Trends and Determinants of Infant Mortality in Empowered Action Group States, India (1990-2006)

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Abstract

Background: Infant Mortality Rate (IMR) is one of the most sensitive indicators to assess the health status of any country. In India there has been a continuous decline in infant mortality rate however for the Empowered Action Group (EAG) states which constitute 45% of the total population of India, still shows very high infant mortality rates. The Ministry of Health and Family Welfare, India, established Empowered Action Group (EAG) namely Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttaranchal and Uttar Pradesh in 2001 to have special focus by monitoring and facilitating the attainment of national health goals on some of these states which are demographically lagging behind.

Objective: This study aimed to explore the trends and determinants of infant mortality in EAG states, India during last one and half decade, (1990-2006).

Methods:: Data from three rounds of the National Family Health Survey (NFHS), the Indian version of the Demographic and Health Survey (DHS) which were canvassed during 1992–93 (NFHS-1), 1998–99 (NFHS-2), and 2005–06 (NFHS-3) in India were analyzed. To identify the disparities and nature of the association between Infant mortality and selected socioeconomic background characteristics, bivariate and multivariate Cox proportional hazard model (both separate and pooled) analysis were performed.

Key findings: In India, there has been a decline in overall infant mortality but still differentials in infant mortality by mother's age at birth, the composite variable of birth order and birth interval, economic status, sanitation facility and region were evident.Controlling for a set of socioeconomic and demographic factors, the hazard of infant mortality was less (CHR=0.77 95% CI=0.75-0.79) (AHR=0.83 95% CI=0.80-0.86) and (CHR=0.87 95% CI=0.85-0.90) (AHR=0.89 95% CI=0.87-0.92) during the period 2005-06 and 1998-1999 respectively as compared to period 1992-1993.

Conclusion: Infant mortality is reducing over the one and half decade but disparities across different socioeconomic and geographical setting remain.Investments that focusing on educating women on increasing age at marriage, age at first birth, and increasing the birth interval between two births. In addition, investments in the quality of care offered by the both the private and public health systems throughout the EAG states may be required in order to ensure continued progress in child health also strengthening health facilities at the district level to save newborns.

Keywords: Infant mortality rate, EAG states, maternal care, NFHS, MDGs and pooled data.

I. INTRODUCTION AND REVIEWS OF LITERATURE

Estimates of child mortality (World Health Report 2005) indicate that nearly 10.1 million children die before their fifth birthday. EAG states which are the most backward states in terms of socio-economic, health status, particularly related to maternal and child health is extremely poor. The EAG states constitute 45% of the total population of India and also have higher neonatal and infant mortality rates. Social and economic development of a nation is often reflected by the existing infant and child mortality rates. India has made significant strides in reducing both infant mortality (40/1000 live births) and under-five mortality (52/1000 live births) but has been unable to achieve the Millennium Development Goal (MDG) by 2015 [1-4]. Studies conducted globally and in India suggest associations of sex of the child, mother's exposure to mass media, use of clean cooking fuel, access to a toilet facility, improved safe drinking water facility, mother's religion and ethnicity, income of the household, birth order, mother's age at birth, birth intervals, availability of professional antenatal and delivery care, full immunization of children, mother's education, and urban-rural residence with

infant and child mortality [5-7]. Mosley Chen Framework categorizes the above determinants of infant and child mortality into three categories (i) biological factors; (ii) socio-economic factors; and (iii) environmental factors [8]. The Government of India (GOI) has prepared a list of eight states which are very poor in respect of demographic as well as the socioeconomic indicators. The GOI has given a name to these eight states as Empowered Action Groups or EAG states. These states are Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttarakhand and Uttar Pradesh [9]. Empowered Action Group (EAG) states, comprised of eight socioeconomically backward states of Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttarakhand and Uttar Pradesh, Table 1 shows the socio-demographic profiles of the eight EAG states. Highest population density is in UP (828) and lowest density is in Chhattisgarh and Uttrakhand (189). The female literacy rate is highest in Uttarakhand 70.7 per cent. According to Sample Registration System 2011, infant mortality rates (IMR) were found to be higher in many states Rajasthan (58), MP (62), Odisha and UP (61) than the country's average of 47 deaths per 1000 live birth.

Table 1. Profiles and demographic characteristics of states in Empowered Action Group states, India

Demographic characteristics	UP	Uttarakhand	Bihar	Jharkhand	Odisha	Chhattisgarh	M. P	Rajasthan
Land areas (sq.km.)[1]	240928	53483	94163	79716	155707	135192	308252	342239
Total population in million[1]	199.58	10.11	103.80	32.97	41.95	25.54	72.60	68.62
% of national population[1]	16.5	0.83	806	2.72	3.47	2.11	6.00	5.66
Population density[1]	828	189	1102	414	269	189	236	201
Female literacy rate (%)[1]	59.26	70.70	53.33	56.21	64.36	60.59	60.02	52.66
Schedule Caste (%)[1]	20.7	17.9	15.7	23.2	22.8	30.6	21.1	13.5
Schedule Tribe (%)[1]	0.6	2.9	1.3	26.2	22.8	30.6	21.1	13.5
Sex ratio-Females per 100 males[1]	912	963	918	948	979	991	931	928
Birth rate[2]	28.3	19.3	20.5	25.3	20.5	25.3	27.3	26.7
Death rate[2]	8.1	6.3	5.9	7.0	8.6	8.0	8.3	6.7
Natural growth rate[2]	2.02	1.30	1.46	1.83	1.19	1.73	1.89	2.00
Infant mortality rate[2]	61	38	31	42	61	51	62	55

Sources: 1-Census of India, 2011, 2-Sample Registration System, 2012.

A few attempts have been made to understand the trends and determinants of infant mortality in EAG states, India during last one and half decade, 1990-2006 from pooled data. Hence, the present study is a modest approach in this direction.

