Maternal Mortality in India: A Review of Trends and Patterns

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ABSTRACT

High maternal mortality in India, particularly across empowered action group (EAG) states, is a critical policy concern. This paper discusses the trends and patterns in reduction in maternal mortality in India, and focuses on highlighting inter- and intra-state disparities. We find that the trends in the maternal mortality ratio (MMR) for the past two decades (particularly, the rate of decline) do not commensurate well with the observed improvements in the socioeconomic indicators of the country. Huge inter-state and intra-state disparities in the MMR constitute a major policy concern. For instance, the MMR reported for the EAG/Assam group was 438 in 2001–03 and 257 in 2010–12, almost five times higher than that of Kerala (MMR 66), which has the least MMR of all states. Further, we draw attention towards the confidence interval around the MMR estimates, and argue that the declines are statistically significant only for large samples obtained after combining the regional sub-samples; for most states, we cannot infer any significant decline. We also examine the relationship between the MMR and economic growth. Our results suggest significant growth elasticity: a 1-per-cent increase in per capita net state domestic product (PCNSDP) is associated with a 0.5-per-cent decline in MMR. This estimate is adjusted for the total fertility rate (TFR) across states, which also finds a positive and significant relationship with MMR. In concluding, we emphasise that integrating developmental and health sector policies would reduce MMR faster.

Keywords: MMR, maternal mortality, maternal health, NRHM, inequity, India

1 INTRODUCTION

The maternal mortality ratio (MMR) is defined as the number of maternal deaths[1] during a given period per 100,000 live births during the same period. For 2010–12, India's MMR was estimated at 178 maternal deaths per 100,000 live births (RGI 2013). In 2010, 19 per cent of the 287,000 maternal deaths estimated worldwide took place in India (WHO 2012). Such a high incidence of maternal mortality causes huge losses of human life and social welfare. Therefore, reducing MMR faster is a fundamental national and international concern[2] (GoI 2011; UN 2000; Souza et al. 2013; WHO 2012; World Bank 2012). In addition, there are critical equity concerns, as studies have noted significant inter- and intra-state disparities, with a disproportionately higher burden of maternal deaths among marginalised communities and tribal populations (Montgomery et al. 2014; Gupta et al. 2010; Subha Sri and Khanna 2014); Kolandaswamy et al. 2010; Banerjee et al. 2013.

The level of MMR could be reduced in a relatively short time by scaling up proven clinical interventions and improving access to primary and referral delivery care (Jahn and De Brouwere 2001). In India, several important initiatives have been rolled out under the Reproductive and Child Health (RCH) programme and National Rural Health Mission (NRHM). Despite such unprecedented attention, however, the reduction in MMR has been decelerating[3] in recent times; and most maternal deaths in India continue to be associated with determinants such as nutrition, poverty, and socioeconomic marginalisation, over which policies have had little or no impact. The current challenge is to identify and outline the role of governments, health and other sectors, communities, and households in population-wide strategies to improve access, delivery, and utilisation of health care services (World Bank 2012; Jeffery and Jeffery 2010). Besides, concerted engagement is necessary to develop comprehensive methods for interpreting, and responding to, the problem of high MMR in India. This, largely, is the spirit that motivates this study in undertaking a systematic assessment of trends and patterns in maternal mortality in India.

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[1] Maternal death is defined as 'the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes' (WHO 2012).

[2] For instance, the International Conference on Population and Development (ICPD 1994) recommended that maternal mortality should be reduced by at least 50 per cent of the 1990 level by 2000, and by another 50 per cent by 2015. The UN Millennium Development Goals (MDG) called for reducing MMR by 75 per cent between 1990 and 2015. For India, this implies that it should have achieved the target of reducing maternal deaths to 200 per 100,000 live births by 2007, and 109 by 2015 (RGI 2006). The NRHM also considers reducing maternal mortality an important goal.

[3] Even the country report on MDGs predicts that India might be able to reduce its MMR to only 139 by 2015; its target is 109 (GoI 2011).

2 TRENDS AND PATTERNS IN MMR

2.1 National and State-level Trends

Despite data and methodological limitations, the Bhore Committee concludes that India's MMR during the 1940s was around 2,000 maternal deaths per 100,000 live births (GoI 1946). Later, the Mudaliar Committee suggested that India's MMR during the 1950s was over 1,000 deaths per 100,000 live births (GoI 1961). The MMR[4] was estimated to be over 800 during 1970s, over 500 during the 1980s, and over 400 during the 1990s (Vora et al. 2009; Bhat et al. 1995; Bhat 2002). While some of these estimates had no sound statistical validity, others lacked reliability in terms of levels, trends, and differences in maternal deaths (RGI 2006). Given such concerns, since 1997, direct estimates[5] of MMR at the national and state level are obtained from the sample registration system (SRS). The SRS is a continual demographic survey[6] conducted by the Office of the Registrar General, India. However, because maternal mortality is a rare statistical event, the SRS methodology uses pooled data for three years to arrive at stable and consistent estimates.[7]

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[4] In later years, hospital- and community-based studies arrived at different estimates of the magnitude of the problem. In the early 1970s, a few studies estimated that the MMR level had declined to 400–500 deaths per 100,000 live births (Sengupta and Kapoor 1972). A few other studies noted MMR in the 800–1000 range (Jejeebhoy and Rao 1992; WHO 1990; Bhatia 1988, 1993). Reviews based on hospital data suggest a MMR of 495 for the nation as a whole (GoI 1994; Kanitkar et al. 1994). The first two national family health surveys (NFHS) suggested a MMR of 424 (1992–1993) and 540 (1998–1999) (GoI 2006). However, none of these estimates has sound statistical validity. Using a parametric approach, Bhat et al. (1995) and Bhat (2002) estimate India's MMR at 580 during 1982–1986, 519 during 1987–91, and 440 during 1992–1996. Broadly, these estimates agree with the estimates based on the SRS, which have been available since 1997.

