on the verge of approaching lower levels of NMR as that of Kerala. The overall decline in the neonatal mortality rates for the Uttar Pradesh, Odisha and Tamil Nadu in the last 45 years were respectively 68%, 50% and 80%.

[Insert Figure 4 here]

This implies that within the states the association between the socioeconomic factors and neonatal deaths is nearly similar but it is not the case in between the states. This is due to the presence of various inter-state disparities in state level characteristics which also contribute in determining the mortality rates which is the basis of this study.

Results

Our analysis starts with the description of the general characteristics of the sample and their association with neonatal deaths using bivariate results and Chi2 test in Table 1. It is followed by Table 2 containing the results of multilevel logistic regression with both fixed effects and random effects to investigate the adjusted association of neonatal mortality with various individual, PSU and state level factors using odd ratios and p values at 5% level of significance and their contribution in explaining neonatal deaths. We have studied this by fitting four models in the analysis and their estimates are represented by four columns of the Table 2.

Characteristics of the Sample:

Table 1 shows background features of the sample under study and the percentage distribution of the neonatal deaths across the categories of each explanatory variable. All the variables were found to be significant by **$\chi 2$** test at 5% level of significance. The community level (PSU and State level) factors are taken as continuous variables in the analysis. So, percentage distributions for these factors are not shown but their association with neonatal deaths is verified to be statistically significant.

[Insert Table 1 here]

Nearly, 80% of the total births under study are found to be wanted whereas the contribution of each of mistimed and unwanted pregnancies is approximately 10%. Large number births (69%) are attributable to the women aged 20 to 30 years at the time of birth but still mothers aged less than 20 years are responsible for 18% of the births. If we come to the neonatal factors, nearly 41% of the births are delivered to the women with no schooling and only 7.7% to those with higher schooling Very few mothers have full exposure to all the media viz. radio, television and newspaper. Male births contributing 52% of the total births are found to be more than those of female births (48%). Nearly 32% of the children are attributed to each of first order births and second/third order with preceding birth interval greater than 23 months respectively. Whereas births of order four or higher with birth interval less than or equal to 23 months account for 6% of the sample. 23%, 57% and 20% of the sample are large, average and small sized births respectively.

The households of 62% of the births are in rural areas and that of 38% in urban areas. Majority of the births have taken place among Hindu communities, nearly 69% as compared to 17% among Muslim and 14% among other communities. The total sample is almost equally distributed among the three categories of castes. It is also evenly distributed among the wealth quintiles.

Bivariate results:

The bivariate result shows the association of neonatal mortality with various characteristics of the study population. Unwanted births are more prone to die before completing one month than those of wanted and mistimed births. 4.4% of unwanted children have died in the neonatal period as compared to 3.64% and 3.29% of wanted and mistimed births respectively. Mother's age and education are also found to be associated with neonatal death. 5.05% of the births to the mothers aged less than 20 years at the time of birth have suffered neonatal death. Whereas, 4.4% and 1.4% of the children delivered to the mothers with no schooling and with higher level of education have died in this vulnerable phase respectively. Male babies (3.84%) are more disadvantageous and more susceptible to die before one month than female neonates (3.53%). The incidence of neonatal deaths is much higher among small sized birth (5.55%) and higher (2 or more) order births with preceding birth interval less than or equal to 23 months (7.58%). Moreover, considerable percentages of deaths have taken place in the poorest (4.65%)

and rural (4.04%) households and among Hindu communities (3.80%) than in the richest (1.99%), urban (2.67%) and other religion households.

Random effects

Table 2 shows the decomposition of the total variance in neonatal mortality among the different individual, PSU and state level factors in the null model (Model 1) with no explanatory variables. Both the community level variances are found to be statistically significant at 5% level of significance. The Intra-cluster correlation coefficients (ICC) reveal that 5% of the total variability is due to differences between the PSUs whereas 4% is because of state level variations. Proceeding next, individual and household factors are introduced in model 2 due to which there is a decline in community level variances. This is because 23% and 49% of the PSU and state variances in neonatal mortality are explained by the individual and household factors. PSU level covariates are incorporated in Model 2 to form Model 3 as a result of which there is a further decline in the variances. PSU level factors have explained only 1% of the remaining PSU level variances as compared to 22% of the remaining state variance. This implies that 24% and 60% of the total PSU and state variances is contributed by all individual, household and PSU level factors respectively. In model 4, state level factors are further introduced resulting in 2% increase in PSU variance from model 3 to model 4 but the state level covariates explain 71% of the remaining state variance in model 3 and 28% of the total state variance. Therefore, 22% and 89 % of the total PSU and state variance in neonatal mortality are explained by all the different factors.

