Components of under-five mortality trends, current stagnation and future forecasting levels

ARVIND PANDEY*, B.N. BHATTACHARYA†, D. SAHU*, REHENA SULTANA*

The infant mortality rate (IMR)—probability of dying before one year of age expressed per 1000 live-births—and under-five mortality rate (U5MR)—probability of dying between birth and age 5 expressed per 1000 live-births—have been used as measures of children's well-being for many years. The International Conference on Primary Health Care held in Alma Ata in 1978 was the first global forum to consider how child mortality could be reduced by systematic development of a primary health care system. Since then, the United Nations has been actively involved in reducing IMR and U5MR in developing countries. To this end, the plan of action adopted at the International Conference on Population and Development (ICPD) held in Cairo in 1994 incorporates the reduction of maternal and child mortality.

In India, during 1968–70, the level of IMR was stable at 130 deaths per 1000 live-births. Following the Alma Ata declaration of 1978, the Government of India envisaged a national goal for the attainment of an IMR of 60 by the year 2000. Since then, substantial resources have been put into the child survival programmes over the past 25 years. The Sixth and Seventh Five-Year Plans had aimed at nationwide programmes to realize this goal. The twenty-point programme included, as a key component, rapid improvement in the conditions of women and children. In 1979, the Expanded Programme of Immunization (EPI) was established to provide tetanus toxoid (TT) vaccine to pregnant women, and BCG, DPT, polio and measles vaccine to children. The Universal Immunization Programme (UIP) and oral rehydration therapy (ORT) were both launched in 1985 and the Safe Motherhood Programme initiated during the Eighth Plan were prominent components of the Family Welfare Programme. In the early 1990s, these programmes were integrated and further strengthened to shape the Child Survival and Safe Motherhood (CSSM) Programme. In 1994, the CSSM Programme was further expanded to the Reproductive and Child Health (RCH) services. These programmes had the desired effect of reducing child mortality and improving child health as evidenced from the child mortality statistics of 1978–2002. The National Population Policy (2000) and National Health Policy (2002) addressed the issues of child survival and maternal health, and increased the outreach and coverage of the comprehensive package of RCH services through the government as well as the voluntary non–government sector together in partnership.

The U5MR, including infant, neonatal and child mortality rates, started declining since the late 1970s and until 1993 the rate of decline was substantial. The decline was, however, slow during 1993–98 (Fig. 1). The country's goal to achieve a U5MR of less than 100 per 1000 live-births and reducing the IMR to less than 60 per 1000 live-births by the year 2000 could not be achieved despite improved interventions and an increase in the overall resources. In the present scenario of IMR (2002), 25 per 1000 newborns died within the first week of birth; 40 per 1000 newborns died before reaching the age of 1 year and 85 per 1000 newborns died before reaching the age of 5 years. The major uncertainty seems to be whether the IMR is approaching a limiting value. This value does not have an ultimate cap that will hold forever. Perhaps the progress in reducing mortality in early infancy is possible with innovative interventions for newborn care. Nevertheless, the IMR and U5MR have become increasingly important indicators that need to be monitored.

The present investigation aimed to study the changes in each of the components of under-five mortality during the period 1978–2002; to analyse the factors associated with the apparent stagnation of the child mortality rate in India; and to develop projection scenarios of the IMR and U5MR

