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SMPOSIUM ON CHILD SURVIVAL-III

Burden, Differentials, and Causes of Child Deaths in India

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Abstract
Objective To review the current information on trends, burden, differentials, causes, and timing of under five (U5) child deaths in India.
Methods We reviewed and analyzed data on child deaths in India from official government sources, reports, surveys, and from the published literature. The secondary analyses were carried out to provide additional insight.
Results An estimated 1.84 million under 5 child deaths, including approx 1.44 million infant and 940,000 neonatal deaths occurred in India during 2007. More than 60% of these Under 5 child deaths occurred in 5 states: Uttar Pradesh (27.0%), Bihar (11.3%), Madhya Pradesh (9.9%), Rajasthan (8.0%) and Andhra Pradesh (5.7%). Approximately 41% of all Under 5 child deaths happen in the first week of life and the risk of deaths during neonatal period was at least 68 times higher than the rest of childhood. The children living in rural areas, in the central Indian states, in the lowest 20% of wealth index have the highest risk of death in India. The mortality rates in under 5, infant, neonates and early neonatal period in India declined by 43.5%, 31.2%, 32.1%, and 21.6%, respectively, between 1990 to 2007. However, the rate of reduction has slowed in last 4 years (2003–2007), with negative trend in the early neonatal mortality rate. Neonatal conditions (33%), pneumonia (22%) and diarrhea (14%) are the leading causes of under 5 deaths in India. Sepsis, pneumonia (30.4%), birth asphyxia (19.5%), and pre-maturity (16.8%) are the 3 commonest causes of neonatal deaths (0–27 days).
Conclusions The reduction in under 5 child mortality in India during 1990–2007 has been insufficient to attain Millennium Development Goal 4 (MDG4). However, there have been variable declines in early neonatal, neonatal, infant and child mortality. Despite the well known importance of neonatal survival to attain MDG4, our data suggest the early neonatal mortality rate in India may be increasing in the recent years, which is a cause for serious concern. Achievement of MDG4 in India will require further acceleration in the reduction of the under 5 mortality rate, particularly, in the 5 highest burden states: Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan and Andhra Pradesh.

Keywords Child survival · Epidemiology · India · Millennium development goal · Neonatal survival

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Introduction

Children born in some countries are more likely to die than others. In 2008, the under 5 mortality rate (U5MR) varied from less than 5 in countries like Sweden, Japan, and Greece to more than 200 per 1,000 live births in Afghanistan, Somalia, and Chad [1]. In the same year, only 60 of 194 countries had an estimated U5MR of more than 50 per 1,000 live births, with India estimated to have an U5MR of 69/1,000 live births, placing the country at 49th position [1]. India's high rate of child mortality exists

in spite of long standing commitment to child survival through a series of national health programs [2]. The country is a signatory to the Millennium Development Goals (MDGs), and has thereby committed to reduce the U5MR to less than 41 per 1,000 live births by 2015 in order to obtain MDG4 [3].

It is well recognised that credible country and state level information on childhood mortality, causes, and timing of these deaths is vital for policy makers to make effective public health decisions to prioritize intervention packages and plan programs. Analysis of this data should also occur and be presented on a regular basis to address the changing epidemiology of child deaths. Estimates of the U5MR and infant mortality rate (IMR) for India have been made available since as early as in 1950s [4]; however, the estimates from survey data are only available from 1970s onwards [5]. In this paper, we review and analyze available data on trends, burden, differentials, causes, and timings of under 5 child deaths in India for the year 2007. This review is intended to support policy makers and program managers in making informed policy decisions to improve child survival in India.

Material and Methods

The first annual and nationwide reporting system of child mortality rates in India, the Sample Registration System (SRS), was established in early 1970s [5]. The initial focus of SRS was registration of births and deaths in the country and the estimates of child mortality indicators like early neonatal mortality rates (ENMR), neonatal mortality rates (NMR), IMR, and child mortality rate (1–4 yrs of age) were projected for the bigger states, and India as a whole [5]. Subsequently, the first National Family Health Survey (NFHS-I) was conducted in 1992–93 [6], which provided additional data on child mortality, as well as coverage indicators for child survival interventions in India [7]. The SRS and NFHS reports remain the two major sources of information on child survival status in the country with the addition of a few supplementary SRS reports during the last decade [8, 9].

The latest data on ENMR, NMR and child mortality rate in India is available from the SRS reports for the year 2007 [5, 8, 9]. In this review, we primarily utilize the recent SRS data with complementary information from previous SRS and NFHS reports in order to estimate the U5MR for India in 2007 [6, 7, 10]. Our assumptions for estimating U5MR were as follows: considering the 1–4 year mortality is estimated after the adjustment of denominator for the infant deaths, we derived adjusted child mortality rate from the following formula [= child mortality rate *(1000− IMR in that year)/1000]. This adjusted rate was then added to the IMR to estimate the U5MR [estimated U5MR = adjusted child mortality rate + IMR]. A similar method has also been used in the past by other authors [11].

We also calculated the Annual Rate of Reduction (ARR) for each of the age specific mortality, for the period of 2000–2007. In order to calculate the ARR, the percentage rate of reduction in age specific mortality rates was calculated annually, followed by totaling the percentage reduction, and dividing the total by the number of years, for which the percentage was calculated. This provided the ARR in percentage for each of the mortality rate. In order to estimate the total percentage reduction in child mortality needed during 2008–2015 to achieve MDG4, we utilized the following equation:

$$= (\text{Year 2015 targeted U5MR} - \text{Estimated U5MR in 2007})/(\text{Estimated U5MR in 2007})$$

The percentage reduction was then divided by 8 in order to estimate the percentage reduction needed per year to attain MDG4.