[Insert Table 2 here]

Fixed effects

Table 2 also presents the association of neonatal mortality with the different level factors in terms of odd ratios. Fixed effects of model 2 shows association of neonatal mortality with the individual and household level factors, that of model 3 shows association of neonatal mortality with the individual, household and PSU level factors whereas its association with the individual, household and all community level covariates are presented in model 4. The log likelihood value progressively increases from model 1 to model 4 which indicates that model 4 will explain the determinants better than the other models.

Interpretation of the adjusted result for all the factors in model 4 reveals that the mistimed pregnancies are less likely to result in neonatal deaths (OR 0.77; $p<0.01$) whereas unwanted births have 1.01 times higher odds to die before completing one month as compared to wanted pregnancies but the latter is not significant. Age and education of the mother are found to play a significant role in determining neonatal mortality. Neonates born to mothers with no schooling and primary schooling are respectively 2.48 and 2.53 times more likely to die than those having higher education and the likelihood decreases as mother's education increases. On the other hand, lower age (below 20 years) of the mother at birth shows 1.26 times higher odds of their children to die as compared to with mother's age at birth being lying between 20 to 30 years. After discussing the maternal factors, we now come to the neonatal determinants. Male children (odds ratio 1.18; $p<0.01$) are slightly more disadvantageous than female children. Neonatal deaths are more common among higher order births with preceding birth interval less than or equal to 23 months (OR 1.36; $p<0.01$) and less among second/third order births (OR 0.56; $p<0.001$) and higher order births (OR 0.60; $p<0.001$) with birth interval for each being greater than 23 months as compared to first order births. Small sized births have 1.90 times higher likelihood of dying than those with average size. Among the household level factors, religion and wealth quintile have significant association with neonatal deaths. Infants born in Muslim households (OR 0.82; $p<0.05$) are less likely to die before one month than those of Hindus. Economically deprived households (OR 1.3; $p<0.05$) contribute more to neonatal mortality than wealthier ones.

Among the PSU level factor, percentage of births attended by skilled birth attendants is found to be negatively associated with neonatal mortality (OR 0.997; $p<0.05$). Whereas all other factors are not significant at 5% level of significance.

The state level covariates like per capita NSDP (Net State Domestic Product) (OR 0.9999; $p<0.05$) and female literacy rate (OR 0.988; $p<0.05$) have negative association with neonatal deaths. Moreover, a significant positive association of urbanization with neonatal deaths is also seen having OR 1.012 and $p<0.05$.

Discussion: Major findings

A lot of research is done in the field of infant and neonatal mortality across the globe, but a very few researches have focused beyond the individual and household level factors and explained their association in their own levels. This study deals with the contribution of different macro level factors in addition to the micro level determinants whose effects are prevalent in the upper strata. Our analysis in this paper begins with the study of the trends of neonatal mortality in India and it proceeds with investigation of the various level determinants associated it. Above all, we have tried to find out how much the contribution of community level characteristics to explain this vulnerable issue. The trend analysis has shown that although two states are having the same socioeconomic backgrounds but still their neonatal mortality rates vary. Even those residing in the urban areas of different states are also having variations in the rates. The most astonishing fact seen in the trend study is much lower NMR in rural Kerala than those of the urban region of other states. It is not possible to explain these with only individual and household level factors. The community level determinants play a significant role in explaining it.

Among the individual level factors sex of the head of the household which is an important determinant of infant mortality in India is found to be insignificant in explaining neonatal mortality in the very beginning. Similar thing happened in case of juvenile sex ratio calculated for each state. These are not included in the analysis. The findings suggest that the chance of neonatal deaths is much higher among those who are born at a younger age of the mother because their reproductive organs are not fully developed to give birth to a baby. This is also true for women without any schooling but the prevalence of neonatal mortality is more common among mothers having primary years of schooling i.e. up to class 5 and it decreases with increase in the level of education of the mother. The lower neonatal deaths associated with mistimed births than wanted births should be due to the lack of effect of unobserved family related factors. Since biologically male fetus is more disadvantaged, male children are more prone to die in the neonatal period. Birth size and birth order and preceding birth interval are crucial determinants and have significant association with neonatal mortality as consistent with the literature. The deaths are much higher among small sized births due to shorter period of gestation and lack of proper nourishment while in mother's womb. Higher order births with low birth spacing have higher likelihood of dying before one month. The larger the birth spacing the lesser is the chance of neonatal mortality as it will provide time for the mother to recover from the injuries of the previous pregnancy and formation of proper ground for the development of the next pregnancy.