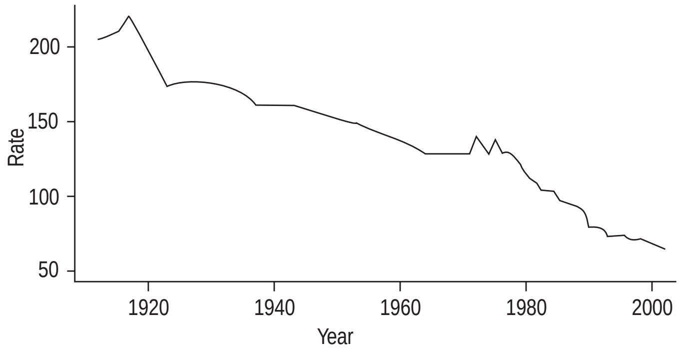

Fig. 1 Trends in the infant mortality rate for 1910–2002, India

*Institute for Research in Medical Statistics, ICMR, New Delhi

†Indian Statistical Institute, Kolkata
e-mail: arvindpandey@vsnl.net

by States by the year 2016. The study examines the impact of utilization of antenatal and natal services on neonatal mortality. It also looks into the levels of IMR and U5MR among socially and economically disadvantaged groups. Besides, the study tries to examine the reasons for the slowing down of the rate of decline in child mortality in recent years by analysing the prevalence of high-risk births among advantaged/disadvantaged groups and relating the same to differentials in the utilization of health care services.

Data

Primarily, two sources of data have been used for the analysis. The Sample Registration System (SRS) under the Registrar General of India provides the estimates of births and deaths at State/national level. The estimates of mortality indicators are used to study the levels and trends in child mortality prevailing during 1978–2002 and also to predict the IMR and U5MR. The study has also used data from two rounds of the National Family Health Surveys (NFHS) conducted during 1992–93 (NFHS-1) and 1998–1999 (NFHS-2). The data in NFHS-1 were collected from a probability sample of 89,777 ever-married women aged 13–49 years from 24 States including the National Capital Territory of Delhi. In NFHS-2, information was collected from a sample of 89,199 ever-married woman aged 15–49 years from all 26 States including Chhattisgarh, Jharkhand and Uttaranchal. Both the surveys included women who were the usual residents of the sample households or visitors who stayed in the sample households the night before the interview, and these women were referred to as eligible women.

Methods

Estimation of trends in components of child mortality

Trends in infant mortality were estimated by fitting a regression line to the relation between observations of IMR and time for each State and for India, allowing the rate of change of mortality to vary according to the number of independent observations available. The methodology is described in detail in Hill *et al.* 1997. The regression line shown below includes an underlying date variable, i.e. calendar year and additional variables measuring time since a series of knot dates (in the present analysis, 1982, 1987, 1992 and 1997). The definition of a knot is based on the idea that each five-year period of vital registration defines a particular slope. The rate of change of IMR can change at each knot. The equation is:

$$\ln({}_nq_0)_i = b_0 + b_1{*}\,\text{date} + b_2{*}\,\text{postk}_1 + b_3{*}\,\text{postk}_2 + \ldots + e_i$$

where

$$\text{postk}_n = \begin{cases} \text{date} - k_n, \text{if date} > k_n \\ 0, \text{otherwise} \end{cases}$$

k_n = 1982, 1987, 1992 and 1997

*indicates multiplication

The rate of change is b_1 during 1977–82, $(b_1 + b_2)$ during 1982–87, $(b_1 + b_2 + b_3)$ during 1987–92, $(b_1 + b_2 + b_3 + b_4)$ during 1992–97and $(b_1 + b_2 + b_3 + b_4 + b_5)$ during 1997–2002.

The average annual rate of change in IMR is:

$$(1/n)\ ((\ln(({}_1q_{0\ [n]}) / ({}_1q_{0\ [n-1]})))$$

where [n] and [n–1] refer to the nth five-year period and the five-year period immediately preceeding it, respectively. A similar procedure is used to obtain the average annual rate of change in early neonatal, neonatal and U5MR.

Absolute changes in early neonatal, neonatal, IMR and U5MR are calculated as ${}_{7\,days}q_{0[n]} - {}_{7\,days}q_{0[n-1]}$, ${}_{28\,days}q_{0[n]} - {}_{28\,days}q_{0[n-1]}$, ${}_1q_{0[n]} - {}_1q_{0[n-1]}$ and ${}_5q_{0[n]} - {}_5q_{0[n-1]}$.