In order to estimate the number of child deaths in India at the state and national level, we utilized state level mortality rates and crude birth rates (CBR) from the SRS [5], in addition to the population projections from Registrar General of India (RGI) [12]. The SRS estimates for ENMR, NMR, and IMR are available for only 20 states, since the sample size was too small to calculate estimates in the least populated Indian states. As a result, we were only able to calculate burden estimates for the 20 states with mortality data, however, the sample from those states was also considered to prepare national estimates. To estimate the number of deaths in different age groups, the birth cohort of the each state was calculated (Birth cohort = Projected population of the state in 2007*CBR in 2007) [5, 12] and then multiplied with the state level ENMR, NMR and IMR data from SRS report. For the reason described above, we were only able to calculate burden estimates for the 20 states with mortality data; a national estimate of the number of child deaths in India was obtained by the same method with our 2007 estimate of the U5MR.

For the differentials on child health we used information from NFHS-III [13]. The SRS data was used to understand the state differentials in the trends in IMR reduction between 1990 to 2007.

A systematic review on the causes of child deaths in India [14] noted that published studies on child deaths in India have been conducted in socio-geographically different populations with dissimilar study designs, and have used non-standardized case definitions, making results not comparable. The authors also noted that an SRS report on the causes of child deaths in India, based upon a sample

population from the entire country and had analyzed the causes of child deaths from 21,658 under 5 deaths (15,450 infant and 6,208 deaths in 1–4 year) in the country was the latest, most representative and comprehensive study of the causes of child deaths in India, which is also our position [9]. The causes of neonatal deaths were not presented in this study, therefore, we identified 3 studies (2 published and 1 unpublished), which had used comparable methodology (verbal autopsy), case definitions, and were conducted after the year 2000 to produce an analysis [15, 16, Arora NK. The INCLEN Trust, New Delhi, India (unpublished data: Personal Communication, 2010)]. We analyzed pooled data from these 3 studies to present the causes and timings of neonatal deaths in India.

The relative risk of death per week in neonatal period compared to the post-neonatal period (1 month- 5 yrs) was determined by calculating the relative risk of death during the entire neonatal period to entire postnatal period (=NMR/ (U5MR-NMR) and then multiplying by the ratio of number of weeks in post neonatal to neonatal period (257/4).

Results

We estimate that 26.2 million births and 1.84 million under five (U5) child deaths occurred in India during 2007 (Table 1). About 78% (1.44 million) of these deaths occurred during the first year of life (infants), including 943,000 deaths in the neonatal period (0–27 days). As a result, neonatal deaths account for 65% of infant and 52% of all U5 child deaths. Further, 760,000 or 81% of neonatal deaths are estimated to have occurred within the first week of life. In summary, this review suggests almost 4/5th of child deaths occur during infancy. Likewise, 2/3rd of infant or half of all child deaths occur during the neonatal period. Around 80% of neonatal deaths took place during the first week of life (early neonatal period), which amounts to approximately 41% of all U5 child deaths in the country. Approximately 80% of all child deaths occurred in 10 Indian states with more than 60% of deaths in Uttar Pradesh (27.0%), Bihar (11.3%), Madhya Pradesh (9.9%), Rajasthan (8.0%) and Andhra Pradesh (5.7%) (Fig. 1).

The reported U5MR and IMR in India for 1970 were 235 and 129 per 1,000 live births, respectively [5, 11], which was reduced to 124 and 80 per 1,000 live births, respectively, in 1990 [5, 6]. For India, to achieve MDG4, a 2/3 reduction in child deaths, the U5MR needs to be to less than 41 per 1,000 live births by 2015. We estimate the U5MR for India in the year 2007 to be 70 per 1,000 live births based on the reported IMR, NMR, and ENMR of 55, 36 and 29 per 1,000 live births, respectively [5]. Table 1 presents mortality rates in 2007 by state and visibly illustrates considerable variability in both the U5MR and IMR; with Kerala having the lowest U5MR (16/1,000 live births) and IMR (13/1,000 live births) and Madhya Pradesh the greatest U5MR (94/1,000 live births) and IMR (72/1,000 live births).

The time trends in mortality rates in India by age for 1990–2007 are presented in Fig. 2. These data indicates that the U5MR, has declined by 43.5% (from 124 to 70 per 1,000 live births); with the infant, neonatal, and early neonatal deaths declining 31.2% (from 80 to 55 per 1,000 live births), 32.1% (from 53 to 36 per 1,000 live births), and 21.6% (from 37 to 29 per 1,000 live births), respectively.

An analysis of the annual rate of reduction (ARR) of mortality suggests that the rate of mortality decline is different for 2000–2003 compared to 2004–2007 (Fig. 3). During the first 4 years of the MDG campaign (2000–2003) there was a rapid ARR in U5MR, IMR, NMR and ENMR; with the ENMR seeing the greatest ARR (7.7%). Figure 3 suggests that the ARR slowed for all age groups during the next 4 years (2004–2007) and there is a suggestion that the ENMR may have actually increased during this time period. In order for India to achieve MDG4, based on these estimates, and an ARR of 8.7% is needed in U5MR for the rest of the period (2008–2015).