This study has not find any significant association of place of residence and caste with neonatal mortality, although it is observed that at the ground level neonatal deaths are high among rural household but with the introduction of the community level factors the direction of association has reversed. This is also consistent with the finding that neonatal mortality increases with increase in urbanization (Kapoor 2010). This is due to the fact that pollution is more in urban areas leading to higher morbidities. Moreover, most of the health centres are located in the urban areas where women from nearby rural areas come for delivery due to lack of health facilities in their areas. Among other household level factors, economic condition of the household determines neonatal mortality. It is higher among poorest households and decreases as the economic condition of the household improves.

The PSU level factors have not shown any significant association with neonatal deaths. But increase in percentage of woman aware of ORS rehydration solution and percentage of births attended by skilled birth attendants in the PSUs decreases the chance of neonatal deaths due to greater awareness of the mother to protect their baby against diarrhea and the importance of supervised delivery for the survival of the neonates. On the other hand, as the modern contraceptive prevalence rate increases among the PSUs, the chance of neonatal death also increases may be because of the failure of the contraceptive method resulting in unwanted pregnancies.

Per capita NSDP, female literacy rate and percent urban reveal a significant association with neonatal mortality in the state level. Those states with high per capita NSDP experience less neonatal deaths due to increase in in per capita health expenditure and less poverty but NMR increases with increase in percent urban. Moreover, female literacy rate is very crucial in determining NMR. With increase in female education, women become much more aware of antenatal care and post natal care and can take the right decision about their child's health, thereby decreasing NMR.

The findings of this study attempt decomposition of the total variance in neonatal deaths between individual, PSU and state level and the contribution of the different level factors used to explain the PSU and state level variances. According to the results 5% and 4% of the variations are due to differences between the PSUs and between the states respectively. This is because the individuals living in the same PSU or the same state are exposed to the same PSU or state level characteristics respectively and thereby experience similar health outcomes. Moreover, those residing in socio-economically and demographically advanced states have lower neonatal mortality rates as compared to those living in deprived communities because it will result in the advancement in the PSU level determinants (nested within those states) which in turn influences the individual level characteristics to improve. Kerala, being a progressive state in various fields like per capita NSDP, female work participation rate, female literacy rates records very low level of neonatal mortality rates both in the rural and urban areas. This is due to better policies and programs executed in the state which provides equal opportunity to both rural and urban areas to develop. Odisha, which is a also a progressive state like Kerala in terms of female literacy rates, shows high neonatal mortality because of poor policy implementation among the states.

Limitations

There are certain limitations of the study which are needed to be considered before going through the paper. First of all, the variable pregnancy intension used as a covariate for neonatal mortality is based on the response after the births have taken place. So, there is a high chance of the actual mistimed and unwanted births being reported as wanted births at the time of survey as a result of bonding. Second, birth weight cannot be used as a covariate in the analysis because of lack of information on more than 50% of the births reported. Another important limitation of the study is that it cannot incorporate the information on antenatal and postnatal care in the analysis which is a most important determinant of neonatal death. The reason is that NFHS did not provide this data for all the births. It is provided only for last birth.

Conclusion

This study investigates a significant association of neonatal mortality with various individual, household and community level factors i.e. PSU and state level factors. Effective Government intervention and policy implications are required not only in the micro level but also in both the state and PSU levels to enhance the per capita NSDP, public health expenditure, female literacy rates, female work participation rate through the establishment of proper health centres, educational institutions and promotion of women empowerment and spreading awareness. Infants and neonates are the future of the nation. They should be protected and prevented from dying by bringing effective changes in all the strata.

References

1. Singh, A., Pathak, P. K., Chauhan, R. K., & Pan, W. (2011). Infant and Child Mortality in India in the Last Two Decades: A Geospatial Analysis. *PLoS ONE*.

2. Arokiasamy, P., & Gautam, A. (2008). Neonatal Mortality in the Empowered Action Group states of India: Trends and Determinants. *J.biosoc.Sci*.

