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NEONATAL DEATHS IN EMPOWERED ACTION GROUP STATES: MULTILEVEL MODELING TO STUDY THE WITHIN DISTRICT EDUCATION EFFECT ON NEONATAL SURVIVAL

Public Health

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ABSTRACT

Neonatal Deaths are deaths that occur during first 28 days of life. It is still very high in demographically poor performing States in India termed as Empowered Action Group (EAG) States. Study using the National Family Health Survey-4 data suggests high neonatal death burden in EAG States including Odisha. Uttar Pradesh recorded the highest neonatal death at 51.6 deaths per 1000 live births and the lowest was recorded in Uttarakhand at 32.3 neonatal deaths per 1000 live births. Neonatal deaths in Chhattisgarh were recorded as 48.2 deaths per 1000 live births, followed by Odisha at 46.9, Madhya Pradesh at 44.9, Bihar at 41.9, Jharkhand at 39.2, Assam at 36.1 and Rajasthan at 34.4 per 1000 live births. The parametric Cox Hazard model was used to study the unobserved heterogeneity. The Weibull distribution shape parameter value greater than one suggests considerable unobserved heterogeneity in the data. Considering district as unit of analysis (group level variable), attempt was made to capture the between district individual variations in neonatal deaths with regard to women educated 12+grades within districts. The low levels of Intra Class Correlation are suggestive of individual level variations than group level differences in studying the variations in neonatal deaths.

KEYWORDS

Neonatal Deaths, Intra Class Correlation, Unobserved Heterogeneity, Weibull Distribution

INTRODUCTION

Infant and child mortality rates are unacceptably high even today in many developing countries. These rates are also used as summary indicators of social development, quality of life, overall health, child health, maternal health and for welfare programs. Since Independence India evolved various programs to reduce infant and child mortality. Neonatal deaths comprise of highest burden of infant deaths as two third of all the infant deaths are neonatal deaths. Off the 3 million neonatal deaths that occur each year globally, approximately 2.4 million occurs in developing countries, which accounts for 80 percent of all neonatal deaths occurring in developing countries as per 2012 UN Inter-agency Group Report, 2012 [1]. Worldwide 3.8 million new born babies use to die in their first month of life [2]. Almost 98 percent of such deaths occurred in low and middle-income countries [3]. This amounts to more than 10,000 neonates dying per day or 430 neonatal deaths in an hour. Reduction in infant and child mortality is not only a major goal but also an important strategy towards achieving health for all. The 1994 International Conference on Population Development (ICPD, 1994) [4] focused on reproductive health with the objective of enabling women to go safely through pregnancy and childbirth and providing couples with the best chance of having healthy infants. The Millennium Declaration in 2000 by the United Nation [5] had set eight Millennium Development Goals (MDG), one of them was to bring down the child mortality level by two-thirds by the year 2015 which did not happen. Renewed commitment in the form of Sustainable Development Goals (SDG) [6] were launched post MDG. It remains to be seen whether the SDGs target of achieving under five mortality rates of 25 per 1000 live births by 2030 is met much of which depends of the reduction in neo natal mortality rates in EAG States. Prior to 1975 the Infant mortality in India was very high it is only after the year 1975 that it started declining steadily, mainly due to the technological advancement in medical science and availability of cheap vaccines to prevent vaccine preventable disease/deaths. As a result, major decline in infant mortality was observed between the decades 1981-91. The current level of Infant Mortality Rate (IMR) for India as per Sample Registration System (SRS) bulletin [7] of December 2016 is 37 per 1000 live births. With steady decline of infant and child mortality in the mid 1980's and early 1990's it appeared that the national goals were well within reach despite large disparities in infant and child mortality levels and plateauing of health determinants in various states. India is a union of 29 states and 6 union territories. Wide variations exist in reduction of infant and child mortality across states.

Demographically progressive states have achieved very low rates of infant and child mortality compared to poor performing north Indian states having high levels of infant and child mortality. Visualizing this dichotomy of poor and better performing states and the worsening demographic disparity/divide among these groups of States, Government of India constituted the Empowered Action Group (EAG) States on 20th March 2001 with prime objective of improving the health conditions in the identified eight demographically poor performing states. The EAG states are Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, Orissa, Chhattisgarh, Jharkhand and Uttaranchal. These EAG states together contribute to 46 percent of the total population of India and 53 percent of Indian's population growth [8]. At the first meeting of the National Commission on Population held on 22 July 2000, the Prime Minister of India announced setting up of an Empowered Action Group to prepare area specific programmes for States which are lagging behind in population stabilization, and which will account for nearly half the country's population by 2021. The launch of National Rural Health Mission Programs [9] in 2005 has seen some paradigm shift and focused attention in establishing quality care centre's (SNCU) for reduction in NMR by improved quality and reach of health care services to the people of India.