To further investigate the trends in infant survival in India, a comparison of the change (or reduction) in IMR for 10 large states of India between 1990 to 2007 is given in the Fig. 4 [5, 10]. This figure shows that a substantial reduction of about 40% in IMR has occurred in Orissa, Maharashtra and West Bengal, while the progress has been relatively slow in Andhra Pradesh, Bihar and Rajasthan states (ranging from 22% to 30%), during the same period.

Figure 5 shows that children in rural areas have almost 30–40% higher risk of death than their urban counterparts in all three subgroups of neonatal, post neonatal (1–11 months) and in childhood (0–4 yrs of age). Interestingly, a female neonate has lower risk of death than male in India. However, the U5MR is greater in girls compared to boys. Children in the lowest 20% of Wealth Index (WI) have almost 2–3 times higher risk of death than those in the highest 20% of WI [13]. Figure 6 provides the spectrum of IMR for selected states of India for the year 2008 [10] showing vast differences.

The most recent data on causes of child deaths in India are from the latest SRS report [9]. Amongst all under 5 deaths, after perinatal conditions (33.1%); respiratory infections (22.0%), diarrheal disease (14%) are the most common causes of deaths (Fig. 7). It is notable that unintentional injuries (3.2%) contribute more deaths than that by nutritional deficiencies (2.8%), congenital anomalies (2.7%) or malaria (2.7%). It is noticeable that proportion

Table 1 Estimated under 5, infant, neonatal and early neonatal deaths in India in 2007

S. No.	Name of the state	Mid year population in 2007 in 1,000 [12]	Crude birth rate [5, 8]	Birth cohort	U5MR[b]	Estimated under 5 deaths in 2007	IMR in 2007 [8]	Total infant deaths	Neonatal mortality rate in 2007 [8]	Total neonatal deaths	Early neonatal mortality rate in 2007 [8]	Early neonatal deaths
1	Andhra Pradesh	81,836	18.7	1,530,333	68	104,353	54	82,638	33	50,501	26	39,789
2	Assam	29,183	24.3	709,147	83	58,726	66	46,804	34	24,111	28	19,856
3	Bihar	92,699	29.4	2,725,351	76	206,849	58	158,070	31	84,486	27	73,584
4	Chhattisgarh	23,048	26.5	610,772	75	45,806	59	36,036	41	25,042	36	21,988
5	Delhi	16,641	18.1	301,202	44	13,166	36	10,843	20	6,024	16	4,819
6	Gujarat	56,088	23.0	1,290,024	66	85,425	52	67,081	37	47,731	29	37,411
7	Haryana	23,888	23.4	558,979	69	38,667	55	30,744	34	19,005	23	12,857
8	Himachal Pradesh	6,550	17.4	113,970	57	6,443	47	5,357	31	3,533	19	2,165
9	Jammu & Kashmir	11,152	19.0	211,888	62	13,219	51	10,806	39	8,264	31	6,569
10	Jharkhand	29,895	26.1	780,260	61	47,852	48	37,452	28	21,847	24	18,726
11	Karnataka	57,128	19.9	1,136,847	58	66,433	47	53,432	26	29,558	20	22,737
12	Kerala	33,626	14.7	494,302	16	7,890	13	6,426	7	3,460	6	2,966
13	Madhya Pradesh	67,967	28.5	1,937,060	94	182,610	72	139,468	49	94,916	38	73,608
14	Maharashtra	106,919	18.1	1,935,234	42	80,753	34	65,798	25	48,381	21	40,640
15	Orissa	39,407	21.5	847,251	90	75,897	71	60,155	49	41,515	37	31,348
16	Punjab	26,503	17.6	466,453	54	24,968	43	20,057	29	13,527	20	9,329
17	Rajasthan	63,789	27.9	1,779,713	83	147,298	65	115,681	44	78,307	34	60,510
18	Tamil Nadu	65,795	15.8	1,039,561	43	44,410	35	36,385	23	23,910	17	17,673
19	Uttar Pradesh	187,928	29.5	5,543,876	89	496,077	69	382,527	48	266,106	36	199,580
20	West Bengal	86,430	17.9	1,547,097	46	70,651	37	57,243	28	43,319	23	35,583
21	India[a]	1,134,023	23.1	26,195,931	70	1,836,859	55	1,440,776	36	943,054	29	759,682

References: Mid year population from Reference [12]; IMR, NMR and ENMR from reference [8]

The detailed methods for estimation has been described in the methods section of the manuscript. The annual birth cohort was estimated by multiplying estimated population with crude birth rate provided by SRS data [8]

All the estimates on the deaths in those age groups were done by multiplying the mortality rate with the birth cohort in that year

[a] The SRS estimates on the IMR, NMR and ENMR are available 20 states of India only. The sample size is not enough from the small states and Union territories to provide state specific mortality rates. However, the national estimates of India includes the data from all the states and UTs in India

[b] The U5MR was estimated by the authors by the following method: The available IMR and 1–4 year mortality rate SRS data [8]. Considering the 1–4 year mortality is estimated after the adjustment of denominator for the infant deaths, we adjusted the 1–4 year mortality rate by multiplying this rate by a formula of = child mortality rate *(1000−IMR in that year)/1000. The rate so adjusted was added to the IMR to get estimated U5MR in India. The similar method has also been used in the past by other authors [11]