3. Bassani, D. G., Kumar, R., Awasthi, S., Morris, S. K., Paul, V. K., Shet, A., et al. (2010). Causes of neonatal and child mortality in India: a nationally representative mortality survey. *Lancet*.

4. Conroy, N., Morrissey, B., & Wolman, Y. (2014). Reducing Neonatal Mortality in Resource-poor Settings: What works? *Neonatal Biol*.

5. Debelew , G. T., Afework, M. F., & Yalew, A. W. (2014). Determinants and Causes of Neonatal Mortality in JimmaZone, Southwest Ethiopia: A Multilevel Analysis of Prospective Follow Up Study. *PLoS ONE*.

6. Fadel, S. A., Ram, U., Morris, S. K., Begum, R., Shet, A., Jotkar, R., et al. (2015). Facility Delivery, Postnatal Care and Neonatal Deaths in India: Nationally Representative Case-Control Studies. *PLoS one*.

7. Gupta , A. K., Borkotoky, K., & Kumar, A. (2015). Household Headship and Infant Mortality in India: Evaluating the Determinants and Differentials. *International Journal of MCH and AIDS*, Volume 3, Issue 1, Pages 44-52.

8. Gupta, A. K., Ladusingh, L., & Borkotoky, K. (2016). Spatial clustering and risk factors of infantmortality: district-level assessment of high focus states in India. *Genus*.

9. Hox, J. J. (2010). *Multilevel Analysis : Techniques and Applications, Second Edition.* Great Britain: Routledge.

10. Kapoor, S. (2010). *Infant Mortality Rates in India: District Level Variations and Correlations.*

11. Kayode, G. A., Ansah, E., Agyepong, I. A., Amoakoh-Coleman, M., Grobbee, D. E., & Klipstein-Grobusch, K. (2014). Individual and community determinants of neonatal mortality in Ghana: a multilevel analysis. *BMC Pregnancy and Childbirth*.

12. Pandey, A., & Nath, D. C. (2012). Does Context Matter? Factors influencing Neonatal Deaths in Rural North Indian (EAG) States: Hierarchical Linear Modeling Approach. *Journal of Mathematics, Statistics and Operations Research*.

13. Rammohan, A., Iqbal, K., & Awofeso, N. (2013). Reducing Neonatal Mortality in India: Critical Role of access to Emergency Obstetric care. *PLoS ONE*.

14. Rani, T. U., Jampana, V. R., & Machiraju, V. M. (2014). Newborn Survival in India – Challenges and Priorities for Andhra Pradesh. *J Neonatal Biol*.

15. Saikia, N., Singh, A., Jasilionis, D., & Ram, F. (2013). Explaining the rural–urban gap in infant mortality in India. *Demographic Research: Volume 29, Article 18*.

16. Sankar, M. J., Neogi, S. B., Sharma, J., Chauhan, M., Srivastava, R., Prabhakar, P. K., et al. (2016). State of newborn health in India. *Journal of Perinatology*.

17. Singh, A., Chalasani, S., Koenig, M. A., & Mahapatra, B. (2012). The consequences of unintended births for maternal and child health in India. *Population Studies*, Vol. 66, No. 3, pp. 223-239.

18. Registrar General (1999) Compendium of India's Fertility and Mortality Indicators 1971–1997 *Based on the Sample Registration System*. Government of India, New Delhi.