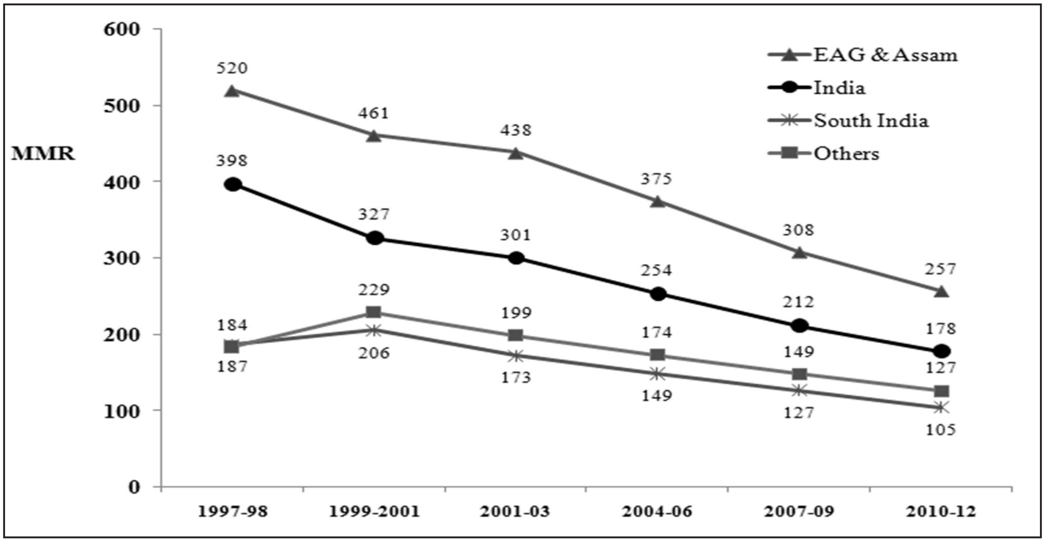
[5] It is only after the launch of the Safe Motherhood Initiative that MMR estimation methodology received considerable attention from researchers and policymakers. Some researchers have argued for the adoption of indirect methods to estimate the levels of maternal mortality. Notable among these indirect techniques is the sisterhood method, wherein women and men are asked to recall the number of their sisters who died during pregnancy, delivery, and the puerperium among those who were ever married at the time of the survey (Graham et al. 1989). However, the sisterhood method can provide consistent estimates only in situations of relatively stationary fertility and mortality levels. Also, it requires the collection of data of a specialised nature (Bhat et al. 1995). Other indirect techniques that are based on Census data depend significantly on assumptions regarding mortality patterns and, particularly, regarding causes of death (Blum and Fargues 1990).

[6] Based on randomly selected sample units (village/segment of a village in rural areas and Census enumeration block in urban areas) spread across the country, the SRS provides reliable annual estimates of fertility, mortality, and other advanced indicators at the state and national level (RGI 2006). Every 10 years, the SRS sample is replaced using the latest Census frame to account for the changing demographic profile of the country (such as age structure, marital status, and literacy).

[7] The computation of MMR, across contexts with varying availability and quality of data, has been facilitated by recent methodological developments, particularly in small area estimation (McCulloch and Searle 2001; Rao 2003; Lohr and Rao 2009), and in correction of known biases in survey sibling history data (Gakidou and King 2006).

The trend analysis presented here is based largely on the SRS estimates presented in four successive MMR bulletins, for 2001–03, 2004–06, 2007–09, and 2010–12. It is immediately discernible from Figure 1 that the MMR in India continues to be very high (178 maternal deaths per 100,000 live births), and that the reduction in MMR has been decelerating in recent times.

Figure 1 Maternal mortality ratio (MMR) by region (SRS 1997–2012)



Source: Office of the Registrar General, India 2013

By the end of Phase 1 of the NRHM (2005–12), the MMR across high focus states (EAG states and, particularly, Assam) is estimated to be 257 deaths per 100,000 live births. Therefore, maternal mortality in these states continues to be a major concern. Also, it is not clear if the national and international goals of faster MMR reduction can be achieved. Although the first and second phases of the RCH (1997–2005 and 2005 onwards) focused substantially on reducing MMR, the 2001–06 period can be considered the pre-NRHM period. During this time, the MMR declined by about 50 points (from 301 in 2001–03 to 254 in 2004–06). The NRHM, which was launched in 2005, invested significantly more resources and effort into strengthening the health system than the earlier vertical programmes. Therefore, the MMR was expected to reduce faster. However, it declined by 42 points between 2004–06 and 2007–09, and is estimated to decline by about 34 points between 2007–09 and 2010–12. Given the scale and expectations of the NRHM, the estimated decline in MMR is rather slow, though it can be argued that achieving faster reductions at lower levels of the phenomenon could be difficult (Sen 1981; Kakwani 1993; Fukuda-Parr et al. 2013).

Table 1 Trends in MMR, Indian states 2001–2012

India & Major States	2001-03	2004-06	2007-09	2010-12
INDIA Total	301	254	212	178
95% CI	[285, 317]	[239, 270]	[199, 226]	[166, 191]
Assam	490	480	390	328
95% CI	[397, 537]	[363, 623]	[288, 517]	[236, 443]
Bihar/Jharkhand	371	312	261	219
95% CI	[315, 433]	[258, 374]	[214, 319]	[174, 270]
Madhya/Chhattisgarh	379	335	269	230
95% CI	[308, 457]	[276, 403]	[216, 331]	[181, 289]
Odisha	358	303	258	235
95% CI	[282, 449]	[233, 387]	[193, 336]	[173, 313]
Rajasthan	445	388	318	255
95% CI	[367, 526]	[317, 469]	[256, 393]	[198, 323]
Uttar Pradesh/Uttarakhand	517	440	359	292
95% CI	[462, 576]	[386, 499]	[310, 413]	[249, 343]
EAG AND ASSAM/SUBTOTAL	438	375	308	257
95% CI	[410, 468]	[347, 403]	[283, 334]	[234, 281]
Andhra Pradesh	195	154	134	110
95% CI	[136, 266]	[108, 215]	[92, 191]	[72, 165]
Karnataka	228	213	178	144
95% CI	[174, 297]	[159, 280]	[129, 243]	[100, 206]
Kerala	110	95	81	66
95% CI	[65,173]	[52,160]	[42, 143]	[31, 120]
Tamil Nadu	134	111	97	90
95% CI	[86, 193]	[72, 164]	[62, 150]	[54, 137]
SOUTH SUBTOTAL	173	149	127	105
95% CI	[146, 205]	[124, 178]	[104, 154]	[85, 130]
Gujarat	172	160	148	122
95% CI	[123, 240]	[114, 217]	[103, 204]	[82, 177]
Haryana	162	186	153	146
95% CI	[109, 237]	[123, 271]	[95, 228]	[91, 225,]
Maharashtra	149	130	104	87
95% CI	[100, 210]	[87, 186]	[67, 159]	[52, 138]
Punjab	178	192	172	155
95% CI	[110, 278]	[125, 284]	[109, 262]	[95, 247]
West Bengal	194	141	145	117
95% CI	[147, 250]	[102, 189]	[106, 195]	[82, 164]
Other states	235	206	160	136
95% CI	[202, 272]	[172, 245]	[132, 195]	[109, 168]
OTHER SUBTOTAL	199	174	149	127
95% CI	[179, 221]	[155, 195]	[131, 168]	[110, 145]

Source: Sample Registration System Bulletin, RGI (Various years)

Note: EAG States: Empowered Action Group includes Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Rajasthan and Odisha. In addition Assam is also considered as a high focus state here.