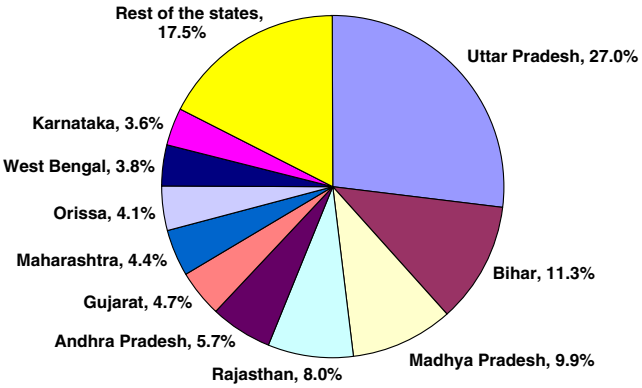

Fig. 1 Proportion of under 5 child deaths in different states of India. NB: derived from Table 1 and also from reference [5, 8, 11]

contribution to all deaths by congenital anomalies is much higher in infancy (3.1%) than in 1–4 year (1.5%) age group. The data from this SRS report also suggests the region wise (Inter-state) and residence wise (urban versus rural) variations in the child deaths in India. The respiratory infections, diarrhea, malaria, and unintentional injuries contribute to a greater proportion of U5 deaths in rural areas, while perinatal causes and congenital anomalies contribute a larger proportion in urban areas.

Further analyses suggest that perinatal conditions (46.3%), followed by respiratory infections (21.8%) and diarrheal diseases (9.7%) are three most common causes of deaths in infants (0–11 months). In contrast, diarrheal diseases (23.8%) followed by respiratory infections (22.5%) and other infections and parasitic diseases (15.9%) were the leading causes of death for children 1–4 yrs of age. Other noteworthy causes of death for children 1–4 yrs were unintentional injuries (7.5%) and malaria (6.6%) [9] (Fig. 8).

The cause of death for the neonatal period were not available from the SRS report, therefore, we pooled data from 3 studies/surveys to present [15, 16, Arora NK. The INCLEN Trust, New Delhi, India (unpublished data: Personal Communication, 2010)] the estimates. We estimate that the major causes of neonatal deaths in India are sepsis and pneumonia: 30.4%; CI (23.7–37.0), birth asphyxia: 19.5%; CI (12.6–26.3) and pre-maturity: 16.8%; CI (3.3–30.3) (Fig. 9) [15, 16, Arora NK. The INCLEN Trust, New Delhi, India (unpublished data: Personal Communication, 2010)]. The pooled analysis (Table 2) further suggests that cumulatively 35.4%, 51.0%, and 71.5% of all neonatal deaths occur by day 1, day 3 and day 7 of life, respectively [15, 16, Arora NK. The INCLEN Trust, New Delhi, India (unpublished data: Personal Communication, 2010)].

The large concentration of deaths within first week of birth prompted us to explore the day wise causes of early neonatal deaths in India. We could identify only one published study, conducted in rural north India, which had reported cause of death by day in first week of life [15]. This study reports that on day 1 birth asphyxia (31.0%), pre-term birth (26.4%) and congenital anomalies (9.6%) are the most common causes of deaths. On days 2 and 3 (day 1 excluded), preterm birth becomes the leading cause (29.0%), followed by sepsis/pneumonia (22.7%) and birth asphyxia/injury (11.8%). The causes of death distribution on day 4–7 are nearly identical to those on day 2 and 3. In this study, the causes of deaths in the first week of life were: Pre-term births (33.0%), birth asphyxia/injuries (18.8%), sepsis and pneumonia (17.4%) and congenital anomalies (6.9%). However, this study had 25.7% of all cases without known causes of deaths.

The neonatal period appears to be a period of highest risk of child deaths in India. We estimated, as per the

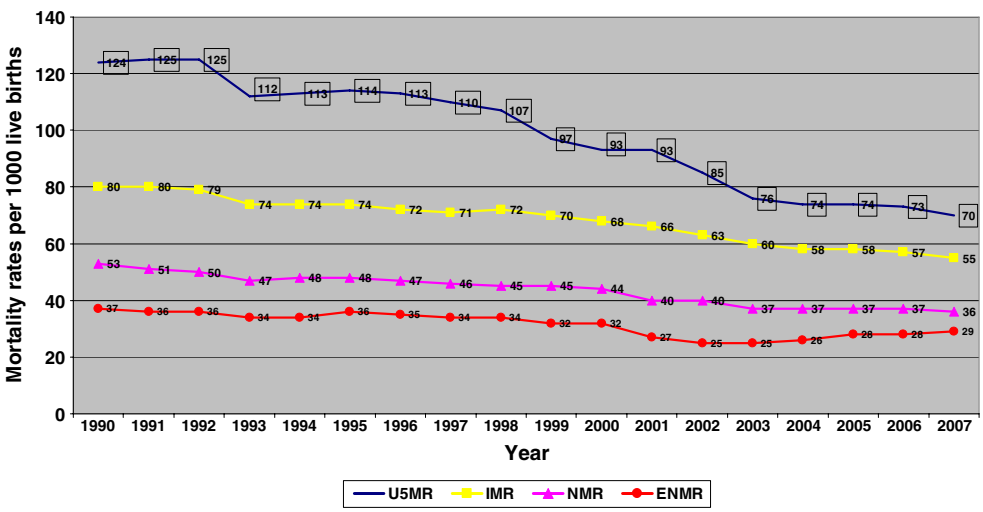

Fig. 2 Trends in mortality rates in India (1990–2007). Sources: IMR, NMR and ENMR: SRS Data [5, 8]. U5MR = estimated by the authors as described in methods section and also from reference [11]