APPENDIX

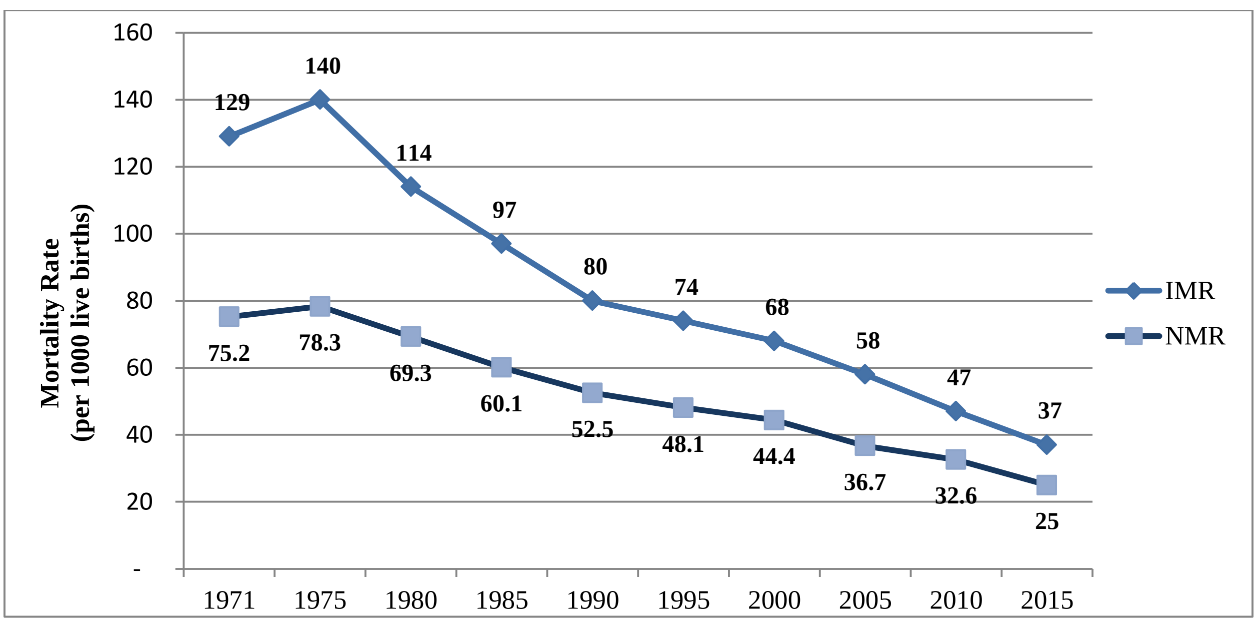

Figure 1: Trends in Infant and Neonatal Mortality Rates in India (1971-2015).
Source*: Registrar General, Sample Registration System, 1971–2015, Government of India*

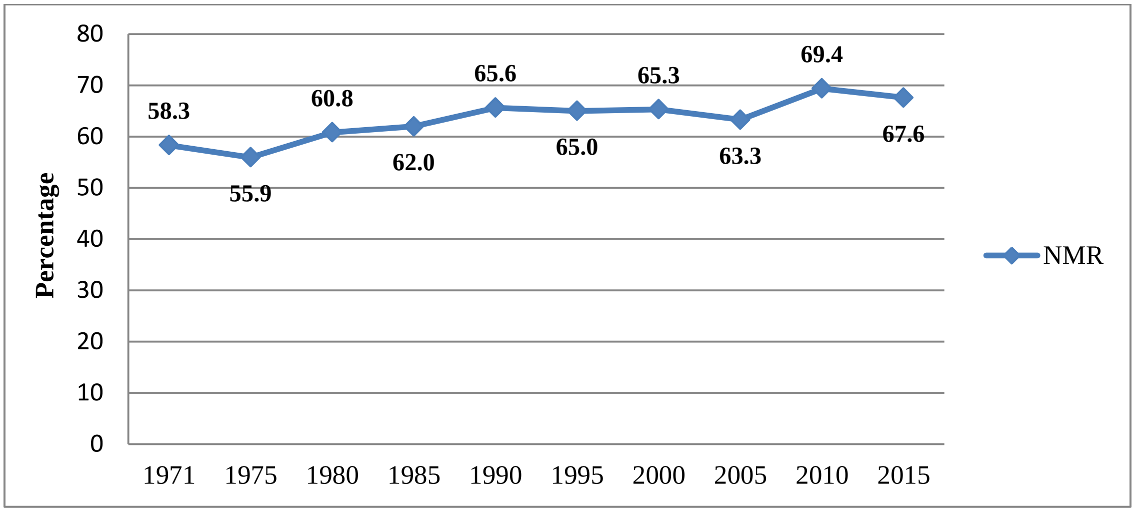

Figure 2: Trends in the percentage share of NMR in IMR in India (1971-2015).
Source: Registrar General, Sample Registration System, 1971–2015, Government of India