II.   STUDY SETTING, DATA, METHOD AND ETHICS

This study is based on three rounds of the National Family Health Survey (NFHS) data, the Indian version of the Demographic and Health Survey (DHS) which were canvassed during 1992–93 (NFHS-1), 1998–99 (NFHS-2), and 2005–06 (NFHS-3) in India [10-12]. All the three rounds of the survey are nationally representative and have covered more than 99% of India's population. The NFHS-1 covered a sample of 89,777 ever-married women aged 13–49, NFHS-2 covered 90,303 ever-married women aged 15–49 and NFHS-3 covered 124,385 women aged 15–49. The primary goal of NFHS survey is to make available state and national level estimates of fertility, mortality, family planning, HIV-related knowledge, and important aspects of nutrition, health and health care. The survey provides state and national level estimates of demographic and health parameters as well as data on various socioeconomic and policy measurements. Different rounds of NFHS collected information related to complete birth history, which included sex, month and year of birth, and survival status for each live birth. The information on age at death was recorded in days for children who had died in the first month of life; in months for children who had died after the first month but before completion of their second birthday, and in years for children who had died at later ages for different reference periods. All three rounds of NFHS survey have adopted similar sampling methods and used similar interview schedules. The household and eligible female respondent response rates were consistently above 90% in all three NFHS survey rounds. Appropriate sample weights were used taking into account the survey design. The details of the sampling weights, as well as extensive information on survey design, data collection, and management procedures, are described in the NFHS reports of the respective rounds [10-12]. Required information/data in states of Sikkim was missing in NFHS-1. Therefore, in order to retain consistency, samples for Sikkim was excluded from the final analytic samples.

III.   OUTCOME MEASUREMENTS

The outcome variable is infant mortality. Infant mortality is defined as the probability of dying before the first birthday. Infant mortality (child who died before his/her first birthday) in the twenty years preceding the survey (0 = alive, died = 1)

IV. DEFINING PREDICTOR VARIABLES

To examine the socio-economic and regional disparities and determinants of child mortality, in EAG states, India during last one and half decade, 1990-2006, socioeconomic and regional predictors were included in the analysis. These indicators are based on their theoretical and observed importance applied in literature and available potential socioeconomic, predictors based on the previous studies [13-14] and availability of information in all three rounds of NFHS survey for better comparability. Socioeconomic and regional predictors such as current age of mother, mother's age at the time of childbirth, mother's education, father's education, mother's occupation, father's occupation, religion, social group, mass media exposure, birth order and interval, status of child, wealth quintile, safe sanitation facility, safe toilet facility, safe drinking water facility, place of residence, city wise residence and region of residence were included as predictor variables in the study. Further socioeconomic and regional variables were categorized into three categories namely individual, household and community characteristics. Individual characteristics included in the analysis were current age of mother, the age of mother at the time of childbirth was categorized into 15–24, 25–34 and 35–49 years. The educational levels of the mother's and fathers were grouped into illiterate and literate. Mother's and father's work status grouped into not working, agricultural work, skilled/unskilled work, professional work. Mass media exposure has been assessed by considering how often the respondents read the newspaper, listen to the radio and watch television. The birth order of children and the interval between the childbirths were grouped as first birth order, birth order 2/3 and interval <= 24, birth order 2/3 and interval >24, birth order-4+ and interval<=24 and birth order-4+ and interval>24.

Household characteristics included in the analysis were the religion of the mother was categorized as Hindu and non-Hindu (Muslim, Sikh, Christians, Buddhist and others). Identification of the social group was based on the women's self-reporting as Scheduled Castes (SCs), Scheduled Tribes (STs) and Other than SC/ST. Similarly, Household wealth index was also calculated from the standard set of assets owned by the household, which included ownership of consumer items and dwelling characteristics. Individuals were ranked on the basis of their household scores and divided into different quintiles, each representing 20 percent of the score, between 1 (poorest) and 5 (wealthiest) [15] and the index has been found to correlate highly with income data in developing countries [16-17]. Safe sanitation facility considered those household having either a flush or pit latrine. Safe cooking fuel was considered from households using liquefied petroleum gas (LPG), electricity, kerosene, and biogas. Safe drinking water considered from households access to private or public piped or tap (hand pump) water as well as covered well.

Community characteristics included in the analysis were the place of residence urban and rural, city-wise residence grouped into capital, large city, small city, town and countryside. Most of the studies indicated regional variations in the determinants of child survival [18-19], this study also tries to explore the regional variation in the determinants of under-five mortality, for this purpose, India was divided into six regions based on geographical location and cultural settings. The six regions consist of North (Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Rajasthan, Delhi and Uttaranchal), Central (Uttar Pradesh, Madhya Pradesh and Chhattisgarh), East (Bihar, Jharkhand, West Bengal and Orissa), North-East (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura), West (Gujarat, Maharashtra and Goa), and South (Andhra Pradesh, Karnataka, Kerala and Tamil Nadu).

V. ANALYTICAL APPROACH

To identify the trends and determinants of under-five mortality in India, the present study tries to understand that whether the association between the predictor variable and the outcome variable varied during the last one and half decade, 1990-2006. This required the data from all three rounds of NFHS to be pooled and tested for the trend using linear or nonlinear trend analysis. As the sampling design of the NFHS offers an opportunity to make all the three rounds of data comparable [20], several earlier studies have pooled the different rounds of DHS/NFHS datasets to observe changes over time [21-24]. Bivariate and multivariate Cox proportional hazard model analysis were performed to examine the nature of the association between under five mortality and selected socioeconomic background characteristics. The hazard estimates were reported using odds ratio with 95% Confidence Interval (CI). The entire analysis was performed using SPSS version 20.0 and STATA version 13.0. To take into account the survey design (i.e. sampling weights with clustering and strata) while estimating bivariate and multivariate statistics, the SVY command [25] in STATA [26] was used. The study used pooled multivariate Cox proportional hazard model to assess the influence or the strength of selected key individual, household, community predictors in explaining infant mortality.

Ethical consideration

The study is based on data available in public domain, therefore no ethical issue is involved. I wish to thank the DHS (NFHS) for making this data available for this study.