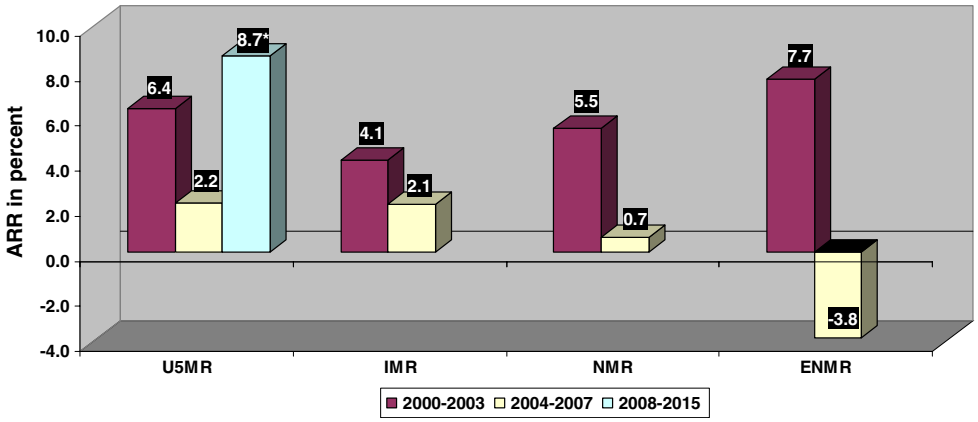

Fig. 3 The Annual Rate of Reduction (ARR) in mortality rates in two periods (of 4 year each) between 2000 to 2007. NB: *The ARR for the period of 2008–2015 has been estimated for U5MR and IMR only. Ref: Source of IMR, NMR and ENMR are reference [5, 8] and while for the U5MR are author estimates and the reference [11]

method described earlier, that the children in the country have 68 times higher risk of dying in neonatal period, than that in the rest of the childhood (1–59 months). This risk is 183 times higher in early neonatal period, than in the rest of the childhood.

Discussion

The findings presented in this review provide new insight into the burden of child deaths in India during 2007. We presented nationwide along with state wise trends in mortality rates by age, along with pooled analyses of the causes and timing of the child and neonatal deaths. The strength of our analysis of burden, causes and changes in mortality rates over time is that a majority of the data is from Registrar General of India (RGI) and SRS, which are the largest and arguably the most methodologically rigorous surveys regularly conduced in India [5, 12]. Utilizing data from a study over a period of time helps increase validity of comparisons overtime along with extrapolations of the future. We also present the causes of child deaths from the recent RGI study, which consisted of verbal autopsies of more than 21,000 deaths from a nationally representative sample [9].

We estimate that the number of child deaths in India has been reduced from 2.4 million in 2000 [17] to 1.84 million in 2007. Therefore, there has been substantial increase in child survival since the institution of the MDGs. However, India is still home to the largest number of child deaths for any single country [1], with around 5,000 under 5 children, including around 2,600 neonates dieing every day.

The greatest number of deaths occurs in the large and populated northern Indian states of Uttar Pradesh, Madhya Pradesh, Bihar, and Rajasthan [18]. In Madhya Pradesh, the total number of annual U5 deaths is more than twice of annual under 5 deaths in Maharashtra, which also has same annual birth cohort (Table 1). Andhra Pradesh (AP) state contributes the fifth largest burden of under 5 deaths in India, has been considered as good health performing state from the planning purpose by the Government of India. Andhra Pradesh has the lowest child survival indicators (U5MR and IMR) amongst 4 southern Indian states (Kerala, Karnataka and Tamil Nadu), which illustrates

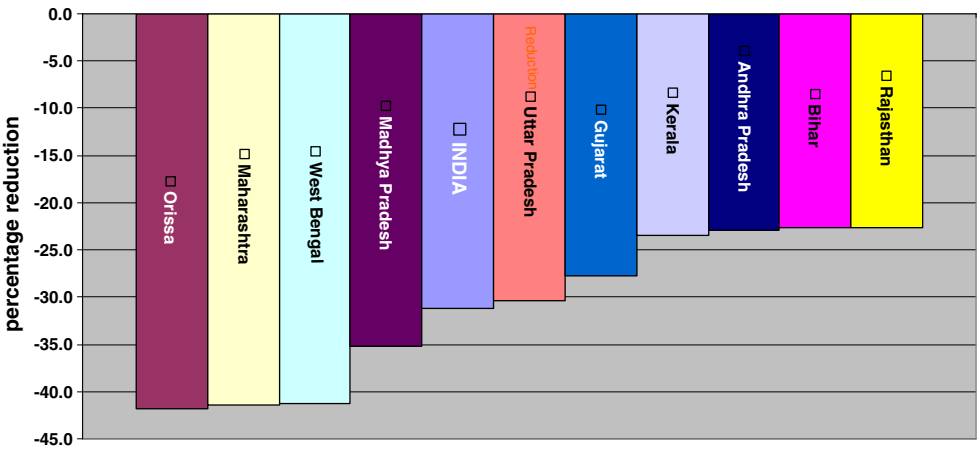

Fig. 4 Percentage reduction in Infant mortality rate from 1990 to 2007 in selected states and India. NB: The reduction was calculated by the following formula: (IMR in 1990- IMR in 2007)/ IMR in 1990*100. Reference: [5, 8]