Literature Review

Neonatal mortality is dominated more by the influence of bio-demographic and health care determinants rather than socio-economic determinants. The 1984 framework of Mosley and Chen [10], focused on a variety of biological, socioeconomic and environmental factors. However, more recent frameworks as given by Rutstein [11] have emphasized the critical role of health care and bio-demographic factors as important determinants of neonatal mortality than socio-demographic factors.

In most population, male mortality is generally found to be higher than female mortality at almost all ages as males are biologically weaker than the females and are highly vulnerable to infectious diseases [12]. Excess of male mortality is pronounced in the first month of life i.e., in the neonatal period, diminishes considerably during post-neonatal period and essentially disappears in 12-59 months period [13]. In India, infant mortality for females is 14 percent lower than male mortality during the neonatal period however it is 19 percent higher than the male mortality in post-neonatal period [14]. The relationship between birth order and mortality at early age is of U-shaped form. Mortality is high for the first-born child; they are on an average at a 33 percent higher risk of dying. Sixth and higher order births are 43 percent more likely to die during the neonatal period compared with the births of second and third order [12]. Mother's age at birth has important health and societal ramifications. Most pronounced effect of mother's age at birth on child survival occurs during the first month of life, although the excess risk persists throughout the five-year period [13]. When women give birth at a young age, they are at an increased risk of complications and child is also at increased risk of having low birth weight and prematurity. Increase in the percentage of births to mother under age 18 and over age 35 is associated with higher neonatal mortality. Maternal depletion is a key factor affecting mortality levels for birth following short birth interval, also competition for resources with similar-aged siblings can affect well-being of a child. Shorter birth intervals are associated with elevated mortality risk [15]. The most pronounced effect of short birth interval on childhood mortality

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occurs during the neonatal period and it is weakest during the period 1-4 years [13].

Health seeking behavior of women especially during pregnancy and at time of childbirth has an important role to play for the health of the newborn [16]. Until the launch of NRHM, India presented a dismal picture as far as antenatal care, institutional delivery and quality of care is concerned [17]. The situation didn't improve much as shown by NFHS-3 data [18] however there have been substantial improvement in ANC and delivery care services as shown in the findings from NFHS-4 dataset. Neonatal mortality declines with the increase in antenatal care visits as improvement in access leads to better utilization of health care services by mother and children leading to better health outcomes. The magnitude of neonatal deaths associated with neonatal tetanus was very high in India. Studies showed that nearly 38 percent of the childhood deaths in slum population of Lucknow, Uttar Pradesh India was due to tetanus [19]. Place of delivery and assistance during delivery also have major contribution in determining neonatal mortality rate. Delivery at an institution is associated with lower neonatal mortality. Until the launch of NRHM, institutional delivery constituted only a quarter of birth in India [18]. Household environment and socioeconomic factors such as women's education, household economic status also tends to affect neonatal mortality. Improvement in environmental (sanitation) and socioeconomic conditions tends to have negative effect on neonatal mortality.

In a community-based behavior change management study done in one of the large north Indian State namely Uttar Pradesh in 2008, Kumar and his colleagues [20] reported 54 % reduction in neonatal mortality by improving birth preparedness, hygienic delivery, thermal care (including skin-to-skin care), umbilical cord care, skin care and breastfeeding as community-based interventions. These reductions were observed even though there was little change in the individual's health seeking behavior as most deliveries were home deliveries. Similar study done in Maharashtra in 1999, Bang and colleague [21] reported even higher percentages of reduction in neonatal deaths (62-70%) by active management of sick new born babies. These findings clearly show that most of the neonatal deaths in the large north Indian States can be prevented by simple community-based interventions and behavior change. In the year 2005 rightly so under the Union Governments Flagship program of National Rural Health Mission (NRHM) many of these states have evolved strategies of mother and child tracking, were each pregnancy not only gets recorded and monitored for Ante Natal, delivery and post-natal care but is provided with due personal attention and care with the help of trained cadre of ASHAs (Accredited Social Health Activist, a community-based female health worker for every 1000 population) [22].