Early neonatal mortality rate (Early NMR) and U5MR are computed as follows:

$$\text{Early NMR} = \frac{\text{Perinatal mortality rate} - \text{stillbirth rate}}{1 - (\text{Stillbirth rate}/1000)}$$

According to the Reed–Merrel formula the U5MR =

$$1000{*}{}_5q_0 = 1000{*}\,(1 - \text{Exp}\,(-5{*}{}_5m_0 - 125{*}{}_5m_0^{\,2}))$$

where a = 0.008.

Because of the non-availability of mortality data for the period 1970–1980 for West Bengal and Bihar, the above indicators could not be calculated for the same period. Similarly, due to non-availability of SRS data for J&K since 1990, J&K is excluded from the analysis.

Estimation of components of child mortality using NFHS-2 data

In the NFHS-2, all eligible women were asked to provide information on 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. However, for children who had died after their second birthday, the imputed values of age at death in months were provided. Detailed information on antenatal, delivery and postnatal care were also obtained only for the two most recent births which occurred to eligible women during the three years preceding the survey.

The present study excluded births that occurred during the month of survey from the analysis (time 0 refers to the last day of the month preceding the survey, referred to hereafter as *the reference date*). A child born on or before the reference date and who died during the month of interview was considered alive as on the reference date. The number of children exposed to the risk of death in the age segment (0, 60) months during the ten years preceding the reference date were those who were born during the ten years preceding the reference date or who were born during 10–14 years preceding the reference date and were alive at the beginning of the 120th month, measured from the reference date.

The levels of neonatal, postneonatal and child mortality across categories of selected predictor variables are based on birth histories of eligible women and their records mentioned above. Children of eligible women who were ever exposed to the risk of death between age 0 and 60 months during the ten years preceding the reference date are considered. The study also examined the effects of health care received by mothers during pregnancy and at delivery on neonatal and postneonatal mortality using information relating to the two most recent births that occurred to eligible women during the thirty-five months preceding the survey date. For each age segment (0, 1), [1, 12) and [12, 60) months, a file of children who were ever exposed to the risk of death during the past ten years in the corresponding age segments was created from the birth histories. In each file, the record of each child included age at entry into the age interval, age at exit from the age interval, which was either due to death or censoring (an outcome associated with exit time wherein 0 means censored and 1 means death), and selected characteristics of the child and his/her mother, and the household.

For each category of predictor variables and for each age-segment (a_1, a_2) months, i.e. (0, 1), [1, 12) and [12, 60) months, the probability of surviving over the interval, given that the child survived at least first a_1 months adjusted for a specified number of covariates at their mean values, are obtained. The adjustment is made by estimating a stratified-on-group Cox-regression model. In stratified Cox regression, the hazard (in deviation form) at age 'a' for a child in the ith category of a factor, which has q categories, is given by:

$$h_i(a) = h^*_{0i}(a)\exp\{\beta_1(z_1 - z_1^*) + \beta_2(z_2 - z_2^*) + \ldots + \beta_k(z_k - z_k^*)\};$$
$i = 1, 2, \ldots, q$

where, $z_1, z_2, \ldots, z_k$ are covariates for which the above relation is descriptive, are $z_1^*, z_2^*, \ldots, z_k^*$, respectively averages of $z_1, z_2, \ldots, z_k$ of children born at a particular moment.

$h_{0i}^*(a) = h_{0i}(a)\exp\{\beta_1 z_1^* + \beta_2 z_2^* + \ldots + \beta_k z_k^*\}$, and $h_{0i}(a)$ is the baseline hazard.

The coefficients $\beta_1, \beta_2, \ldots\beta_k$ are assumed to be the same regardless of category but the baseline hazard h_{0i} is allowed to be category-specific. $h^*_{0i}(t)$ is the baseline hazard for children belonging to ith category of the predictor variable for whom $z_j = z_j^*$ (j= 1, 2…, k).