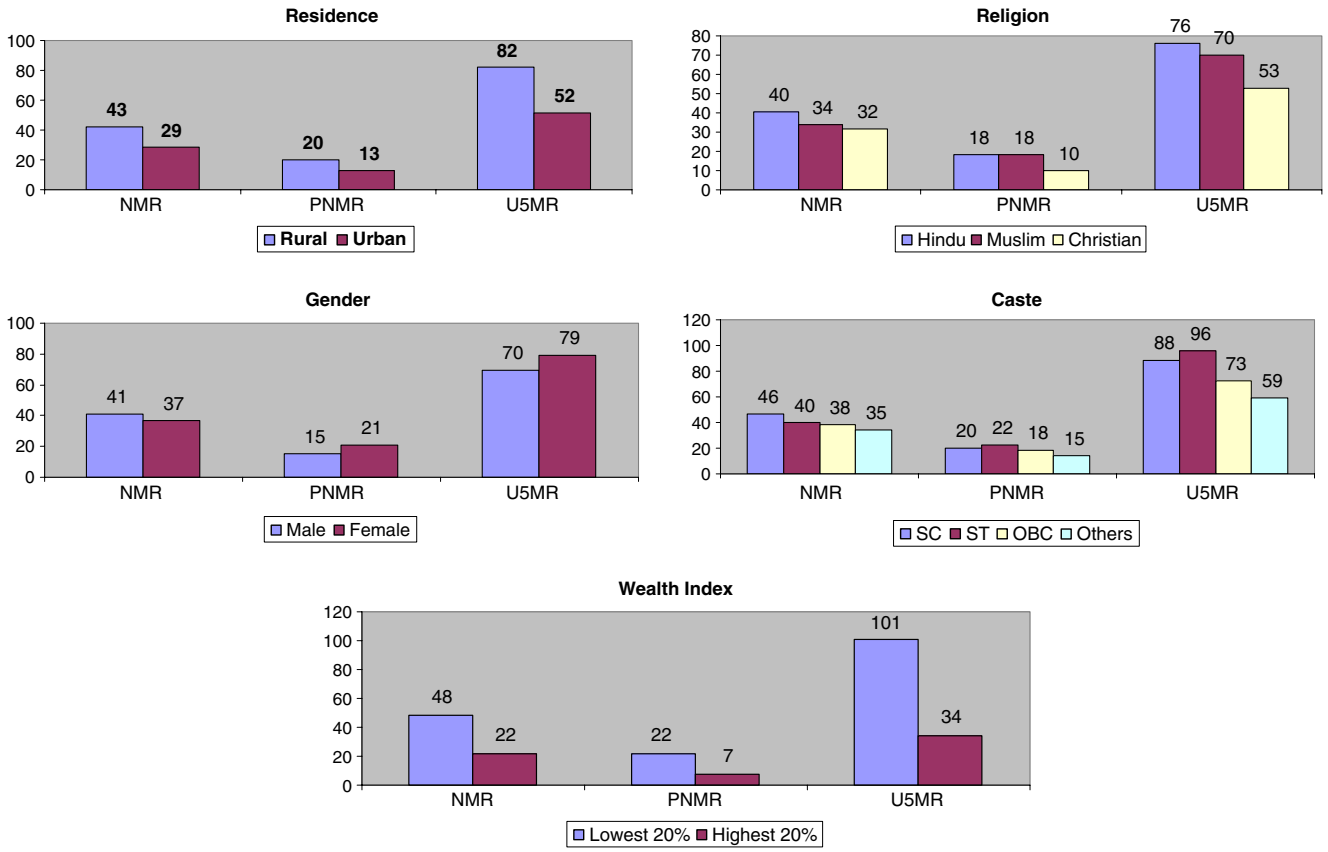

Fig. 5 The determinants of child mortalities in India [13]

the need to present regular updates of state specific to policymakers and program leaders in order to implementing appropriate, high-impact interventions to improve child survival.

The rate of reduction in child mortality in India has been relatively slow in last 17 years, but has increased since institution of the MDGs in 2000. However, the current rate of reduction is not enough to achieve MDG4 for India. In a