VI.   RESULTS

Profile of respondents

Table 1 represents the weighted percentage distribution of the women age group 15-49 years, who had delivered the child during the twenty years preceding the survey by select Socio-demographic characteristics. About half of the women age were 35 years and above at the time of survey irrespective of time (1990-93, 1996-99 and 2003-2006). The majority of the women, all most two third had given birth between age 15-24 years during 1990-93, 1996-99 and 2003-2006. Male children found higher as compared to female children in all three round survey. More than two third (81.1%), women were illiterate during 1990-93 while 75.3% and 72.68% women were illiterate during 1996-99 and 2003-2006 respectively in EAG states India. More than 80 percent women belonged to the Hindu religion irrespective of the time period (1990-93, 1996-99 and 2003-2006)), among them more than two-third of women were from other than SC/ST Social group. About one-third (30.3%) and more than one-third (36.7%) and more than half (56.6%) women had mass media exposure in different time during 1990-93, 1996-99 and 2003-2006 respectively. More than 80 percent women belonged to rural areas, and among them, one third belonged to poorest wealth quintile . In India among EAG states only eighteen percent household during 1990-1993, twenty-one percent household during 1996-99 and twenty-three percent household during 2003-06 were using safe sanitation. Since EAG states which are demographically and economically backward states, only 8.2 per cent during 1990-93 while 11.3 per cent and 11.5 per cent during 1996-99 and 2003-2006 respectively were using safe cooking fuel.

Table 1. Percentage distribution of women who had at least one live birth in their maternal age (aged 15–49) during the last three years preceding the survey by selected individual, household and community characteristics, in EAG states, India, 1990–2006.

background characteristics	NFHS-1 (1990–93)		NFHS-2 (1996–99)		NFHS-3 (2003–06)	
	%	*n*	*%*	*n*	*%*	*n*
Individual characteristics						
Current mother's age						
15-24	11.7	15338	12.1	15453	10.8	15492
25-34	37.6	49185	38.3	48995	37	53111
35-49	50.6	66115	49.7	63628	52.3	75078
Mother's age at birth of child						
15-24	59.6	77812	63.1	80787	62	89109
25-34	35.4	46300	33.1	42413	34.1	48957
35-49	5.0	6527	3.8	4876	3.9	5614
Sex of Child						
Male	52.1	68000	52.2	66861	51.9	74607
Female	47.9	62640	47.8	61214	48.1	69073
Birth order and interval						
Birth order 1	26.1	34114	26.2	33495	27	38728
Birth order-2/3 and interval<=24	14.6	19037	15.4	19748	16.1	23084
Birth order-2/3 and interval>24	24.8	32344	24.7	31572	24.8	35558
Birth order-4+ and interval<=24	13.4	17448	13.7	17537	13.4	19245
Birth order-4+ and interval>24	21.1	27576	20	25572	18.7	26902
Mother's education						
Illiterate	81.1	105696	75.3	96484	72.6	104344
Literate	18.9	24706	24.7	31572	27.4	39329
Father's education						
Illiterate	44.1	57296	38.2	48803	39	55959
Literate	55.9	72701	61.8	78980	61	87348
Mother's occupation						
Not working	73.8	96224	62.6	80092	49.9	71748
Agricultural work	16.6	21664	31.2	39886	37.2	53465
Skilled/Unskilled work	7.2	9377	3.7	4727	8	11500
Professional work	2.4	3091	2.5	3245	4.8	6942
Father's occupation						

Not working	2.1	2767	3.2	4074	1.7	2474
Agricultural work	46.5	60674	44.4	56826	37.6	53904
Skilled/Unskilled work	28.8	37524	30.6	39187	36.9	52976
Professional work	22.6	29418	21.8	27830	23.7	34060
Mass media exposure						
No exposure	69.7	91046	63.3	81035	43.4	62286
Any exposure	30.3	39594	36.7	47041	56.6	81395
Household characteristics						
Religion						
Hindu	85.7	111922	84.8	108550	84.2	120804
Non-Hindu	14.4	18717	15.2	19440	15.8	22671
Social group						
Scheduled caste (SCs)	13.9	18129	20.1	25196	20.9	29936
Scheduled tribe (STs)	10.4	13547	9.9	12485	10.2	14691
Others than SC/ST	75.8	98963	70	87868	68.9	98856
Wealth quintile						
Poorest	31.3	40708	33.8	43264	32.4	46615
Poorer	28.5	37029	27.7	35474	25.4	36526
Middle	18.9	24621	17.4	22345	17.7	25473
Richer	11.9	15516	12.5	15965	14.1	20191
Richest	9.3	12081	8.6	11028	10.4	14875
Sanitation facility						
Unsafe	82.3	107382	78.8	100930	77.2	110751
Safe	17.7	23156	21.2	27139	22.8	32740
Cooking fuel						
Unsafe	91.8	119913	88.7	68787	88.5	127151
Safe	8.2	10726	11.3	59288	11.5	16530
Drinking water						
Unsafe	76.4	99774	53.7	68787	18.5	26550
Safe	23.6	30865	46.3	59288	81.5	117130
Community characteristics						
Type of residence						
Urban	17.8	23203	17.7	22653	20.3	29104
Rural	82.2	107436	82.3	105423	79.7	114576
City-wise residence						
Capital, large city	2.4	3181	2.2	2772	4.5	6419
Small city	7.5	9736	5.2	6627	6.9	9905
Town	7.9	10286	10.3	13255	8.9	12780
Countryside	82.2	107436	82.3	105423	79.7	114576
States						
Bihar	22.9	29900	23.1	29522	24.5	35151
Madhya Pradesh	17	22234	18	23058	17.8	25646
Odisha	7.8	10217	7.1	9068	6.8	9832
Rajasthan	11.4	14871	12.3	15800	12.2	17543
Uttar Pradesh	40.9	53417	39.5	50627	38.6	55508
Total	**100**	**130639**	**100**	**128076**	**100**	**143680**

Note: All 'n' are weighted. Total may not be equal due to some missing cases.