For a child belonging the ith category of the factor, the probability of surviving over the age interval [a_1, a_2) is:

$$S^*_i[(a_1, a_2)] = \exp\{-\int_{a_1}^{a_2} h^*_{0i}(t)\},\ i = 1, 2, \ldots, q$$

The averages of covariates for children born at a particular time are taken as averages of covariates for children born to eligible women during the 35 months preceding the reference date. The unadjusted conditional survival probabilities over different age intervals for each category of a predictor variable are obtained separately by using the Kaplan–Meier method. For each child at the country level, a weight was used for tabulation and hazard model (Cox regression) analysis.

Projection

A time series structure analysis is carried out by applying the autoregressive integrated moving averages (ARIMA) model to the IMR and U5MR to forecast beyond the series up to 2016. This technique allows for description of the degree of auto-explanation between observations based on the parameter p associated to auto-regression[1]; d specifies the number of times the series is to be differentiated in order to become stationary; and q indicates the number of moving average terms.

Time series IMR_t ($U5MR_t$), t=1977, 2002 which is non-stationary, is converted into a stationary series through a two-step transformation process. First, the series is transformed by taking its natural logarithm; the second step involves successive differencing of the transformed series. If we define the observed series IMR_t ($U5MR_t$) at time t as Y_t and define another transformed series $Z_t = \ln(Y_t)$, the series Z_t is an ARIMA (p,d,q) , and it may be expressed as:

$$\phi(B)(1 - B)^d Z_t = \delta + \theta(B)\,\varepsilon_t$$

where

$$\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \ldots\phi_p B^p$$
$$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \ldots\theta_q B^q$$

and

$$BZ_{t+1} = Z_t$$

The estimated future values of Z_t are converted into those of Y_t to obtain the predicted values.

Results and discussion

Trends in child mortality

The level of IMR declined from about 220 deaths per 1000 live-births per year at the time of India's Independence to about 130 during the 1960s and remained stable at the same level for a decade. It started declining further after 1978 (Fig. 2). The momentum of decline continued until 1993 and the rate was halved during 1978–1993. The lowest decline was noticed in 1992–97. The IMR was found to be stagnating at around 72–74 per 1000 live-births during 1992–97 and this was followed by a slow pace of decline. Thus, India could not achieve the goal of reducing the IMR to less than 60 per 1000 live-births by the year 2000.

The State-wise average annual rates of change and absolute change in early neonatal, neonatal, infant and under-five mortality rates over the 25-year period 1977–

[1] The parameter provides information concerning the order of structural dependence existent between adjacent observations, indicating the existence of autocorrelation

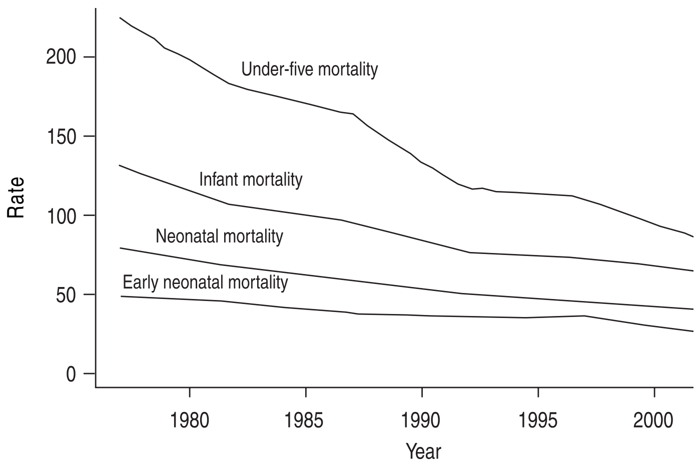

Fig. 2 Fitted trends in early neonatal, neonatal, infant and under-five mortality rates, India 1977–2002