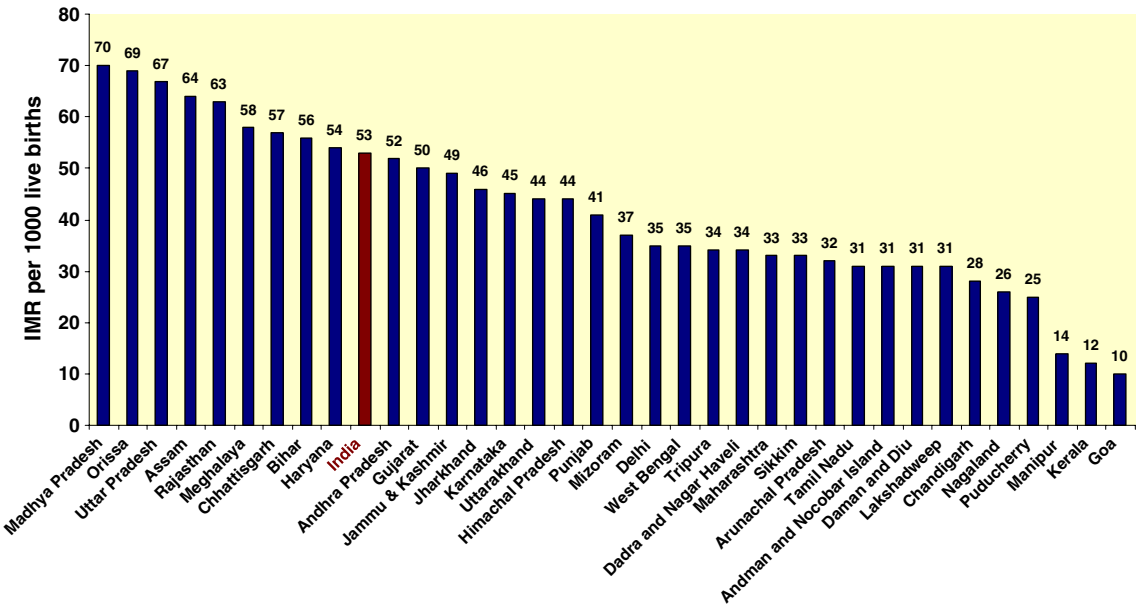

Fig. 6 Infant Mortality Rate in different states and in India in 2008. Ref: [10]

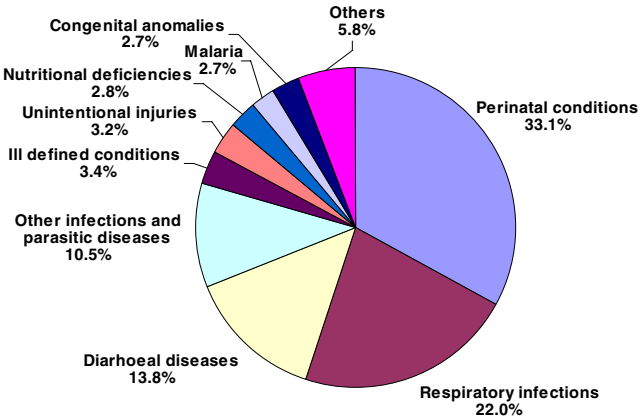

Fig. 7 Top 10 causes of child deaths in India. Ref: [9]

recently published estimates by Rajaratnam et al. [19], India's estimated U5MR is 62.6 per 1,000 live births (for the year 2010), which is much higher compared to 36.6, 19.9, 15.4, 10.1 per 1,000 live births in Indonesia, Brazil, China and Sri Lanka, respectively. We want to highlight that the largest birth cohort is not the only reason for large number of child deaths in India, but the U5MR is also high in comparison of other developing countries with large population sizes. It may be noted that estimates in our review are similar to the recently published above refereed child mortality estimates, which used different methods [19]. Further while we have single source data for majority of the estimates, Rajaratnam et al. have based their estimates by modeling [19].

Our detailed analysis of the trends in child mortality, for the post MDG declaration years, suggest that during the first 4 years (2000–2003) India achieved comparatively higher annual rate of reduction in all 4 subgroups in comparison than the later 4 years (2004–2007). This suggests that sustained rapid reduction in child mortality may not be feasible in India. Further, despite an early alarm and the recognition of neonatal survival as a key to child survival [20], poor progress in neonatal survival and deterioration in the ENMR in India, are of severe concern.

In the past 2 decades, there appears a shift in proportional contribution of different mortality subgroups, probably due the variable reduction in the age specific mortalities. In early 1990s, the 'rule of 2/3rd' was applicable where IMR contributed 2/3rd of U5MR; NMR, 2/3rd of IMR; and ENMR contributed 2/3rd of NMR. Seventeen years later, in the year 2007, the contribution of IMR to U5MR has increased to 3/4th, the NMR still contributes to 2/3rd of IMR but, the proportion of ENMR to NMR has increased to almost 4/5th. Neonatal mortality reduction is a key to child survival.

The states with a high burden have both, larger birth cohort and higher mortality rates. However, the trends shared in Fig. 4 shows that the rate of reduction in IMR in 4 of these 5 states has also been less than the national average. Therefore, the states with high birth cohort, and high mortality rates are also affected by the 'third burden' of slow rate of mortality reduction.

The gross inequities in child survival rates have been reported by many surveys [6, 7, 13]. Children residing in rural areas, girls in post-neonatal period, children of scheduled castes, and children in the lowest 20% of wealth index experience disproportionately high risk of mortality. Even within the urban areas, the slums and peri-urban localities have better child survival indicators than children in the rural areas [13, 21]. The urban Christians in India have the best survival rates of all subgroups. While efforts have been made to address these in-equities but success has been partial [22], often the insufficient care at different stages of pregnancy, during the delivery, and in the early weeks of life is attributed to the high child mortality in India [23].