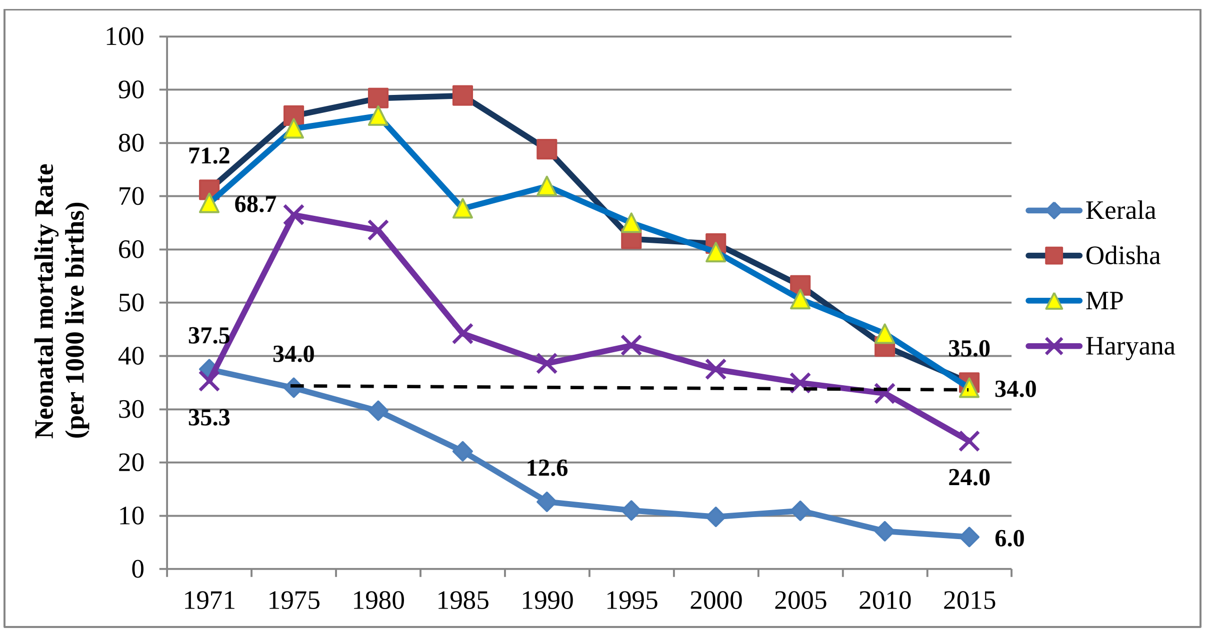

Figure 3: Trends in NMR in some States of India (1971-2015).
Source: Registrar General, Sample Registration System, 1971–2015, Government of India

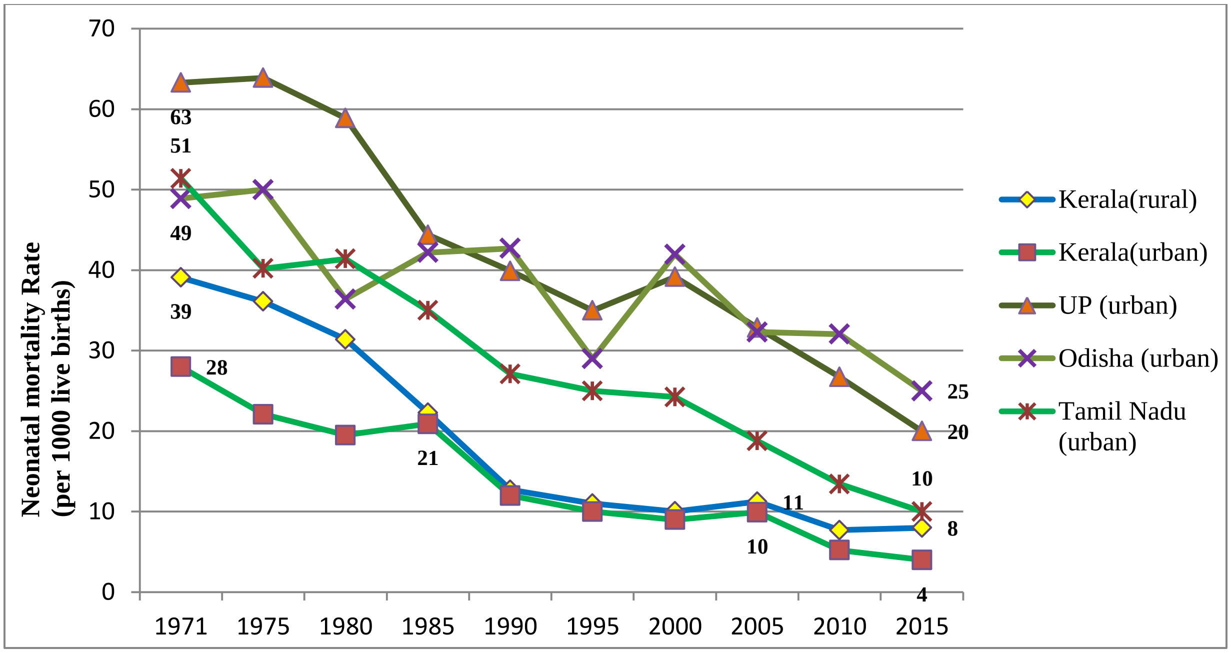

Figure 4: Trends in NMR in some of the States of India by place of residence (1971-2015). *Source: Registrar General, Sample Registration System, 1971–2015, Government of India*