VII. DIFFERENTIALSIN INFANT MORTALITY

To identify the factors associated with the infant mortality examined the bivariate differential by selected socioeconomic characteristics. Table 2 shows the weighted percentage of infant mortality by selected background characteristics. The proportion of infant mortality in EAG states India decreasing by nearly three percentage points from a level of 12.7% during 1990–93 to 10.3% during 2003-06. Results indicate that infant mortality varied by mother' age at birth of child, women education, religion social group, safe sanitation facility, safe drinking facility, safe water facility, place of residence and income strata. Infant mortality proportion was high (14.1%) among older age 35 years and above as compared to younger age 15-24 years (10.9%) during 1990-1993 and same trends were found during 1996-1999 and 2003-06. Illiterate women had more (13.8%) infant mortality as compared women with High school and above education (8.4%) during 1990-1993 and same trends observed during 1996-1999 and 2003-06. There were not much differential were found among sex of

children irrespective of the time period. Birth order and the birth interval were strongly associated with the infant mortality. Results indicated that the children born to mothers with birth order four and above with a preceding birth interval of fewer than 24 months have experienced two times more (17.8%) infant mortality as compared to birth order four and above but preceding birth interval of 24 months or more (8.0%) only. Results also show that the birth order two-three and with a preceding birth interval of fewer than 24 months were two times more (18.3%) risk of dying before completed their first birthday as compared to birth order two-three but preceding birth interval is 24 months or more (9.5%) only. Its indicates that the preceding birth interval was a significant determinant of infant mortality. Children born to the household having unsafe sanitation facility were almost two times more (13.4%) more risk to dying before completed age one year, as compared to household having safe sanitation facility (6.1%) only during 1990-93 and same trend have been showing during 1996-1999 and 2003-06. Those household using safe cooking fuel have almost 50 percent less chance of dying children before his/ her first birthday as compared to household using unsafe cooking fuel during 1990-93 while during 1996-99 and 2003-06 this gap was slightest between safe and unsafe cooking fuel use. Further analysis indicates that effect of economic strata is a most important factor of infant mortality. Children born in the richest family have very less (6.1%) chance to dying before completed his/her first birthday as compared to children born in the poorest family (15.4%), and the pattern was found same during 1996-99 and 2003-06. As regards to the state, results indicates that the Uttar Pradesh (15.0%) and Odisha (14.9%) have higher infant mortality followed by Madya Pradesh (11.8%), Bihar (11.1%) and Rajasthan (7.9%) only during 1990-93. However infant mortality was found less during 1996-99 and 2003-06 according to state but trends was same as during 1990-1993.

Table 2. Percentage of infant mortality by selected individual, household and community characteristics, in EAG states, India, 1990–2006.

Background characteristics	Infant mortality								
	NFHS-1 (1990–93)		NFHS-2 (1996–99)		NFHS-3 (2003–06)		Absolute change		
	%	95% CI	%	95% CI	%	95% CI	a	b	c
Individual characteristics									
Current mother's age									
15-24	10.9	[10.2-11.7]	10.5	[09.9-11.1]	8.3	[07.6-09.0]	0.4	2.2	2.6
25-34	11.6	[11.0-12.1]	9.7	[09.3-10.1]	8.7	[08.3-09.2]	1.9	1	2.9
35-39	14.1	[13.5-14.7]	12.0	[11.5-12.5]	11.8	[11.4-12.3]	2.1	0.2	2.3
Mother's age at birth of child									
15-24	13.8	[13.3-14.3]	12.0	[11.6-12.3]	11.5	[11.1-11.9]	1.8	0.5	2.3
25-34	11.1	[10.6-11.6]	9.1	[08.7-09.5]	8.2	[07.8-08.6]	2	0.9	2.9
35-39	11.5	[10.3-12.9]	10.0	[08.9-11.2]	8.8	[07.8-10.0]	1.5	1.2	2.7
Sex of child									
Male	12.6	[12.2-13.1]	11.1	[10.7-11.4]	10.3	[09.9-10.7]	1.5	0.8	2.3
Female	12.9	[12.4-13.4]	10.8	[10.3-11.2]	10.2	[09.8-10.6]	2.1	0.6	2.7
Birth order and interval									
Birth order 1	13.8	[13.2-14.4]	12.6	[12.1-13.1]	12.2	[11.7-12.7]	1.2	0.4	1.6
Birth order-2/3 and interval<=24	17.8	[16.9-18.7]	14.1	[13.5-14.8]	14.1	[13.4-14.9]	3.7	0	3.7
Birth order-2/3 and interval>24	8.0	[07.5-08.4]	7.0	[06.6-07.4]	5.8	[05.5-06.2]	1	1.2	2.2
Birth order-4+ and interval<=24	19.8	[18.9-20.7]	15.7	[14.8-16.6]	15.3	[14.4-16.2]	4.1	0.4	4.5
Birth order-4+ and interval>24	9.2	[08.6-09.8]	7.7	[07.3-08.2]	6.4	[06.0-06.9]	1.5	1.3	2.8
Mother's education									
Illiterate	13.8	[13.3-14.3]	11.9	[11.5-12.3]	11.3	[10.9-11.7]	1.9	0.6	2.5
Literate	8.4	[00.9-09.0]	8.1	[07.7-08.6]	7.7	[07.2-08.1]	0.3	0.4	0.7
Father's education									
Illiterate	14.9	[14.3-15.6]	12.4	[11.8-12.9]	11.7	[11.2-12.2]	2.5	0.7	3.2
Literate	11.1	[10.6-11.6]	10.0	[09.7-10.4]	9.3	[09.0-09.7]	1.1	0.7	1.8
Mother's occupation									
Not working	12.2	[11.7-12.7]	9.9	[9.5-10.3]	9.3	[08.9-09.7]	2.3	0.6	2.9
Agricultural work	14.2	[13.3-15.1]	13.2	[12.6-13.8]	11.3	[10.8-11.8]	1	1.9	2.9
Skilled/Unskilled work	15.2	[13.9-16.5]	11.2	[10.0-12.6]	11.4	[10.5-12.3]	4	-0.2	3.8
Professional work	12.5	[10.6-14.6]	8.6	[07.4-10.0]	10.1	[09.0-11.4]	3.9	-1.5	2.4
Father's occupation									
Not working	11.1	[09.4-13.0]	10.3	[08.9-11.8]	9.6	[07.9-11.6]	0.8	0.7	1.5
Agricultural work	14.1	[13.5-14.7]	11.8	[11.4-12.3]	11.5	[11.0-12.1]	2.3	0.3	2.6
Skilled/Unskilled work	13.1	[12.5-13.8]	11.0	[10.4-11.6]	10.2	[09.7-10.6]	2.1	0.8	2.9