These CIs have been increasing systematically over time and across states. While the width of the CI for India as a whole (or for group of states such EAG/Assam) is narrower, these intervals are much broader for a number of states, including Kerala, Maharashtra, and Tamil Nadu. In 2010–12, these states had the lowest MMR estimates: 66 (Kerala); 87 (Maharashtra); and 90 (Tamil Nadu). Interestingly, even in these three states, the upper confidence limit of the estimate exceeds 100. Based on these inferences, it is statistically difficult to stress that the MMR in Kerala, Tamil Nadu, and Maharashtra is significantly below 100. Clearly, it is critical to consider these issues while commenting upon state-level MMR reduction. Given the limitations of the SRS sample, it is worthwhile to engage with alternative (indirect) methods simultaneously to estimate MMR (see, for instance, Bhat et al. 1995; Hogan et al. 2010; Hill et al. 2006; Ahmed and Hill 2011). However, it is worth emphasising that the best option is a complete vital registration system for births and deaths.

These wider CIs around the estimate also compel us to examine if the state-level declines in MMR over the years are significant. For this purpose, we perform the test of equality of proportions using large sample statistics. The results reported in Table 2 suggest that the declines are statistically significant only for pooled regional sub-samples.

Table 2 Statistical significance of MMR reduction, India 2001–03 to 2010–12

India & Major States	2001/03–2004/06	2004/06–2007/09	2007/09–2010/12	2004/06–2010/12
INDIA Total	***	***	***	***
Assam				*
Bihar/Jharkhand				**
Madhya/Chhattisgarh				**
Odisha				
Rajasthan				***
Uttar/Pradesh/Uttarakhand	*	**	*	***
EAG & ASSAM	***	***	***	***
Andhra Pradesh				
Karnataka				*
Kerala				
Tamil Nadu				
SOUTH SUBTOTAL				**
Gujarat				
Haryana				
Maharashtra				
Punjab				
West Bengal				
Others				***
OTHER SUBTOTAL	*	*	*	***

Source: Authors based on Sample Registration System Bulletin, RGI (Various years)

Note: EAG States: Empowered Action Group includes Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Rajasthan and Odisha. In addition Assam is also considered as a high focus state here.

*** $p<.01$, ** $p<.05$ *$p<.10$ represents significance of difference at 1%, 5% and 10%, respectively.

For instance, the differences are significant at 99 per cent at the all-India level or for the EAGs and Assam, taken together. Statistically, the reduction in MMR is significant only for Uttar Pradesh/Uttarakhand. In a long-term comparison—that is over the pre-NRHM (2004–06) and NRHM (2010–12) periods—mostly, the decline in the NRHM period has been significant over EAG states. In the other (non-EAG) states, the decline has been insignificant.

In part, this reflects the problems of a lower sample size.[8] Nevertheless, as an alternative, we also examine the declines in maternal mortality rate[9] (MM Rate), and find that it is significant across most states (results not reported here). This decline may also be related with reducing fertility over the years.

2.2 Absolute and Relative Reductions

Progress assessment is an integral part of policy review and analysis. Here, we adopt both absolute (A) and relative (R) approach to progress assessments. For any two periods, t_1 and t_2, these indicators are computed as follows:

Absolute progress (A) = $MMR_{t1} - MMR_{t2}$

Relative progress (R) = $1 - MMR_{t2} / MMR_{t1}$

Table 3 presents the results and state-level rankings based on absolute and relative approach to progress assessments.

Table 3 Absolute, relative and level-sensitive progress assessment, MMR 2001-2012

India & Major States	Pre-NRHM (2001-06)				NRHM (2004-09)				NRHM (2007-12)			
	A	Rank	R	Rank	A	Rank	R	Rank	A	Rank	R	Rank
Andhra Pradesh	41	7	21.0%	2	20	11	13.0%	12	24	9	17.9%	6
Assam	10	14	2.0%	14	90	1	18.8%	4	62	3	15.9%	10
Bihar/Jharkhand	59	2	15.9%	4	51	5	16.3%	9	42	4	16.1%	9
Gujarat	12	13	7.0%	12	12	15	7.5%	15	26	8	17.6%	7
Haryana	-24	16	-14.8%	16	33	9	17.7%	7	7	15	4.6%	16
Karnataka	15	11	6.6%	13	35	8	16.4%	8	34	6	19.1%	3
Kerala	15	11	13.6%	7	14	14	14.7%	11	15	14	18.5%	5
Madhya Pradesh/Chhattisgarh	44	6	11.6%	11	66	4	19.7%	3	39	5	14.5%	12
Maharashtra	19	10	12.8%	8	26	10	20.0%	2	17	12	16.3%	8
Odisha	55	4	15.4%	5	45	7	14.9%	10	23	11	8.9%	14
Other states	29	8	12.3%	10	46	6	22.3%	1	24	9	15.0%	11
Punjab	-14	15	-7.9%	15	20	11	10.4%	14	17	13	9.9%	13
Rajasthan	57	3	12.8%	8	70	3	18.0%	6	63	2	19.8%	1
Tamil Nadu	23	9	17.2%	3	14	13	12.6%	13	7	15	7.2%	15
Uttar Pradesh/Uttarakhand	77	1	14.9%	6	81	2	18.4%	5	67	1	18.7%	4
West Bengal	53	5	27.3%	1	-4	16	-2.8%	16	28	7	19.3%	2
India	**47**		**15.6%**		**42**		**16.5%**		**34**		**16.0%**	

Source: Authors based on SRS bulletin (RGI, various years)

[8] Maternal deaths are relatively rare. If sample survey methods are considered, estimation becomes difficult from a statistical perspective (Campbell and Graham 1991). For instance, MMR rarely exceeded 1,000 per 100,000 live births. Therefore, and as noted by Graham et al. (1996): To obtain current estimates of maternal and child mortality, of the same relative precision from a single round cross-sectional survey at expected levels of, say, 500 maternal deaths per 100,000 live births and 200 under-five deaths per 1000 live births, would require sample sizes of, respectively, 324,800 and 6,400 households.

[9] Maternal mortality rate (MMRate) is defined as the number of maternal deaths in a population divided by the number of women aged 15–49 years (or woman years lived at ages 15–49 years). Generally, it is expressed as the number of maternal deaths per 1,000 women during a given period (see WHO 2012).

Specifically, we examine the progress over three periods: 2001–06, 2004–09, and 2007–12. Here, the first period can be regarded as the pre-NRHM period; the second and third periods can be regarded to fall in Phase 1 of the NRHM (2005–12). We can expect some effect of the NRHM during the second period, but greater results in the third period. Interestingly, the all-India reduction in MMR for the three periods was 47 points, 42 points, and 34 points, respectively. This absolute view suggests that the pace of reduction has been slowing down in recent years. However, a relative approach informs that the pace of reduction has been more or less constant (around 16 per cent) since 2000.

Further, the absolute approach suggests that over 2001–2006, the MMR dropped over 50 points in Uttar Pradesh/Uttarakhand, Bihar/Jharkhand, Rajasthan, Odisha, and West Bengal, but perhaps increased in Haryana and Punjab. The decline was steep in most states with high MMR, but only 10 points in Assam. However, Assam showed considerable improvement during the NRHM period: it achieved large reductions of 90 points during 2004–2009 and 62 points during 2007–2012.