Sources:
1. Under-five mortality rate: Sample Registration System, 1977–2002
2. Infant mortality rate: Sample Registration System, 1977–2002
3. Neonatal mortality rate: Sample Registration System, 1977–2002
4. Early neonatal mortality rate: Sample Registration System, 1977–2002

2002 are provided in Tables 1a–1d while the levels of still-birth rates, early neonatal mortality rates, neonatal mortality rates and post-neonatal mortality rates are given in Appendix 1, Table A1.1 and the levels of IMR, child mortality rates ($_4q_1$) and U5MR are provided in Appendix 1, Table A1.2. The levels, rates of change and absolute change in IMR and U5MR over the 25-year period from 1977 to 2002 are summarized as box plots for major States of India (Figs 3a–3c). It may be observed that the IMR was continuously declining in every five-year period between 1977 and 2002; it declined from 130 infant deaths per 1000 live-births in 1977 to 63 infant deaths per 1000 live births in 2002, with the sharpest decline of 4.3% during 1977–1982 and 4.5% during 1987–1992. The average annual rates of change and absolute change corroborate these findings. The absolute decline in IMR was, however, not uniform during 1977–2002. The highest decline was 25 infant deaths per 1000 in 1977–82 followed by 19 infant deaths per 1000 during 1987–92. The lowest decline of only 4 infant deaths per 1000 was observed during 1992–97. Within India, there are large differences in IMR among States; States have shown a decline in the levels of IMR over time but the pace of decline varies from one State to the other. Kerala had the lowest IMR in 1977, at 47 infant deaths per 1000 live-births, which fell to 10 infant deaths per 1000 live births in 2002, again the lowest among the States. UP had the highest level in 1977 (at about 177 per 1000 live-births), which fell to 79 per 1000 in 2002, again the second-highest among the States. The most dramatic decline in absolute values occurred in Gujarat, Tamil Nadu and Punjab—the level of IMR in these States was about 138, 103 and 105, respectively in 1977 and fell to 60, 44 and 51, respectively in 2002. The absolute decline in IMR was between 59 and 69 in Madhya Pradesh, Andhra Pradesh, Orissa, Punjab, Bihar, Gujarat and Tamil Nadu, around 50 in Haryana, Himachal Pradesh and Assam, around and below 40 in Maharashtra, J&K, West Bengal and Karnataka (Tables 1c–d).

Out of 16 major States, 9 experienced systematic decline in IMR during 1977–2002 (1982–2002 for West Bengal) (Table 1d). Of the 7 remaining States, the average annual rate of change during 1982–87 was positive (about 1%) in three States (AP, Assam and Rajasthan); during 1992–97 it was a little above zero (0.3%) in Assam, Bihar and Haryana, and about 1% in Rajasthan. If we ignore the small amount of positive value of the average annual rate of change in these States during the aforesaid period (which could be due to one or more reasons of underreporting of early infant deaths, sampling fluctuations, stagnation rates during these periods), we could say that 14 out of 16 States showed more or less declining trends in IMR over the past 25 years. Himachal Pradesh and Karnataka showed a declining trend since 1987, Karnataka experienced the highest decline in the average annual rate of change of 6% while the figure for India was 1.2% during the period 1992–97.

In summary, in the past 25 years, the most precipitous decline in IMR occurred during the period 1977–82 (a drop of 25 points) and during 1987–92 (a drop of 16 points). The smallest decline was seen during 1992–97 (8 points) (Appendix 1, Table A1.2). The highest decline in the absolute value of IMR occurred in Andhra Pradesh, Himachal Pradesh, Maharashtra, Punjab and Rajasthan during 1977–82; Assam, Bihar, Gujarat and Uttar Pradesh during 1987–92; Orissa during 1992–97; Haryana, Kerala, Tamil Nadu during 1977–82 and 1987–92; and Karnataka during 1977–82 and 1992–97.