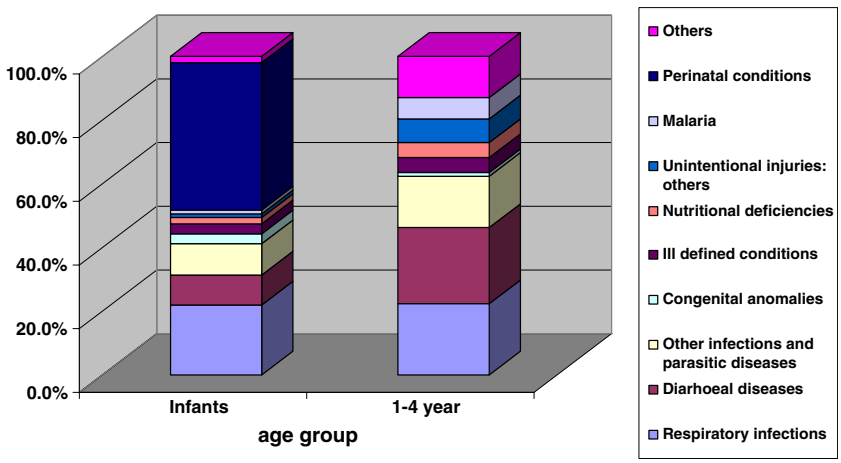

Fig. 8 Proportional contribution of causes of deaths in infants and 1–4 years of age of children in India. Ref: [9]

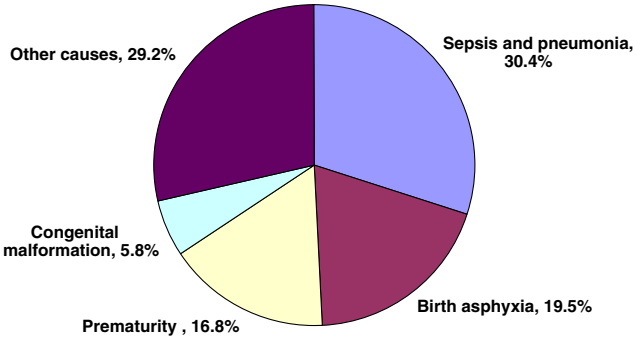

Fig. 9 Causes of neonatal deaths in India. NB: Pooled estimated done by the authors, and based upon reference no. [15, 16, Arora NK. The INCLEN Trust, New Delhi, India (unpublished data: Personal Communication, 2010)]

The averages have inherent risk of masking the age specific differences. The sub group analysis notes that the causes of deaths in different age groups are not the same. The country is going through a transition and the epidemiology of child deaths is changing (IMR, now contributes almost 3/4th of U5MR, and the ENMR contributes around 41% of child deaths). Interventions need to be targeted upon the age specific causes of deaths in India. We want to underline that the unintentional injuries are emerging as a major contributor of child deaths in India (3.2%) and this burden is relatively higher in 1–4 yrs of age group at 7.5% [9]. The experts have opined that the health survey findings should be utilized for timely and regular midcourse corrections in the health programs [24]. We suggest that the newly available data on child deaths be utilized by the states for the programmatic interventions, and focus should be upon the specific causes of deaths prevalent in those settings.

The pooled estimates on the causes and timings of neonatal mortality presented in this paper suggest that the causes of neonatal deaths in India, may be slightly different from the causes reported worldwide i.e. the prematurity, in our pooled analysis, contributed approximately 16.8% of neonatal deaths, however, it was almost 28–29% for the global estimates [25, 26]. These differences may partly be attributed to the methodological differences, where the studies from India, have a large proportion deaths classified as 'other causes'. Similarly, the neonatal deaths contribute to approximately half of the child deaths in India, while this proportion is 2/5th for the rest of the world [26].

The estimates in this paper have limitation that these are based upon data from 20 large states of India and the smaller states are not included in the analysis. Secondly, the mortality estimates in this paper can not be utilized for the extrapolation of cause specific mortality in India as these two are from different time period.

Conclusions

More children in India die annually than in any other country in the world, and thus far the rate of reduction in the U5MR has not been sufficient to attain Millennium Development Goal 4 by 2015. Furthermore, the epidemiology of child deaths in India is undergoing a transition and our review suggests that more resources be allocated to neonatal interventions in order to continue to reduce the U5MR. The 5 states, which contribute to 60% of all child deaths in India, also carry the 'triple burden' of a large birth cohort, high mortality rates, and slow annual rate of reduction in child mortality. Additionally, a nationwide increase in the early neonatal mortality rate is cause for major concern. The achievement of MDG4 in India will depend upon decisive action to further acceleration in the rate of reduction in child deaths in India, focusing upon the 5 high burden states: Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan and Andhra Pradesh.

Table 2 Timing of neonatal deaths in India

Study no.	Ref. no.	Sample size	Cumulative proportion of deaths to all neonatal deaths					
			Day 1		Day 3		Day 7	
			N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
1	Baqui et al. [15]	618	198	32.0 (28.4–35.9)	309	50.0 (46.0–54.0)	437	70.7 (67.0–74.3)
2	ICMR [16]	1,521	595	39.1 (36.7–41.6)	864	56.8 (54.3–59.3)	1,112	73.1 (70.8–75.3)
3	Arora NK. The INCLEN Trust, New Delhi, India (unpublished data: Personal Communication, 2010)	642	221	34.5 (30.7–38.2)	295	45.9 (42.0–49.9)	447	69.7 (65.9–73.2)
Pooled		2,781	1,014	35.4 (30.9–39.8)	1,468	51.0 (44.3–57.8)	1,996	71.5 (69.4–73.7)

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Conflict of Interest None.

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