Nath et al [23] in their work outlined the importance of breastfeeding in the early period of child's life. Using the data from Assam they have shown the positive predictive power of breastfeeding on child survival. Cabigon [24] had shown that breastfeeding could reduce the death risk by 80-90 percent during the 0-2 months of births. Defo [25] elaborated that while the breastfeeding is important its strength and limitations must be carefully interpreted as in many societies mixed feeding practices are common practice. Retherford et al [26] observed from Bangladesh data that breastfeeding does not explain the previous birth interval effect on infant and child mortality, but it partly explains the following birth interval effect.

Previous all-most all of the studies in Indian context have examined determinants of neonatal, infant and child mortality in India using data mainly at individual level. The program intervention variables (or the contextual level variables) such as availability of health facilities within the village/community, connectivity with all-weather roads, electricity, availability of health functionaries, may be important in determining neo-natal deaths within the community. Among the four rounds of NFHS conducted in India only NFHS-2 [27] provides data at village level that too to a limited extent. The study by Kumar [20] and Bang et al., [21] and many such studies have greatly emphasized the importance of community (or cluster) level variables. A population that has superior infrastructures such as approach to all weather road, health centre, education facilities etc. is likely to have better health condition of people and low level of neonatal, infant and child mortality. Such factors as above at the community level definitely influence individual perception and decision to access services. Under this premise it is very important to know the effectiveness of community level indicators and their linkages with individual level indicators to guide program managers to achieve the program convergence and greater programmatic outcome. Despite the importance of these contextual variables, previous studies have used analytic tools that could handle variations at best at individual level or single level analysis technique. To overcome the effect of contextual variables researchers often disaggregated group-level information into individual level so that all predictors in a multiple regression model are tied to the individual unit of analysis. This leads to at least two problems. First, all of the un-modeled contextual information ends up pooled into the single individual error term of the model [28]. This is problematic because individuals belonging to the same context will presumably have correlated errors, which violates one of the basic assumptions of the multiple regression analysis. Second problem is that by ignoring context, the model assumes that the regression coefficients apply equally to all contexts, "thus propagating the notion that processes work out in the same way in different contexts" [28]. Hierarchical Linear Models [29] or multilevel models or the random effect model [30] can be used to overcome such problems in the data and it can capture the relative influence of such contextual variables. In other words, multilevel is statistical model applied to data collected at more than one level in order to elucidate relationships at more than one level.

OBJECTIVES

The specific objectives of the study are:

- To estimate neonatal deaths in EAG States and the relative influence background characteristics on neonatal mortality in EAG states using parametric Cox Hazard Model.
- To study the district effect (group level) with regard to percentage of women educated 12+ within EAG districts and its impact on neo-natal deaths.

DATA & METHODS

The data from the National Family Health Survey-4 [27] is used in the analysis. NFHS-4 provides data on infant and child morality and the factors associated with the survival of young children e.g., demographic and socio-economic characteristics. It also provides information on utilization of maternal and child health services for children born in the last three years. To study the district impact and estimation of ICC the GLIMMIX procedure in SAS is used [31] [32].

FINDINGS & DISCUSSIONS

The percentage distribution of the study sample by selected variables sows 34163 neonatal deaths in the EAG states. Off these 32 percent were from Uttar Pradesh, 17 percent from Madhya Pradesh, 13.1 percent from Bihar, 8.04 percent from Rajasthan, 7.94 percent in Odisha, 6.77 percent in Jharkhand, 6.50 percent in Chhattisgarh, 5.49 percent in Assam and 3.1 percent in Uttarakhand. Off the total neonatal deaths 82.2 percent are from rural areas and 17.78 percent from urban areas. Off the total deaths 85.27 percent are Hindus, 12.88 percent are Muslims, and share of other religious group is less than one percent. Eleven percent of the deaths were from tribes and 87.1 percent had some caste while about 2 percent deaths were among those who had no caste. Sixty two percent of the neonatal deaths belonged to households who do not have any toilet facility, while 29.2 percent were those using any kind of flush toilet, and about six percent in those households who use pit toilets. Share of neonatal death was 41 percent from poorest wealth quintile households, and another 27 percent from those belonging to poorer wealth quintile. Sixteen percent neonatal deaths among middle income household, while 10 percent from richer and 6 percent from richest households. Sixty three percent of the neonatal deaths belonged to individuals having no education, seven percent to those who had incomplete primary, eight percent to those who had primary schooling completed, eighteen percent to those with incomplete secondary, two percent to those with complete secondary and two percent to those who have higher educational levels. Thirty two percent of the neonatal deaths occurred in home delivery cases, forty eight percent among deliveries conducted at public institution and nineteen percent among those who chose private institution as place of delivery. Neonatal deaths share among average sized babies was 54 percent, 15 percent was among babies born from very large to larger than average while 24 percent was to babies born smaller than average to very small.