An absolute view of assessing progress proves disadvantageous for states with lower base levels, such as Kerala, Tamil Nadu, and Maharashtra. For instance, during 2001–06, both Karnataka and Kerala achieved a 15-point reduction in MMR. Consequently, the absolute approach ranks both states equally. However, Kerala achieved this reduction from a lower base level (MMR 110 in 2001–03) than Karnataka (MMR 228 in 2001–03). It is argued that an improvement at a higher level represents a greater achievement than an equal improvement at a lower level (Joe 2014; Waage et al. 2010; Fukuda-Parr et al. 2013; Prennushi et al. 2002; Sen 1981; Dasgupta 1990; Kakwani 1993). Also, consensus is growing that the non-linear dynamics of improvement at different levels should be considered, as at higher levels the marginal social cost for improvement increases disproportionately (Easterly 2009; Osório 2008; Vandemoortele 2009; Vandemoortele and Delamonica 2010; Addison et al. 2005). It is important to approach progress assessment by allowing for level-sensitive assessments, and to acknowledge the commitment of states that continue to progress despite lower net benefits. The relative approach offers a crude method to capture level-sensitive[10] behaviour, as it provides greater weights to a similar improvement achieved from a lower base level. For instance, using this method, we notice that for 2001–06 Kerala is ranked seventh and is placed ahead of Karnataka (ranked 13) in MMR reduction.

[10] To assess inter-temporal progress, methods such as rate differentials (absolute changes) and rate ratios (relative changes) are commonly applied. However, a few indicators account for level differentials in progress assessments (see, among others, Kakwani 1993; Sen 1981; Mishra and Subramanian 2006; Joe 2014). Here, we rely exclusively on the implicit level-sensitive property of the relative progress indicator, R. The index A is based on simple rate differentials and provides equal weight to progress, irrespective of base-level differentials. This implies that the rate differential indicator will not exhibit level sensitivity as, for instance, the effort leading to a decrease in MMR from 500 to 400 will be considered as good as the effort required for a decrease from 200 to 100. However, in the case of indicator R, the weights are such that for a given improvement in MMR, regions or groups with a higher base level of MMR would receive lower weights.

In relative terms, both Rajasthan and West Bengal have shown good progress during the NRHM (2007–12), but performance has stagnated recently in some states. In Punjab and Haryana, in particular, the pace of reduction does not augur well with their developmental profile. Also, it is surprising to observe the slow pace of improvements in the better performing state of Tamil Nadu: the MMR has improved by only 7 points between 2006–09 and 2007–12. The state government estimates of the 2010–12 MMR levels (73–79; Government of Tamil Nadu 2014) are inconsistent with the SRS estimates (90). Nevertheless, even the state estimates show a stagnant picture in MMR reduction: the most recent state government estimates, for 2013–14, suggest a MMR of 68.

2.3 Inter- and Intra-state Disparities

Given such wide variations in MMR, it is critical to examine the inter- and intra-state disparities to comprehend whether the disparities are narrowing. For this purpose, we apply the following indicators: range; ratio of worst and best performing states; standard deviation; coefficient of variation; and Gini coefficient. The MMR range across states, computed as the difference between the highest and the lowest MMR, state has been narrowing over the years. For instance, during 2001–03, there was a 407-point difference in MMR of the highest (Uttar Pradesh/Uttarakhand) and lowest (Kerala) MMR states. In 2010–12, the gap between the highest (Assam) and the lowest (Kerala) MMR states was 262 points. Although the gaps between the extremes are reducing, the range ratio, computed as the ratio of the highest MMR state to lowest MMR state, has not shown any significant reduction. In fact, the MMR of the worst performing state is almost five times that of the best performing state. The standard deviation indicates that the spread of MMR across states is also narrowing. Nevertheless, the magnitude of inter-state disparities remains high and is confirmed by the coefficient of variation and the Gini coefficient for the various years (Table 4).

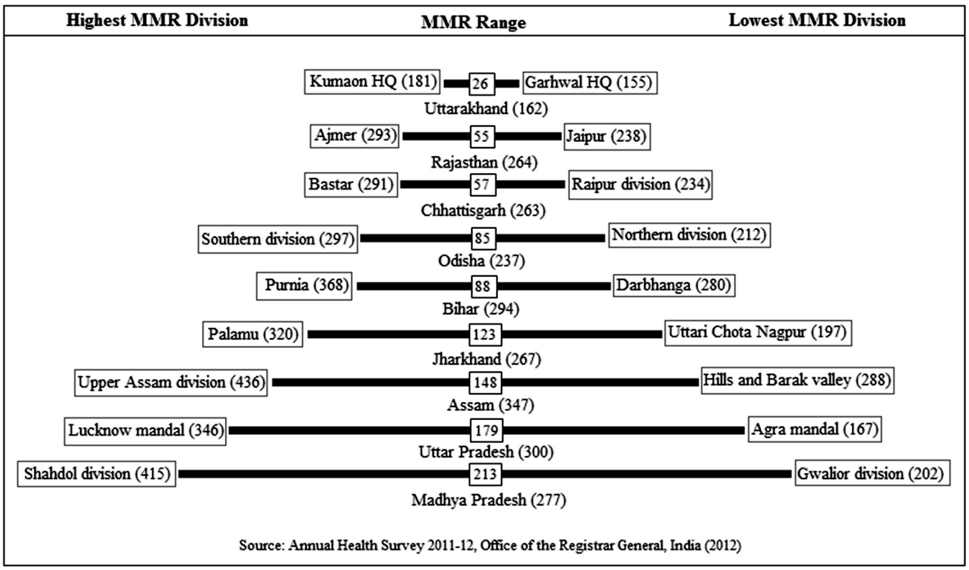
Table 4 Magnitude of inter-state disparities in MMR, India 2001-03 to 2010-12

Inequality Indices	2001/03	2004/06	2007/09	2010/12
Range difference (Highest – Lowest MMR)	407	385	309	262
Range ratio: Highest/ Lowest MMR	4.70	5.05	4.81	4.97
Standard deviation	139.2	124.4	98.0	80.8
Coefficient of variation	0.512	0.513	0.479	0.476
Gini coefficient	0.272	0.276	0.258	0.253

Source: Authors based on Sample Registration System Bulletin, RGI (Various years)

Data inadequacies restrict comprehensive analysis and discussion regarding magnitude of intra-state disparities in maternal mortality but nevertheless it is critical to flag these concerns to improve divisional administration and policy implementation. In this regard, the Annual Health Survey (AHS) conducted across EAG states and Assam provides some understanding regarding the patterns of intra-state distribution (Figure 2). The MMR ranges from 155 for Garhwal (Uttarakhand) division to 436 for Upper Assam division (Assam). The intra-state range is the highest for Madhya Pradesh (213) and lowest for Uttarakhand (26). In Madhya Pradesh, highest MMR of 415 deaths per 100,000 live births is estimated for Shahdol division whereas Gwalior division has lowest MMR of 202. The data clearly indicates that there is considerable scope for focused division-specific interventions for further reduction in MMR across EAG and Assam. The AHS also informs that none of the administrative divisions of these EAG/Assam states have MMR below 100. In fact, around 31 administrative divisions or regions have MMR levels of 200-300 while MMR of other 12 divisions or regions is in between 300-400.