Table 1: Background Characteristics of the Study Population and their association with Neonatal deaths, India, 2005-06

Covariates	Neonatal deaths (%)	Total (%)	χ2
Individual level factors			
Pregnancy intension			
wanted	3.64	40,057 (79.9)	
mistimed	3.29	5,132 (10.2)	7.91*
unwanted	4.40	4,952 (9.9)	
Mother's age at birth (in completed years)			
less_than_20	5.05	9,068 (18.1)	
20-30	3.30	34,665 (69.1)	84.65***
over_30	3.48	6,408 (12.8)	
Mother's education			
no schooling	4.39	20,403 (40.7)	
primary	4.27	7,236 (14.4)	
secondary	2.68	18,650 (37.2)	133.43***
higher	1.40	3,852 (7.7)	

Mother's media exposure			
No exposure	4.35	12,297 (24.5)	33.04***
partial exposure	3.41	36,494 (72.8)	
full exposure	2.12	1,350 (2.7)	
Sex of the child			
female	3.53	24,080 (48)	6.89**
male	3.84	26,061 (52)	
Birth order and birth interval			
first order	4.39	16,177 (32.3)	172.00***
order 2 or 3 and interval<=23 months	4.45	6,251 (12.4)	
order 2 or 3 and interval>23 months	2.23	15,805 (31.5)	
order 4 or higher and interval<=23 months	7.58	3,097 (6.2)	
order 4 or higher and interval>23 months	3.04	8,811 (17.6)	
Birth size			
large	3.47	11,441 (22.8)	153.70***
average	3.08	28,465 (56.8)	
small	5.55	10,235 (20.4)	
Household level factors			
Place of residence			
urban	2.67	19,013 (37.9)	36.67***
rural	4.04	31,128 (62.1)	
Religion			
Hindu	3.80	34,635 (69.1)	29.05***
Muslim	3.31	8,372 (16.7)	
others	3.35	7,134 (14.2)	
Caste			
scheduled caste/ scheduled tribe	4.11	17,008 (33.9)	11.02**
other backward class	3.60	16,642 (33.2)	
others	3.38	16,491 (32.9)	
Wealth quintile			
poorest	4.65	8,886 (17.7)	134.08***
poorer	4.27	9,257 (18.5)	
middle	3.63	10,330 (20.6)	
richer	3.06	11,034 (22)	

richest	1.99	10,634 (21.2)	
Overall	**1594 (3.7%)**	**50141 (100%)**	

Note: ***p < 0.001, **p < 0.01, and *p < 0.05.

Table 2: Multilevel Logistic regression estimates showing association of Individual, Household, PSU and State level determinants with Neonatal Mortality in India, 2005-06

Covariates	Model 1	Model 2	Model 3	Model 4
Individual level factors				
Pregnancy intension				
wanted ®		1.00	1.00	1.00
mistimed		0.77 (0.64, 0.93)**	0.77 (0.64, 0.93)**	0.77 (0.64, 0.93)**
unwanted		1.01 (0.85, 1.21)	1.01 (0.85, 1.21)	1.01 (.84, 1.21)
Mother's age at birth				
less_than_20		1.27 (1.10, 1.45)**	1.26 (1.10, 1.45)**	1.26 (1.10, 1.44)**
20-30®		1.00	1.00	1.00
over_30		1.10 (0.92, 1.31)	1.10 (0.92, 1.31)	1.11 (0.93, 1.32)
Mother's education				
no schooling		2.54 (1.77, 3.62)***	2.47 (1.73, 3.54)***	2.48 (1.73, 3.55)***
primary		2.54 (1.77, 3.65)***	2.50 (1.74, 3.60)***	2.53 (1.76, 3.64)***
secondary		1.96 (1.40, 2.73)***	1.94 (1.39, 2.71)***	1.97 (1.41, 2.75)***
higher®		1.00	1.00	1.00
Mother's media exposure				
No exposure®		1.00	1.00	1.00
partial exposure		1.08 (0.95, 1.23)	1.10 (0.96, 1.25)	1.09 (0.96, 1.25)
full exposure		1.33 (0.87, 2.05)	1.36 (0.89, 2.09)	1.34 (0.87, 2.05)
sex of the child				
female®		1.00	1.00	1.00
male		1.18 (1.06, 1.30)**	1.18 (1.06, 1.30)**	1.18 (1.06, 1.30)**