Table 1 presents the life table estimates on neonatal deaths by the selected background characteristics. The neonatal death in EAG States is 43.9 per 1000 live births which are still very high. Among the EAG States Uttar Pradesh recorded the highest neonatal death at 51.6 deaths per 1000 live births and the lowest amongst the EAG State is recorded in Uttarakhand at 32.3 neonatal deaths per 1000 live births. Neonatal deaths in Chhattisgarh recorded as 48.2, Odisha 46.9, Madhya Pradesh

44.9, Bihar 41.9, Jharkhand 39.2, Assam 36.1 and Rajasthan 34.4 per 1000 live births.

Neonatal deaths in rural area were 45.7 deaths per 1000 live birth while in urban areas the neonatal death was 37 per 1000 live births. The neonatal deaths among Hindus were 44.9 while among Muslims it was 39, among Christians it was 35.9 and Sikhs 32.4 per 1000 live births.

Schedule Caste have highest rate of Neo-natal mortality at 50.3 per 1000 live births followed by other backward caste at 44.2 and schedule tribes at 43.4 per 1000 live births. Those who have any kind of toilets facility either flush or pit have lower neonatal deaths compared to those who defecate in open. This re-enforces the importance of toilets in lowering neonatal deaths by reduction in neonatal sepsis due to unhygienic condition. Those in the poorest category wealth quintile have highest neonatal deaths at 51.7 per 1000 live births, while the richest category wealth quintile has the lowest neonatal deaths at 26.9 per 1000 live births. Neonatal deaths is considerably lower among those who deliver at public health facilities compared to those who deliver at home. Incidentally, those delivering at private sector health facility have the highest neonatal deaths. Average sized births have the lowest neonatal deaths compared to very large or larger than average or very small and smaller than average sized babies.

Table:1 Neonatal Deaths in EAG States: Life Table Estimates-NFHS-4 (2015-16)

EAG States	NMR
Assam	36.1
Bihar	41.1
Chhattisgarh	48.2
Jharkhand	39.2
Madhya Pradesh	44.9
Odisha	46.9
Rajasthan	34.4
Uttar Pradesh	51.6
Uttarakhand	32.3
EAG States	**43.9**
Place of Residence	
Rural	45.7
Urban	37
Religion	
Hindu	44.9
Muslim	39
Christian	35.9
Sikh	32.4
other	35.3
Caste	
schedule caste	50.3
schedule tribe	43.4
obc	44.2
none of them	37
don't know	46.8
Type of Toilet	
flush to piped sewer system	29.8
flush to septic tank	36.5
flush to pit latrine	38.6
flush to somewhere else	43.7
flush, don't know where	24.1
ventilated improved pit latrine (vip)	41.5
pit latrine with slab	37.3
pit latrine without slab/open pit	39
no facility/bush/field	49.4
composting toilet	41.5
dry toilet	45.9
other	48.3
not a de jure resident	41.1
Wealth Index	
Poorest	51.7
Poorer	46.4
Middle	40.6
Richer	35.7
richest	26.9
Educational attainment	
no education	48.9
incomplete primary	48.9
complete primary	42.7
incomplete secondary	35.8
complete secondary	29.3
higher	22.6
Place of Delivery	
respondent's home	41.9
other home	51.5
parents' home	42.5
public: govt./munic. hospital	33.1
public: govt. dispensary	36.6
public: uhc/uhp/ufwc	29.4
public: chc/rural hospital/block phc	31.8
public: phc/additional phc	31.6
public: sub-centre	32.2
other public sector health facility	19.7
private: hospital/maternity home/clinic	41.2
other private sector health facility	56
ngo or trust hospital/clinic	30.5
Other	48.1
Size at the time of Birth	
very large	46.2
larger than average	35.6
Average	28.3
smaller than average	50.6
very small	105.9
don't know	116.6

Table 2 presents the findings from the proportional hazards model capturing un-observed heterogeneity. The value of shape parameter 1.71, which is greater than one indicating unobserved heterogeneity in the data. The findings predict the risk of neonatal death after controlling for age, age square, education, wealth, place of residence, type of toilet, religion, caste, place of delivery & size of the baby at the time of birth. It is important to notice that education effect became statistically non-significant though the effects of age and wealth quintile are in the expected direction and statistically significant. Compared to schedule caste category those who are schedule tribe and from backward caste category have statistically significant lower risk of neonatal deaths. Place of residence, religion & type of toilet as pit or bush does not have statistically significant impact on risk of neonatal deaths. Compared to home delivery those delivering at private institute have statistically significant higher risk of neonatal deaths. This may be due to complicated pregnancies reaching private hospitals and needs further research. Compared to very large sized babies the risk of neonatal deaths is less among larger than average size babies and is statistically significant at 5 percent level of significance, while it is highly significant compared to average sized babies. Very small babies have significantly higher risk (2.2 times) of neonatal deaths compared to very large babies.