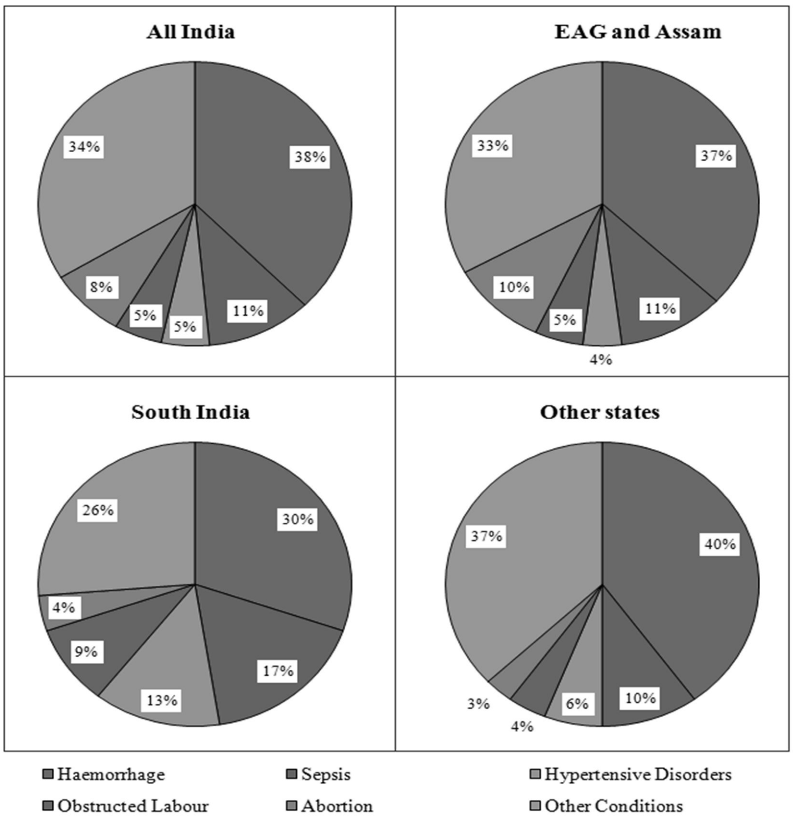
Figure 2 Intra-state disparities: MMR range across administrative divisions 2011-12



2.4 Causes of Maternal Death

An improved understanding of the causes of maternal death is essential to conceptualise strategies for MMR reduction. Under the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10), the causes of maternal deaths are categorised broadly into *direct* and *indirect*. The former category includes maternal deaths resulting from obstetric complications of the pregnant state (pregnancy, delivery, and post-partum), interventions, omissions, incorrect treatment, or a chain of events resulting from any of the above. The latter consists of deaths resulting from previously existing diseases, or from diseases that developed during pregnancy and that were not due to direct obstetric causes, but were aggravated by the physiological effects of pregnancy (WHO 2012). As shown in Figure 3, the 2001–03 SRS data suggest that haemorrhage (38 per cent) is the leading cause of death in India, and is followed by sepsis (11 per cent) and abortion (8 per cent). The relative shares of these causes were notably similar across regions such as EAG states and Assam, South India, and other states. However, hypertensive disorders are much higher in South India, whereas abortion-related deaths are higher in EAG states and Assam (RGI 2003).

Figure 3 Causes of maternal death in India (2001-03)



Source: The data for India and Tamil Nadu are reported in Montgomery et al (2014) and Kolandaswamy (2010), respectively.

Using data from the SRS 2001–03, Montgomery et al. (2014) re-examine the causes of maternal mortality in India, and find that direct obstetric causes account for over 80 per cent of maternal deaths in India. The pattern is notably similar across rural and urban areas as well as across different states. Obstetric haemorrhage causes about 25 per cent of the total maternal deaths, whereas other obstetric complications lead to over 20 per cent of maternal deaths. Pregnancy-related infection (17 per cent) and complications following spontaneous/therapeutic abortion (9 per cent) are also identified as important causes of maternal deaths in India. Studies based on data sources other than the SRS also shed light on the causes of maternal death in India. For instance, a civil society report analyses124 maternal deaths (in 2012–13) across 10 major states of India, and finds that about 28 per cent of the deaths are due to haemorrhage (Subha Sri and Khanna 2014). Importantly, this study identifies that 18 per cent of the maternal deaths reviewed were caused by anaemia. Abortion-related complications are responsible for about 4 per cent of the investigated maternal deaths. Similar inferences are available from the description of causes of maternal death in Tamil Nadu during 2008–09 (Kolandaswamy 2010), which finds that the proportion of direct (81 per cent) and indirect (19 per cent) causes of maternal death is similar to the all-India proportion. Again, haemorrhage is identified as the cause of about 24 per cent of maternal deaths in the state. Tamil Nadu is witnessing an increase in hypertension-related maternal deaths. Eclampsia and pulmonary embolism are identified as other major direct causes of maternal death during 2008–09. However, abortion-related maternal deaths are not identified as a significant cause of maternal death. Such increasing share of indirect causes is also noted in other parts of the country.

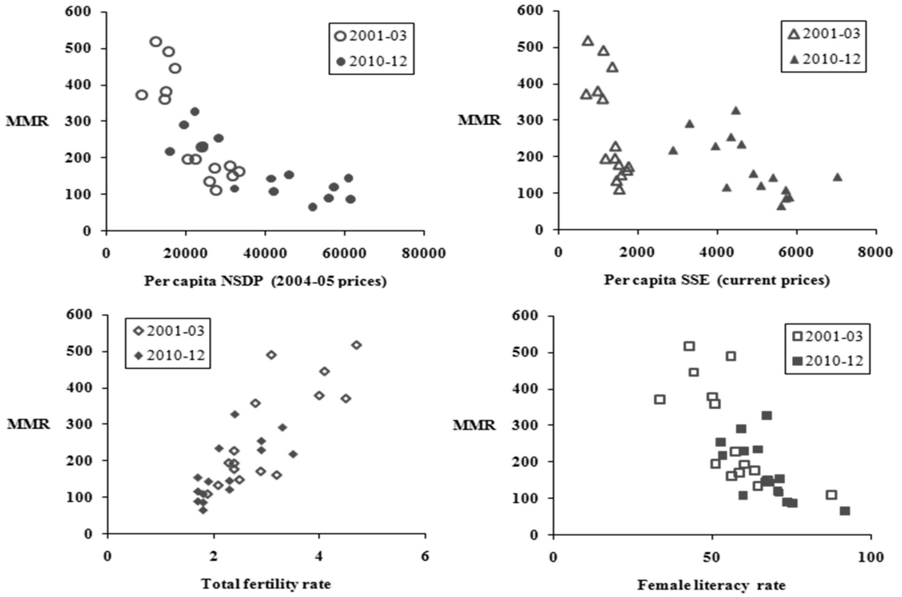
With advances in scientific knowledge and proven clinical interventions, it is possible to prevent most maternal deaths. Therefore, it is critical to understand if the deaths were caused due to delays in decision making and care seeking at the household level, or in arranging transport and reaching the health facility, or in receiving appropriate care at the health facility (Thaddeus and Maine 1994). Each of these dimensions has different implications for policy. Verbal autopsies based on the SRS 2001–03 suggest that about 50 per cent of maternal deaths occurred at home, 14 per cent occurred during transit, and 36 per cent occurred at the health facility (Montgomery et al. 2014). However, the more recent review of selected maternal death cases by Subha Sri and Khanna (2014) suggests that with improving access there may be a possible change in the reporting of place of maternal deaths. This study finds that about 26 per cent of maternal deaths occurred at home, 25 per cent occurred in transit, and 48 per cent occurred at the health facility. In Tamil Nadu, less than 10 percent of deaths occurred in the health facilities where the expectant mother was admitted; the corresponding all-India figure is about 33 per cent (Kolandaswamy 2010; Montgomery et al. 2014; Subha Sri and Khanna 2014).