In Madhya Pradesh, the decline in the absolute value of IMR and the average annual rate of change in IMR during the periods 1977–1982 to 1997–2002 was small. In Uttar Pradesh, a rapid decline in the absolute value as well as average annual rate of change of IMR was observed during the consecutive five-year period from 1977–82 to 1987–92 (Tables 1b and 1d). The average annual rate of change in U5MR and IMR were more or less the same during each five-year period except during 1987–92 and 1997–2002, which indicated a faster decline in child mortality compared to IMR during the three periods (Table 1b). Also, during 1982–87 and 1997–2002, the annual rate of decline in neonatal mortality rate (NMR) was faster than the decline in IMR (Tables 1a and 1b) and the average rate of decline in early neonatal mortality was faster than the neonatal mortality rate, indicating relatively greater improvement in early neonatal mortality as compared to late neonatal mortality, and in neonatal mortality than post-neonatal mortality during the said periods. All the States experienced a substantial decline in infant and child mortality during 1978–93. Orissa had the highest points and Kerala the lowest. Orissa, Rajasthan and Uttar Pradesh exhibited declines in child mortality of at least 100 points. The IMR in India

Table 1a. Average annual rates of change in mortality according to five-year periods by States and India

	Percentage decline in									
	Early neonatal mortality					Neonatal mortality				
State/India	1977–82	1982–87	1987–92	1992–97	1997–2002	1977–82	1982–87	1987–92	1992–97	1997–2002
Andhra Pradesh	–11.1	3.2	–2.0	0.1	–5.9	–9.3	0.8	–3.1	–0.2	–3.4
Assam	–2.5	7.6	–13.5	6.1	–3.6	–2.5	2.3	–8.2	0.9	–2.1
Bihar	NA	–4.2	–2.4	1.1	–4.4	NA	–2.1	–6.3	0.9	–3.6
Gujarat	–0.3	–3.2	–6.1	0.5	0.2	–1.4	–3.0	–7.1	–0.4	–0.1
Haryana	–1.4	–2.0	–2.1	3.6	–7.6	–3.5	–3.6	–3.3	1.2	–3.8
Himachal Pradesh	–6.6	3.6	–5.9	–1.3	–3.0	–6.6	3.6	–5.9	–1.3	–3.0
Karnataka	–2.6	4.8	1.0	–4.3	–4.0	–4.1	3.6	–0.4	–5.9	0.4
Kerala	1.0	–6.2	–7.8	–3.1	–7.0	–4.2	–4.9	–11.4	–0.5	–4.6
Madhya Pradesh	3.4	–5.5	2.4	0.6	–6.3	–0.1	–3.0	–0.7	–0.6	–4.1
Maharashtra	–3.7	–2.9	–1.4	–2.3	–4.9	–4.0	–2.5	–2.2	–4.4	–2.4
Orissa	0.9	–0.4	0.6	–1.2	–2.6	1.1	–0.7	–1.0	–3.6	–2.1
Punjab	–3.6	–3.6	–3.6	4.4	–2.6	–6.9	–3.9	–3.3	–0.5	1.6
Rajasthan	–4.2	2.2	–2.2	2.3	–6.9	–4.2	1.7	–5.1	1.3	–3.4
Tamil Nadu	–3.4	0.7	–3.7	–1.4	–9.6	–4.6	–2.0	–3.8	–2.4	–4.3
Uttar Pradesh	4.4	–9.4	–1.3	–0.3	–3.9	1.9	–5.9	–5.0	–2.7	–1.0
West Bengal	NA	–10.1	3.4	–2.1	–5.8	NA	–7.0	0.3	–3.2	–4.0
India	–1.5	–3.8	–1.2	0.6	–6.3	–3.2	–2.7	–3.5	–1.1	–3.0

Table 1b. Average annual rates of change in mortality according to five-year periods by States and India