Professional work	9.7	[09.2-10.3]	9.1	[08.6-09.6]	8.5	[08.0-09.0]	0.6	0.6	1.2
Mass media exposure									
No exposure	13.9	[13.4-14.4]	11.8	[11.4-12.2]	11.4	[11.0-11.9]	2.1	0.4	2.5
Any exposure	10.2	[09.7-10.8]	9.4	[09.0-09.9]	9.4	[09.0-09.8]	0.8	0	0.8
Household characteristics									
Religion									
Hindu	13.2	[12.7-13.6]	11.3	[10.9-11.6]	10.6	[10.2-10.9]	1.9	0.7	2.6
Non-Hindu	10.2	[09.5-11.0]	8.9	[08.3-09.6]	8.7	[08.1-09.3]	1.3	0.2	1.5
Social group									
Scheduled caste (SCs)	15.2	[14.3-16.3]	12.4	[11.7-13.2]	11.7	[11.1-12.5]	2.8	0.7	3.5
Scheduled tribe (STs)	11.7	[10.5-12.9]	11.4	[10.5-12.5]	12.1	[11.3-13.0]	0.3	-0.7	-0.4
Others than SC/ST	12.4	[12.0-12.9]	10.3	[10.0-10.7]	9.5	[09.2-09.9]	2.1	0.8	2.9
Wealth quintile									
Poorest	15.4	[14.6-16.2]	12.9	[12.3-13.4]	12.0	[11.4-12.6]	2.5	0.9	3.4
Poorer	13.8	[13.2-14.5]	11.5	[11.0-12.1]	11.2	[10.7-11.9]	2.3	0.3	2.6
Middle	12.3	[11.6-13.1]	10.3	[09.7-11.0]	9.8	[09.1-10.4]	2	0.5	2.5
Richer	9.5	[08.8-10.3]	8.6	[08.0-09.3]	8.2	[07.6-08.8]	0.9	0.4	1.3
Richest	6.1	[05.5-06.8]	6.2	[05.7-06.8]	6.2	[05.6-06.9]	-0.1	0	-0.1
Sanitation facility									
Unsafe	13.9	[13.4-14.3]	11.8	[11.5-12.2]	11.0	[10.6-11.3]	2.1	0.8	2.9
Safe	7.7	[07.2-08.3]	7.6	[07.2-08.1]	7.9	[07.4-08.4]	0.1	-0.3	-0.2
Cooking fuel									
Unsafe	13.4	[12.9-13.8]	11.4	[11.0-11.8]	10.7	[10.4-11.1]	2	0.7	2.7
Safe	6.1	[05.5-06.8]	7.3	[06.8-07.8]	6.8	[06.2-07.5]	-1.2	0.5	-0.7
Drinking water									
Unsafe	13.8	[13.4-14.3]	12.1	[11.7-12.6]	10.3	[9.6-11.0]	1.7	1.8	3.5
Safe	9.2	[08.6-9.9]	9.5	[09.1-10.0]	10.3	[9.9-10.6]	-0.3	-0.8	-1.1
Community characteristics									
Type of residence									
Urban	8.2	[07.6-08.9]	8.3	[07.7-09.0]	8.0	[07.4-08.5]	-0.1	0.3	0.2
Rural	13.7	[13.3-14.2]	11.5	[11.1-11.9]	10.8	[10.5-11.2]	2.2	0.7	2.9
City-wise residence									
Capital, large city	8.1	[06.4-10.3]	8.3	[05.8-11.8]	7.8	[06.6-09.2]	-0.2	0.5	0.3
Small city	7.5	[06.5-08.7]	7.4	[06.4-08.5]	8.1	[07.2-09.2]	0.1	-0.7	-0.6
Town	8.9	[07.9-10.0]	8.8	[08.1-09.6]	7.9	[07.3-08.7]	0.1	0.9	1
Countryside	13.7	[13.3-14.2]	11.5	[11.1-11.9]	10.8	[10.5-11.2]	2.2	0.7	2.9
States									
Bihar	11.1	[10.4-11.9]	8.3	[07.7-08.9]	8.9	[08.3-09.6]	2.8	-0.6	2.2
Madhya Pradesh	11.8	[10.9-12.8]	11.9	[11.2-12.7]	10.8	[10.1-11.5]	-0.1	1.1	1
Odisha	14.9	[13.8-16.2]	10.9	[10.1-11.8]	10.6	[09.7-11.5]	4	0.3	4.3
Rajasthan	7.9	[07.1-08.8]	10.4	[09.8-11.0]	9.8	[09.1-10.7]	-2.5	0.6	-1.9
Uttar Pradesh	15.0	[14.2-15.8]	12.2	[11.5-12.8]	10.9	[10.4-11.4]	2.8	1.3	4.1
Total	**12.7**	**[12.3-13.2]**	**10.9**	**[10.6-11.3]**	**10.3**	**[9.9,10.6]**	**1.8**	**0.6**	**2.4**

[a]Calculated as absolute change = [NFHS 1-NFHS 2].
[b]Calculated as absolute change = [NFHS 3-NFHS 2].
[c]Calculated as absolute change = [NFHS 3-NFHS 1].