3 STRUCTURAL ENVIRONMENT AND MMR REDUCTION

This section reviews the ecological association between important structural factors and MMR across 15 major states. It is widely acknowledged that economic growth is an important determinant of maternal and child health. Economic growth not only helps boost public and private sector investments in health care but also affects several immediate and intermediate factors, such as transportation and infrastructure, which improve access to health care.

Similarly, MMR levels and reduction are significantly influenced by socio-cultural, health system, and demographic factors. These aspects of the structural environment can be reasonably captured by proxy variables such as public spending on social sector, female literacy rate, and total fertility rate (TFR).

Figure 4 Association of MMR with PCNSDP, PCSSE, TFR and female literacy



Source: SRS Bulletin (2001-03 & 2010-12), Census of India (2001 & 2011) and RBI report on state finances.

The top left panel in Figure 4 plots the association between per capita net state domestic product (PCNSDP) and MMR for the pooled SRS data points (2001–03 and 2010–12). A parabolic shape of the PCNSDP-MMR scatter (top left panel) resembles a unitary elasticity plot indicating that, wherever the states are, a given percentage increase in PCNSDP should result in an identical percentage decline in the MMR. In other words, this ecological association suggests that economic growth at lower levels of income can have significant impact in achieving faster decline in MMR. Also, the Pearson correlation between MMR and PCNSDP for all the four SRS data points is found to be negative and significant at 1 per cent level for significance. The Pearson correlations coefficients are as follows:

- 2001–03: Correlation -0.843 (p-value 0.0001);
- 2004–06: Correlation -0.794 (p-value 0.0004);
- 2007–09: Correlation -0.830 (p-value 0.0001); and
- 2010–12: Correlation -0.817 (p-value 0.0002).

It is also worthwhile to examine a somewhat longer relationship (2001–12) by observing the changes in MMR associated with absolute and relative changes in the PCNSDP. This change-in-change analysis (results not reported) informs that smaller absolute increments in per capita incomes had had a significant impact on MMR reductions than large absolute increments. Such smaller absolute increment in PCNSDP and faster MMR reduction are noted across low-income states such as Uttar Pradesh and Assam. In relative terms, it implies that rapid economic growth can also accelerate MMR reductions.

Figure 4 also reiterates the increasing importance of non-income factors to accelerate MMR reductions. This is immediately discernible from the association of MMR with per capita social sector expenditure (PCSSE in current prices), total fertility rate (TFR), and female literacy rate. The female literacy rate and TFR share a significant relationship with maternal mortality. The bottom left plot indicates that faster progress towards lower TFR levels can have a direct and independent effect on MMR. Similarly, female literacy and education emerges as a key developmental issue for reducing MMR.

Levels of per capita social sector expenditure and MMR are also positively associated. This fact is well established by the MMR profiles of states such as Kerala and Tamil Nadu, which have consistently devoted significant public resources to the social sector.

Table 5 Public spending on the social sector by selected states, 1990-2010

State	**PCSSE***		**% PCSSE/PCTE***	
	1990s	2000s	1990s	2000s
Assam	660	1721	38.6	37.0
Bihar	553	1081	41.8	39.5
Uttar Pradesh	472	1247	33.3	32.0
Kerala	962	2348	41.3	34.6
Tamil Nadu	913	2413	40.3	36.1

Source: State Finances — A Study of Budgets of 2012-2013, RBI (2013)

Note: All figures are in current prices

*Average annual PCSSE (per capita social sector expenditure) and PCTE (per capita total expenditure) are taken for the decade of 1990s and 2000s.

The social sector expenditure includes expenditure on social services, rural development and food storage and warehousing under revenue expenditure, capital outlay and loans and advances by the State Governments.

As shown in Table 5, the per capita social sector expenditure (PCSSE) has almost tripled for Kerala and Tamil Nadu since 1990.Bihar and Uttar Pradesh have the lowest level of per capita social sector spending. To illustrate, for every rupee Tamil Nadu and Kerala spend per capita, Uttar Pradesh spends 50 paise, Bihar 46 paise, and Assam spends 73 paise.

Notwithstanding these bivariate relations, it is also critical to highlight their relative importance in a multivariate framework. For this purpose, first we draw inferences based on an ordinary least squares (OLS) regression analysis, by including a time period dummy (2001–03 = 0 and 2010–12 = 1) to adjust for time-varying factors. The time dummy can also provide some insight into the plausible role of the NRHM in reducing MMR during the past decade. While testing for multicollinearity, it is observed that per capita social sector spending has a high variance inflation factor and is highly correlated with the PCNSDP (Pearson correlation: -0.796). Therefore, it is dropped from the OLS regression. The coefficient estimates for the other variables are reported in Table 6.

Table 6 Ordinary least squares (OLS), maximum likelihood (ML) and restricted maximum likelihood (REML) estimates, MMR 2001-12

	OLS		**ML**		**REML**	
Variables	Estimate	(std.err)	Estimate	(std.err)	Estimate	(std.err)
Fixed part						
Intercept	10.12**	(1.882)	10.27**	(0.926)	10.22**	(0.961)
Log of PCNSDP	-0.520**	(0.167)	-0.538**	(0.079)	-0.534**	(0.082)
TFR	0.200^	(0.109)	0.189**	(0.053)	0.192**	(0.054)
Female literacy	-0.006	(0.008)	-		-	
% SC population	0.010	(0.009)	-		-	
% ST population	0.170*	(0.007)	-		-	
Period dummy (2010-12=1)	0.056	(0.109)	-		-	
Random part						
Standard deviation (year)	-		0.002	(0.079)	0.012	(0.020)
Standard deviation (state)	-		0.253	(0.047)	0.264	(0.051)
Standard deviation (residual)	0.213	(0.039)	0.072	(0.008)	0.073	(0.008)
Adjusted R-square	0.801		-		-	
Log-likelihood	-		43.1		37.1#	
N	30		60		60	

Note: Standard error in parenthesis.
**, * and ^ denote significance at 1%, 5% and 10%, respectively.
restricted log-likelihood.