birth order and birth interval				
first order®		1.00	1.00	1.00
order 2 or 3 and interval<=23 months		0.99 (0.84, 1.16)	0.99 (0.84, 1.16)	0.99 (0.84, 1.16)
order 2 or 3 and interval>23 months		0.56 (0.48, 0.65)***	0.56 (0.48, 0.65)***	0.56 (0.48, 0.65)***
order 4 or higher and interval<=23 months		1.38 (1.13,1.69)**	1.36 (1.11, 1.67)**	1.36 (1.11, 1.66)**
order 4 or higher and interval>23 months		0.61 (0.50, 0.74)***	0.60 (0.49, 0.73)***	0.60 (0.49, 0.72)***
Birth size				
large		1.14 (0.99, 1.30)	1.14 (0.99, 1.30)	1.13 (0.99, 1.29)
average®		1.00	1.00	1.00
small		1.92 (1.70, 2.16)***	1.91 (1.70, 2.15)***	1.90 (1.69, 2.14)***
Household level factors				
Place of residence				
urban®		1.00	1.00	1.00
rural		1.04 (0.91, 1.20)	0.98 (0.84, 1.14)	0.99 (0.85, 1.15)
Religion				
Hindu®		1.00	1.00	1.00
Muslim		0.84 (0.71, 0.98)*	0.82 (0.70, 0.97)*	0.82 (0.70, 0.97)*
others		0.87 (0.69, 1.09)	0.84 (0.67, 1.05)	0.87 (0.69, 1.09)
Caste				
SC/ ST		0.94 (0.81, 1.09)	0.93 (0.80, 1.08)	0.92 (0.79, 1.06)
OBC		0.92 (0.80, 1.07)	0.92 (0.80, 1.06)	0.89 (0.77, 1.02)
others®		1.00	1.00	1.00
Wealth quintile				
poorest		1.47 (1.14 1.88)**	1.38 (1.07, 1.78)*	1.33 (1.03, 1.72)*
poorer		1.41 (1.12, 1.78)**	1.34 (1.06, 1.70)*	1.31 (1.04, 1.66)*
middle		1.26 (1.02, 1.56)*	1.22 (0.98, 1.51)	1.19 (0.96, 1.48)
richer		1.18 (0.97, 1.45)	1.16 (0.95, 1.42)	1.15(0.94, 1.41)
richest®		1.00	1.00	1.00

PSU level factors				
Percentage of births by Caesarian section			1.002 (0.997, 1.007)	1.002 (0.997, 1.008)
Percentage of births attended by skilled birth attendant			0.997 (0.994, 1.000)*	0.997 (0.994,0.999)*
Modern contraceptive prevalence rate			0.999 (0.996, 1.004)	1.0004 (0.996,1.005)
Percentage of woman knowing about ORS			0.999 (0.996, 1.002)	0.999 (0.996, 1.002)
State level factors				
Percent urban				1.012(1.003, 1.021)*
per capita NSDP				0.9999 (0.999,1.00)*
Female literacy rate				0.988 (0.978,0.998)*
Poverty ratio				1.003 (0.994, 1.012)
% male in non - agricultural sector				1.002 (0.989, 1.015)
Random effect				
Log likelihood	-6998.0	-6782.8	-6779.4	-6768.1
PSU variance	0.172*	0.132*	0.131*	0.135*
State variance	0.142*	0.072*	0.056*	0.016*
ICC for PSU	0.048	0.038	0.038	0.039
ICC for State	0.039	0.020	0.016	0.005

® represents the reference category.
Model 1 is the null model with no explanatory variable.
Model 2 adjusted for individual level factors.
Model 3 adjusted for both individual-level and PSU-level factors.
Model 4 adjusted for all individual-level, PSU-level and State level factors.
Abbreviations: OR for odds ratio, 95%, CI for 95% confidence interval, ICC intra-class correlation coefficient.
***p < 0.001, **p < 0.01, and *p < 0.05.