VIII.   DETERMINANTS OF INFANT MORTALITY

To identify the factors associated with the infant mortality, Cox proportional hazard model with the selected socioeconomic characteristics. Table 3 reiterate that some important factors such as mother age at the time of birth, birth order and birth interval, wealth quintile, sanitation facility, cooking fuel, place of residence and state are significant factors associated with infant mortality during 1990-93, 1996-99 and 2003-2006. After controlling the other socioeconomic variables, the hazard of under-five mortality was highest among births to mothers aged 25-34 years (HR=3.09, 95% CI=2.93-3.27) and mothers aged 35 years or more (HR=7.35 95% CI=5.53-9.38) than with births to the mother's age at childbirth 15-24 years during 1990-93 almost same trends were found during 1996-99 and 2003-06. The risk of infant mortality was marginally higher among female (HR=1.01 95% CI=0.98-1.05) as compared to male during 1990-93 but during 2003-06 the trend was showing in reverse. However, the risk of infant mortality was marginally less among female (HR=0.96 95% CI=0.92-1.00) as compared to male children during 2003-06. For 1992-1993, babies with birth order four or more and the

birth interval were less than two years had more (HR=3.43 95% CI=3.22-3.65) hazard of death children before reaching their first birthday as compared with first birth order baby. The almost same trend observed during 1996-99 and 2003-06. Literature has shown that economic status is an important factor for mortality in EAG states India. This study also indicates that children born to the richest quintile (47%), richer wealth quintile (32%) and middle wealth quintile (15%) less hazard of infant mortality than those born to the poorest wealth quintile during 1990-93 while children born in richest family (55%) during 1996-99 and (61%) during 2003-06 less hazard of infant mortality as compared to children born in poorest family. Results clearly indicate that children born to the household having safe sanitation, safe cooking fuel, safe drinking water were less hazard of infant mortality than those born to the household having unsafe sanitation, unsafe cooking fuel, and unsafe water. As regards to state, results indicates that the children born in Uttar Pradesh (47.0%), Odisha (33.0%) and Madhya Pradesh (25%) have higher infant mortality as compared to children born in Bihar, while children born in Rajasthan (12.0%) had less chance to infant mortality as compared to Bihar during 1990-93. However, infant mortality was found less during 1996-99 and 2003-06 according to state but the pattern was same observed as during 1990-1993.

Table 3. Adjusted hazard ratio of Infant mortality by selected individual, household and community characteristics, in EAG states, India, 1990–2006

Background characteristics	Infant mortality					
	NFHS-1 (1990–93)		NFHS-2 (1996–99)		NFHS-3 (2003–06)	
	AHR	95% CI	AHR	95% CI	AHR	95% CI
Individual characteristics						
Current mother's age						
15-24 (ref)	1.00		1.00		1.00	
25-34	0.10***	[0.09-0.10]	0.09***	[0.09-0.10]	0.09***	[0.08-0.10]
35-49	0.01***	[0.01-0.01]	0.01***	[0.01-0.01]	0.01***	[0.01-0.01]
Mother's age at birth of child						
15-24 (ref)	1.00		1.00		1.00	
25-34	3.09***	[2.93-3.27]	3.26***	[3.07-3.46]	3.00***	[2.81-3.20]
35-49	7.35***	[5.53-9.38]	5.06***	[5.46-9.00]	7.71***	[5.31-9.48]
Sex of Child						
Male (ref)	1.00		1.00		1.00	
Female	1.01	[0.98-1.05]	0.99	[0.95-1.03]	0.96**	[0.92-1.00]
Birth order and interval						
Birth order 1 (ref)	1.00		1.00		1.00	
Birth order-2/3 and interval<=24	1.89***	[1.79-1.99]	1.73***	[1.64-1.82]	1.73***	[1.64-1.83]
Birth order-2/3 and interval>24	1.17***	[1.11-1.24]	1.13***	[1.06-1.20]	0.95	[0.89-1.01]
Birth order-4+ and interval<=24	3.43***	[3.22-3.65]	3.02***	[2.83-3.22]	3.15***	[2.93-3.39]
Birth order-4+ and interval>24	1.97***	[1.83-2.12]	1.85***	[1.71-1.99]	1.62***	[1.48-1.77]
Mother's education						
Illiterate (ref)	1.00		1.00		1.00	
Literate	1.05	[0.97-1.09]	1.07***	[1.01-1.13]	1.11***	[1.05-1.17]
Father's education						
Illiterate (ref)	1.00		1.00		1.00	
Literate	1.03	[0.99-1.07]	1.05**	[1.00-1.09]	0.99	[0.94-1.04]
Mother's occupation						
Not working (ref)	1.00		1.00		1.00	
Agricultural work	0.95	[0.90-0.99]	1.02	[0.98-1.07]	0.96	[0.92-1.02]
Skilled/Unskilled work	1.03	[0.96-1.10]	1.08	[0.98-1.19]	1.00	[0.93-1.08]
Professional work	1.04	[0.93-1.17]	0.84***	[0.73-0.95]	0.95	[0.86-1.04]
Father's occupation						
Not working (ref)	1.00		1.00		1.00	
Agricultural work	1.29***	[1.13-1.48]	1.23***	[1.10-1.37]	1.36***	[1.16-1.58]
Skilled/Unskilled work	1.40***	[1.22-1.61]	1.42***	[1.27-1.58]	1.49***	[1.28-1.74]
Professional work	1.24***	[1.07-1.43]	1.31***	[1.17-1.47]	1.37***	[1.18-1.60]
Mass media exposure						
No exposure (ref)	1.00		1.00		1.00	
Any exposure	1.03	[0.98-1.08]	0.98	[0.93-1.03]	0.99	[0.94-1.03]