Since natural logarithms transformation of both MMR and PCNSDP is specified, we find that a 1-per-cent increase in the PCNSDP is associated with a 0.52-per-cent decline in the MMR. Besides, the other two variables (TFR and female literacy) bear the expected sign, though only the former is found significant, at 10 percent. Nevertheless, it also suggests that a

1-per-centreduction in TFR can be associated with an about 20-per-centdecline in MMR. We have also included the proportion of Scheduled Caste (SC) and Scheduled Tribe (ST) populations as explanatory variables, as these vulnerable social groups share a higher burden of health deprivations. The coefficient for the ST population is also significant, at 5 percent, and suggests that a large concentration of tribal sub-groups is associated with a higher MMR. Interestingly, the time dummy, which plausibly informs about the role of the NRHM, does not bear any statistical significance.

Further, we use the MMR, PCNSDP, and TFR data at four time points to draw additional inferences about their association (we dropped female literacy as data is not available). Specifically, the MMR data are cross-classified by state and years. Therefore, we treat both these factors as random, develop two simple two-way error component models, and present the results in Table 6 (Rabe-Hesketh and Skrondal 2012; Goldstein 1987). First, we fit the model using the maximum likelihood (ML) estimation method. The coefficient of the log of PCNSDP is estimated to be -0.54 and is closer to the one obtained using ordinary least squares method. Interestingly, the significance of TFR increases after dropping female literacy from the analysis; this suggests that a 1-point-decline in TFR is associated with a 18.9-per-cent decline in MMR. The estimated residual standard deviation between years is only 0.002, whereas the estimated residual standard deviation between states is 0.253, and indicates greater heterogeneity between states. The leftover residual standard deviation is estimated to be 0.072. A similar between-state heterogeneity is revealed from the residual standard deviation of the OLS (0.237), though it is lower than the ML estimates.

As the number of clusters is small, the ML estimates of variance components are biased downward. Hence, we also report the estimates based on restricted maximum likelihood (REML), as it yields unbiased estimates. Compared to ML estimates, we find that only the random effects parameters for years and states show some variation. Based on the REML estimates, the cross-sectional intra-class correlation between states within years is estimated at 0.002, whereas the residual intra-class correlation within states is estimated at 0.927. After adjusting for the PCNSDP and TFR, there is a negligible correlation in MMR over states within years, whereas a very high correlation exists for MMR over years within states. We also obtain the empirical Bayes predictions for the REML estimates, which are adjusted for PCNSDP and TFR. These predictions inform that the MMR in Assam, Haryana, Karnataka, Madhya Pradesh, Odisha, Punjab, Rajasthan, and Uttar Pradesh is higher than the state average, and that the SRS 2004–06 estimates have a higher MMR than the average over the 10-year period.

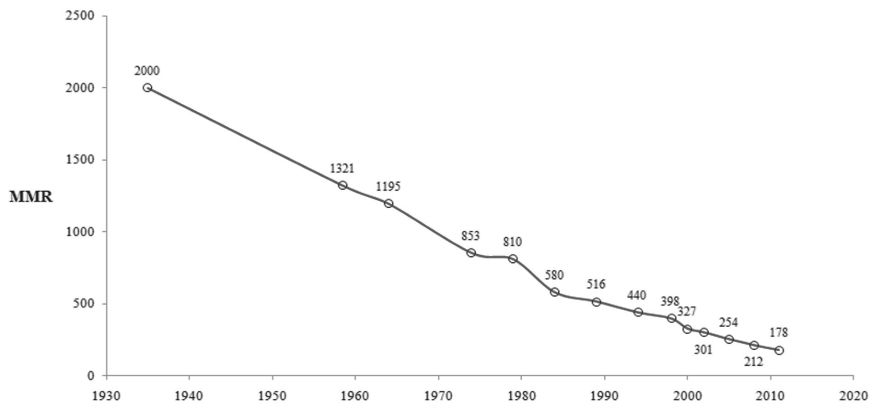
4 DISCUSSION

India's MMR reduction scenario can be summarised using the obstetric transition framework. Souza et al. (2014) describe five stages of obstetric transition:

1. Stage 1 (MMR > 1,000)
2. Stage2 (300 ≤ MMR < 1,000)
3. Stage3 (50 ≤ MMR < 300)
4. Stage4 (5 ≤ MMR < 50)
5. Stage5 (MMR < 5)

The timeline of MMR decline informs that India remained in Stage 1 for almost two decades after independence (Figure 5).

Figure 5 Timeline for India's progress to Stage III of obstetric transition



Source: Based on Radkar (2012). Also see Bhat et al (1995), Vora et al (2009) and RGI (various years)

It is only during the 1960s that India reached MMR levels of less than 1,000 maternal deaths per 100,000 live births. For almost four decades (1960–2000), India remained in Stage 2, and entered Stage 3 in the early 2000s. It should reach Stage 4 by the late2020s. However, a synergistic policy approach is required to capture the whole gamut of factors, including health system, economic growth, developmental infrastructure, education, nutritional status, and an exclusive focus on the marginalised sub-groups. In fact, some of the existing frameworks[11] for MMR causes and reduction (see McCarthy and Maine 1992; Campbell et al.

[11] Readers may refer to the companion piece (Joe et al. 2015) for a further discussion on framework and important policy lessons for improving primary health care to reduce maternal mortality in India.

2006; World Bank 2012) emphasise on strengthening the health system, and argue that sustained MMR reduction requires a synergistic environment with rapid improvement in health system, economic performance, socio-cultural outlook, and governance. Therefore, without undertaking anything in the nature of a summary, this section comments on India's performance in these domains.

It is well known that the health system in India has a history of gross neglect, largely because the egalitarian goals of equity and universal care have been pursued exclusively via what could be referred to as the utilitarian means. The problem is deeply rooted in the nature of fiscal management and business environment in India, which has inextricably linked social sector investment with economic performance. This has not only squeezed the space for pursuing egalitarian goals of *health as an end in itself* but has also altered the discourse by emphasising on the utilitarian role of *health as an input for economic growth* and *vice versa*. The issue[12] of high maternal mortality in India was singled out as early as in 1946 by the report of the government's Health Survey and Development Committee (Bhore Committee).But Indiahas not been able to cater adequately to established health care norms, or allocate much needed resources to the public health sector. India has one of the lowest public health spending figures, of about 1.2 per cent of GDP (HLEG 2011). The lack of funding implies that the health system lacks its own agenda, and that problems bearing an economic dimension supercede the more fundamental criteria of rights and equity. India's attention to maternal mortality is synonymous with the launch of the Child Survival and Safe Motherhood in 1992 (CSSM), which is an outcome of global attention[13] to hitherto neglected tragedy of maternal deaths in low-income countries. Other international events, including the International Conference on Population and Development (ICPD 1994) and the MDGs, played an important role in integrating the fragmented family welfare, child health, and maternal health components into the RCH programme and the NRHM (Vora et al. 2009).