The GLIMMIX procedure in SAS provided the estimates of intra-class correlation using women educated 12 plus grades with-in district as group level variable. There were 779519 observations nested in 304 districts across EAG States. The ICC values of 0.0028761 indicates that the variation in neonatal deaths is primarily due to within district individual differences and not due to differences in education achievements between district. The findings from GLIMMIX models also predict higher percentages of women educated 12+ grades within district lowers the risk of neonatal deaths and is statistically significant at 5 percent level of significance.

CONCLUSIONS

The findings suggest high neonatal death burden in EAG States. Uttar Pradesh recorded the highest neonatal death at 51.6 deaths per 1000 live births and the lowest amongst the EAG State is recorded in Uttarakhand at 32.3 neonatal deaths per 1000 live births. Neonatal deaths in Chhattisgarh were recorded at 48.2, Odisha at 46.9, Madhya Pradesh as 44.9, Bihar at 41.9, Jharkhand at 39.2, Assam at 36.1 and Rajasthan at 34.4 per 1000 live births. If India has to meet SDG target relating to Infant Mortality Rates the reduction in neonatal deaths is must. Findings suggest unobserved heterogeneity in the data. The low value of intra-class correlation is suggestive of individual level variation in the dataset than group group/district level differences. Higher educated women within district have significantly lower risk of neonatal deaths as predicted in the random-effect model.

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Table 2: Factors influencing neonatal mortality in EAG States: Hazards Model

	Haz. Ratio	Std. Err.	z	P>z	[95% Conf.	Interval]
Current Age	0.61	0.01	-25.98	0.00	0.59	0.64
Age Sq	1.01	0.00	23.39	0.00	1.01	1.01
Education						
no education (ref)	1.00					
primary	1.01	0.04	0.19	0.85	0.93	1.09
secondary	0.97	0.04	-0.91	0.36	0.90	1.04
higher	1.00	0.08	-0.05	0.96	0.86	1.16
Wealth Index						
poorest (ref)	1.00					
poorer	0.95	0.04	-1.49	0.14	0.88	1.02
middle	0.89	0.04	-2.38	0.02	0.81	0.98
richer	0.80	0.05	-3.39	0.00	0.71	0.91
richest	0.60	0.05	-5.97	0.00	0.50	0.71
Caste						
schedule caste						
(ref)	1.00					
schedule tribe	0.80	0.04	-4.53	0.00	0.73	0.88
obc	0.87	0.03	-3.87	0.00	0.81	0.93
none of them	0.83	0.04	-3.49	0.00	0.75	0.92
don't know	0.70	0.15	-1.69	0.09	0.46	1.06
Place of Residence						
urban (ref)						
rural	1.08	0.05	1.61	0.11	0.98	1.18
Type of Toilet						
flush (ref.)	1.00					
pit	0.91	0.07	-1.25	0.21	0.79	1.05
bush	1.02	0.05	0.39	0.70	0.93	1.11
'other'	1.17	0.07	2.45	0.01	1.03	1.32
Religion						
hindu (ref)	1.00					
muslim	1.03	0.05	0.68	0.50	0.94	1.13
others	0.83	0.09	-1.67	0.10	0.67	1.03
Place of Delivery						
home						
'public'	0.94	0.03	-1.81	0.07	0.88	1.01
'private'	1.46	0.07	8.26	0.00	1.33	1.59
'other'	1.13	0.29	0.45	0.65	0.68	1.87
Size of Baby						
very large	1.00					
larger than						
average	0.83	0.07	-2.34	0.02	0.71	0.97
average	0.67	0.05	-5.85	0.00	0.59	0.77
smaller than aver..	1.11	0.08	1.33	0.19	0.95	1.29
very small	2.21	0.18	9.93	0.00	1.89	2.59
don't know	2.43	0.21	10.20	0.00	2.05	2.88
_cons	0.29	0.09	-4.13	0.00	0.16	0.52
/ln_p	0.53	0.01	44.64	0.00	0.51	0.56
P	1.71	0.02			1.67	1.75
1/p	0.59	0.01			0.57	0.60

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