Household characteristics

Religion

Hindu (ref)	1.00		1.00		1.00	
Non Hindu	0.86***	[0.81-0.92]	0.94**	[0.89-1.01]	0.96	[0.90-1.02]
Social group						
Scheduled caste (SCs) (ref)	1.00		1.00		1.00	
Scheduled tribe (STs)	0.80***	[0.75-0.86]	0.86***	[0.80-0.92]	1.04	[0.97-1.12]
Others than SC/ST	0.93***	[0.89-0.98]	0.96	[0.92-1.01]	0.97	[0.92-1.02]
Wealth quintile						
Poorest (ref)	1.00		1.00		1.00	
Poorer	0.91***	[0.87-0.95]	0.87***	[0.83-0.91]	0.85***	[0.80-0.90]
Middle	0.85***	[0.80-0.89]	0.76***	[072-0.81]	0.74***	[0.69-0.79]
Richer	0.68***	[0.63-0.74]	0.61***	[0.56- 0.67]	0.62***	[0.56-0.67]
Richest	0.53***	[0.46-0.61]	0.45***	[0.39- 0.53]	0.39***	[0.34-0.44]
Sanitation facility						
Unsafe (ref)	1.00		1.00		1.00	
Safe	0.91***	[0.84-0.98]	0.89***	[0.83-0.97]	1.00	[0.93-1.08]
Cooking fuel						
Unsafe (ref)	1.00		1.00		1.00	
Safe	0.95	[0.84-1.06]	1.04	[0.94-1.15]	1.01	[0.91-1.11]
Drinking water						
Unsafe (ref)	1.00		1.00		1.00	
Safe	0.88***	[0.84-0.92]	0.99	[0.94-1.03]	1.01	[0.95-1.07]
Community characteristics						
Type of residence						
Urban (ref)	1.00		1.00		1.00	
Rural	1.06	[0.99-1.13]	1.01	[0.94-1.08]	1.01	[0.94-1.08]
States						
Bihar (ref)	1.00		1.00		1.00	
Madhya Pradesh	1.25***	[1.17-1.33]	1.46***	[1.37-1.56]	1.02	[0.95-1.10]
Oddisa	1.33***	[1.25-1.43]	1.28***	[1.19-1.38]	1.08*	[0.99-1.18]
Rajsthan	0.88***	[0.81-0.95]	1.55***	[1.47-1.68]	1.21***	[1.11-1.32]
Uttar Pradesh	1.47***	[1.39-1.55]	1.58***	[1.48-1.66]	1.28***	[1.20-1.36]

Levels of significance: *p<0.10; **p<0.05; ***p<0.01.HR= Hazard Ratio
City wise residence was excluded from the multivariate analysis after examining high collinearity between type of residence and city wise residence.

IX. DETERMINANTS OF INFANT MORTALITY (POOLED DATA)

Table 4 presents the influence of socioeconomic predictors on infant mortality from pooled data of three round of NFHS survey. Controlling for a set of socio-economic and demographic factors, the hazard of infant mortality was less (CHR=0.77 95% CI=0.75-0.79) (AOR=0.83 95% CI=0.80-0.86) and (CHR=0.87 95% CI=0.85-0.90) (AOR=0.89 95% CI=0.87-0.92) during the period period 2005-06 and 1998-1999 respectively as compared to period 1992-1993. The overall hazard of infant mortality was 29 percent less among births to mothers aged 35 years and above as compared with births to the mother's age at childbirth 15-24 years. Higher birth order child (4+) with more than two years birth interval had 38 percent more chance of dying children before completing his/her first birthday as compared to the first birth order child. Children born to the richest household were less hazard of infant mortality as compared to children born in the poorest household. After controlling the set of socioeconomic and demographic factors, children born to the richest quintile (41.0%), richer wealth quintile (23.0%) and middle wealth quintile (13.0%) less hazard of infant mortality than children born to the poorest wealth quintile household. The adjusted hazard shows that children born to the household having safe sanitation, safe cooking fuel, safe drinking water were less hazard of infant mortality than those born to the household having unsafe sanitation, cooking fuel, and unsafe water. Analysis indicates that the children born in Uttar Pradesh (39.0%), Odisha (30.0%) and Madhya Pradesh (25%) had higher infant mortality as compared to children born in Bihar.

Table 4. Hazard ratio of infant mortality by selected individual, household and community characteristics, in EAG States, India, 1990–2006 (pooled data)

Background characteristics	Infant Mortality			
	CHR	95% CI	AHR	95% CI
Period				
1990–93 (ref)	1.00		1.00	
1996–99	0.87***	[0.85-0.90]	0.89***	[0.87-0.92]
2003–06	0.77***	[0.75-0.79]	0.83***	[0.80-0.86]
Individual characteristics				
Current mother's age				
15-24 (ref)	1.00		1.00	
25-34	0.95	[0.91-0.98]	1.08***	[1.04-1.13]
35-49	1.17	[1.13-1.22]	1.47***	[1.41-1.53]
Mother's age at birth of child				
15-24 (ref)	1.00		1.00	
25-34	0.74***	[0.72-0.76]	0.74***	[0.71-0.76]
35-49	0.82***	[0.77-0.86]	0.71***	[0.66-0.75]
Sex of Child				
Male (ref)	1.00		1.00	
Female	0.98	[0.96-1.00]	0.98	[0.96-1.01]
Birth order and interval				
Birth order 1 (ref)	1.00		1.00	
Birth order-2/3 and interval<=24	1.20***	[1.16-1.23]	1.20***	[1.16-1.24]
Birth order-2/3 and interval>24	0.53***	[0.52-0.55]	0.54***	[0.52-0.56]
Birth order-4+ and interval<=24	1.36***	[1.32-1.40]	1.38***	[1.33-1.43]
Birth order-4+ and interval>24	0.61***	[0.59-0.63]	0.63***	[0.61-0.66]
Mother's education				
Illiterate (ref)	1.00		1.00	
Literate	0.62***	[0.61-0.64]	0.82***	[0.80-0.85]
Father's education				
Illiterate (ref)	1.00		1.00	
Literate	0.75***	[0.74-0.77]	0.93***	[0.90-0.95]
Mother's occupation				
Not working (ref)	1.00		1.00	
Agricultural work	1.21***	[1.18-1.24]	1.04***	[1.01-1.07]
Skilled/Unskilled work	1.20***	[1.15-1.25]	1.10***	[1.05-1.15]
Professional work	0.92***	[0.87-0.98]	1.06	[1.00-1.13]
Father's occupation				
Not working (ref)	1.00		1.00	
Agricultural work	1.21***	[1.12-1.30]	1.04	[0.96-1.12]
Skilled/Unskilled work	1.06***	[0.99-1.15]	1.05	[0.98-1.13]
Professional work	0.82***	[0.76-0.88]	0.99	[0.92-1.07]
Mass media exposure				
No exposure (ref)	1.00		1.00	
Any exposure	0.74	[0.72-0.75]	0.98	[0.96-1.01]
Household characteristics				
Religion				
Hindu (ref)	1.00		1.00	
Non Hindu	0.78***	[0.75-0.80]	0.84***	[0.81-0.87]
Social group				
Scheduled caste (SCs) (ref)	1.00		1.00	
Scheduled tribe (STs)	0.91***	[0.87-0.95]	0.86***	[0.82-0.89]
Others than SC/ST	0.82***	[0.80-0.85]	0.94***	[0.91-0.96]
Wealth quintile				
Poorest (ref)	1.00		1.00	