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[12] Interestingly, even the Alma Ata declaration (1978) on primary health care had no direct reference to maternal mortality or the plight of mothers at childbirth. It was only in the late 1980s that researchers emphasised maternal deaths (WHO 1978; Rosenfield and Maine 1985; Van Lerberghe and De Brouwere 2001). The global attention to maternal mortality is synonymous with the launch of the Safe Motherhood Initiative in 1987 by international agencies and governments to raise global awareness about the impact of maternal mortality and morbidity, and find solutions. The state of affairs was disquieting: Every four hours, day in, day out, a jumbo jet crashes and all on board are killed. The 250 passengers are all women, most in the prime of life, some still in their teens…(WHO 1986). During this period, WHO and UNICEF (1996) estimated that globally 585,000 women die due to pregnancy-related causes.

[13] International events in the 1990s, including the International Conference on Population and Development (ICPD 1994), incorporated human rights into the definition of Safe Motherhood and emphasised broader political, social, and economic interventions to reduce maternal mortality (UNFPA et al. 1997). These events played an important role while deciding upon interventions for improving reproductive health and family welfare services, particularly among the marginalised sections of the population. More recently, the UN declaration of the MDGs provided the much necessary impetus by promoting inter-sectoral convergence across international, national, private, and civil society organisations.

In India, public health is also affected by governance standards. Good governance facilitates development of appropriate policy frameworks and monitoring systems to support programme implementation. Several studies argue that governance and strong political support to the health system are key to a good public health system, such as in Tamil Nadu (Muraleedharan et al. 2011; Mehrotra 2006; Padmanaban et al. 2009; Vora et al. 2009; WHO 2009; Kalaiyarasan 2014). Although the public health system in India is well structured (sub-centre, primary health centre, community health centre, district hospitals, and medical colleges), it fails to meet even customary service standards. The shortage of human resources hampers the functionality and quality of public health facilities, and is a critical concern. Renewed emphasis on medical education is necessary, as is the resolve to have at least one medical college per district. This requires substantial investment and policy commitment, which Tamil Nadu and Kerala have succeeded in making. Medical education should be expanded to support the training of staff and functionaries to provide comprehensive emergency obstetrics and neonatal care, which is critical to save maternal and neonatal lives. Meanwhile, improvements in human resource management can help to fill the gaps in health care provision. In fact, improvements in health administration is a major challenge, as several states (and the central government) lack the appropriate structure, and a clear division of roles and functions across departments (Vora et al. 2009). It is important to create a separate public health cadre in all states; with the shifting demographic and epidemiological profile of the country, the importance of this requirement is only increasing.

High fertility, abortion, transport, and emergency care are among the key determinants of maternal mortality. Improvement is critical to achieve faster reductions in MMR (McCarthy and Maine 1992). In fact, the TFR among EAG states continues to be much higher than in others and increases the risk of maternal death. Similarly, the availability and quality of Emergency Obstetric Care (EmOC) is essential to prevent maternal deaths. Several skilled birth attendants (SBA) lack the skills to provide even basic emergency care, and there is a shortage of specialists and a poor spread of EmOC facilities in several states with high MMR. The lack of availability and access to blood transfusion contributes to maternal mortality, but is a key gap in many states, especially because sometimes members of the immediate family refuse to donate blood for surgical interventions. In fact, EAG states should emphasise public awareness campaigns and mobilisation to increase the voluntary donation of blood. Clearly, emergency care is an area where innovative strategies are required, including the mapping of health facilities for referral and improved communication before referrals.

The maternal death review system should become a mechanism by which it learns and institutes corrective action to prevent and reduce any such incidence. However, the lack of timely and complete information on maternal deaths is a major challenge. Partly, the problem lies in poor surveillance and monitoring systems for maternal and child health care in India. In the past few years, surveillance has received considerable attention, and new initiatives such as Mother and Child Tracking System (MCTS) and Health Management Information

System (HMIS) have been rolled out. Their success varies across regions, but these initiatives are expected to evolve into a proxy system over time for vital registration and provide comprehensive information for beneficiary care and policymaking. But, for this purpose, states must start using the surveillance system to undertake a comprehensive maternal death review, to undertake corrective measures and policy action. All the reporting (including private sector deaths) should take place within 24 hours, and the reviews should be carried out at community, facility, district, and state level. Such a practice can self-propel improvement in surveillance and monitoring.

Health care promotion cannot be complete unless the health system empowers communities and shares mutual respect and trust. In fact, fear and embarrassment among both beneficiaries and grassroots workers have not received adequate attention, unlike in countries such as Malaysia and Sri Lanka, where competence, status, and the role of midwives and nurse–midwives are critical in reducing MMR (Pathmanathan et al. 2003). These factors are also noted in South Indian states, where women enjoy better sociocultural status. In Bangladesh, the MMR has declined steadily, although only 18 per cent of births are attended by SBAs (Prata et al. 2011). This paradoxical situation may be explained by environmental factors, such as high enrolment of girls in school, and well performing family planning programmes that not only lowered the fertility rate but also enabled women avoid unsafe abortions. However, India is increasingly relying on monetary mechanisms (cash transfers and incentives) to achieve policy objectives, and has failed to leverage the influential ethical tools of duty, principles, and pride in health care achievement. Unsurprisingly, therefore, few conclusions of the impact of such policies on maternal health are favourable (Lim et al. 2010; NHSRC 2011; Sharma and Joe 2014; Montgomery et al. 2014b). Also, the practice of applying all international goals and targets uniformly across all regions needs to be revisited (see Easterly 2009). Such burdensome targets only lead to easy labeling of regions as failures and potentially *demotivating* stakeholders, including grassroots workers.

5 CONCLUSION

The analysis outlines that the high level of maternal mortality in India, particularly across EAG states and Assam, is a critical policy concern. Besides, the pace of reduction for the past two decades (particularly, the rate of decline) does not commensurate well with the observed improvements in socioeconomic indicators across states. Also, huge inter-state and intra-state disparities in MMR remain a major concern. Therefore, in concluding, it is important to mention that economic performance alone would be insufficient to achieve faster reductions in MMR. The economic system works on a quid pro quo basis, which implies that it would neglect social groups unable to offer the system any economic service. In India, these groups largely include women and tribal sub-groups living in unfavourable geographic locations (inaccessible rural areas and hilly regions). Moreover, states with high MMR also tend to have an unfavourable geography; therefore, economic growth would largely be confined to advantaged locations, and the remotest and tribal areas will remain underserved and have high levels of MMR (Banerjee et al. 2013). Economic growth may help initiate improvements in MMR but, to reduce MMR faster, simultaneous investment is important in strengthening the health system; education and empowering women; and making available qualified human resources in health, good governance, and transportation facilities. Also, improvement in recording and sharing vital health (and health-related) information is critical to facilitate policymaking and enhance effectiveness of various interventions. India's developmental narrative should display increased socio-political commitment towards health, one that could place India ahead of other countries.

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