Poorer	0.91***	[0.89-0.94]	0.92***	[0.90-0.95]
Middle	0.80***	[0.78-0.83]	0.87***	[0.84-0.90]
Richer	0.65***	[0.62-0.67]	0.77***	[0.74-0.81]
Richest	0.43***	[0.41-0.45]	0.59***	[0.55-0.64]
Sanitation facility				
Unsafe (ref)	1.00		1.00	
Safe	0.60***	[0.58-0.62]	0.94***	[0.90-0.98]
Cooking fuel				
Unsafe (ref)	1.00		1.00	
Safe	0.55	[0.53-0.57]	0.99	[0.93-1.05]
Drinking water				
Unsafe (ref)	1.00		1.00	
Safe	0.74***	[0.73-0.76]	0.93***	[0.91-0.96]
Community characteristics				
Type of residence				
Urban (ref)	1.00		1.00	
Rural	1.53***	[1.48-1.57]	1.05***	[1.01-1.09]
States				
Bihar (ref)	1.00		1.00	
Madhya Pradesh	1.22***	[1.18-1.27]	1.25***	[1.20-1.29]
Odisha	1.31***	[1.26-1.36]	1.30***	[1.25-1.36]
Rajasthan	1.03	[0.99-1.07]	1.01	[0.97-1.06]
Uttar Pradesh	1.34***	[1.30-1.39]	1.39***	[1.34-1.43]

Levels of significance: *$p<0.10$; **$p<0.05$; ***$p<0.01$; CHR= Crude Hazard Ratio; AOR= Adjusted Hazard Ratio
City wise residence was excluded from the multivariate analysis after examining high collinearity between the type of residence and city wise residence.

X.   DISCUSSION

The present study has comprehensively demonstrated the trends and determinants of infant mortality among EAG state India during last one and half decade, 1990–2006. Over the last one and a half decades, a modest decrease in infant mortality was evident. Both bivariate and multivariate analysis indicate that children born during 2005-2006 and during 1996-99, the hazard risk of infant mortality was less compared to the period 1992-1993. As true in the case of infant mortality in India [27], and earlier study shown that the infant mortality varies by socio- economic and demographic characteristics, and also reveals that those mothers have comparatively lower education whose children are more likely to die before celebrating their first birthday [28]. Earlier studies reveals that the birth order and birth interval of the child significantly associated with mortality [29] and a study on utilization of maternal health care services suggested that higher mortality risk among first order birth could be linked to the early childbearing trends and lower utilization of maternity health care services in developing countries like India [30]. However, this study indicated that the risk of infant mortality was lower with the higher birth order. Economic status was found to be another significant determinant of infant mortality. Studies indicated that low per capita expenditure on health had comparatively higher chances to die before celebrating their first birthday [28]. A Study highlighted that the risk of the infant dying was 20 percent less among rich than poor wealth quintile [31]. Several others study also reveals that the economic inequality and health care access is a significantly associated with infant mortality [32] and studies also shows that the Poor health indicators and high mortality in Empowered Action Group (EAG) due to poor health system performance and lower utilization of maternal and child health services [33]. The results from both bivariate and multivariate analyses reveal that children born in poorest wealth quintile household had relatively higher chances to children die before celebrating his/her first birthday. Household using safe sanitation and safe drinking water facility had less chance to children die before celebrating their first birthday which already established in another study [31]. The study found that children born in Uttar Pradesh, Orissa, and Madhya Pradesh had a higher risk of the die before celebrating their first birthday. These states require health interventions that target infant mortality reduction, particularly in rural areas.

XI.   CONCLUSION

The focus should be more on states like Uttar Pradesh, Rajasthan and Madhya Pradesh of the north and central regions, which known as EAG states constitute 45% of the total population of India and also have higher mortality rates. Efforts are needed to educate young women in matters of reproductive health and the benefits of delaying pregnancies. The government of India has taken several initiatives to reduce infant and under-five

mortality. Universal Immunization Program (UIP), probably, is one of the key interventions in this area. Among the recent initiatives, Integrated Management of Neonatal and Childhood Illnesses (IMNCI) has been one of the key interventions aiming at reducing malnutrition among children by initiating exclusive breastfeeding till the age of six months.

XII.   ACKNOWLEDGMENTS

XIII.   LIMITATION OF THE STUDY

Although this study examines the several unfold dimensions of infant mortality in EAG states, India but in order to maintain consistency across the three rounds of NFHS surveys, concede a few limitations. First the most important are the retrospective nature of the survey, which may be associated with recall bias, more pronounced for events that took place 20 years before the survey. Second, the population belonging to the so-called ''Other Backward Classes" (OBC) are identified as economically and socially deprived by the Mandal Commission that reported to the Indian government in 1980 [34]. Since the NFHS-1 (1992–93) data contained only three categories of the social/caste group – SC, ST and Other, we were forced to pool OBC and the Other social group in the successive two NFHS rounds (i.e., NFHS-2 (1998–99), and NFHS-3 (2005–06)), which provided separate information for OBC. Third, some others predictors variables of infant mortality type of family, presence of ASHA, visited health provider during pregnancy, women autonomy and anemia in women, which were not collected in NFHS-1 and NFHS-2, could not be used for this study to maintain consistency across the three round of survey.

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