	Percentage decline in									
	Infant mortality					Under-five mortality				
State/India	1977–82	1982–87	1987–92	1992–97	1997–2002	1977–82	1982–87	1987–92	1992–97	1997–2002
Andhra Pradesh	–9.8	1.3	–3.8	–1.2	0.0	–9.7	0.4	–7.9	–1.1	–2.4
Assam	–3.1	1.0	–6.4	0.3	–1.5	1.3	–1.2	–4.3	–2.9	–2.0
Bihar	NA	–0.7	–7.6	0.4	–3.3	NA	–1.7	–10.1	2.0	–8.8
Gujarat	–3.9	–1.9	–9.2	–0.1	–0.6	–5.1	–2.5	–8.4	–1.7	–1.8
Haryana	–3.2	–1.8	–4.8	0.3	–1.8	–7.0	–1.4	–5.8	1.4	–5.2
Himachal Pradesh	–6.6	3.6	–5.9	–1.3	–3.0	–5.8	0.8	–7.7	–0.7	–6.9
Karnataka	–4.9	2.4	–0.6	–6.0	1.2	–4.5	0.1	–3.1	–5.5	–1.2
Kerala	–7.4	–3.2	–12.7	–0.3	–5.7	–5.6	–6.7	–15.7	0.8	–8.8
Madhya Pradesh	–2.4	–2.1	–2.0	–2.6	–2.3	–4.3	–1.0	–4.9	–3.1	–4.0
Maharashtra	–5.2	–2.2	–3.1	–3.0	–1.3	–5.3	–3.1	–6.6	–3.8	–3.2
Orissa	–1.8	–1.2	–1.6	–3.7	–1.4	–2.2	0.8	–4.9	–2.8	–3.8
Punjab	–7.5	–3.4	–3.2	–1.1	–0.2	–9.3	–0.7	–6.5	–1.6	–0.8
Rajasthan	–5.6	0.9	–5.5	0.9	–2.1	–3.1	–0.7	–8.0	0.4	–5.2
Tamil Nadu	–4.3	–2.3	–6.3	–0.5	–3.3	–4.7	–6.0	–9.2	–1.7	–3.5
Uttar Pradesh	–2.2	–3.3	–6.7	–2.1	–0.7	–5.0	–1.8	–7.6	–1.8	–4.0
West Bengal	NA	–3.8	–1.7	–3.9	–1.5	NA	–6.5	–4.7	–1.9	–7.3
India	–4.3	–1.9	–4.5	–1.2	–2.3	–4.3	–1.9	–6.9	–1.0	–5.1

declined by 63 points (51%) from 129 in 1976 to 63 in 2002 (SRS) (Appendix 1, Table A1.3). However, during the same period, the post-neonatal component declined (54%) slightly more than the NMR (Appendix 1, Table A1.4), which declined by 48%, resulting in an increase in the share of the NMR in the IMR. The trend suggested that with the progressive decline in IMR, the share of the NMR would increase. The child mortality declined by 76 points (78 in rural) from 98 in 1976 to 22 in 2002 (Appendix 1, Table A1.2). Much of the decline in IMR, which occurred due to faster decline in post-neonatal mortality, is attributed to improvements in general nutrition, environmental sanitation and immunization coverage.

Some determinants of child health: An evaluation of their effects

The complex setting and the interaction of social, economic, biological and demographic factors in developing countries often act as detriments to maternal, infant and child survival in the population (Govindasamy and Ramesh 1997; Govindasamy *et al.* 1993). Mosley and Chen (1984) have

Table 1c. Absolute change in components of under-five mortality rate according to five-year periods by States and India

	Absolute change in									
	Early neonatal mortality					Neonatal mortality				
State/India	1977–82	1982–87	1987–92	1992–97	1997–2002	1977–82	1982–87	1987–92	1992–97	1997–2002
Andhra Pradesh	–27.0	6.4	–4.0	0.1	–9.9	–32.3	2.3	–8.2	–0.4	–7.5
Assam	–4.9	17.2	–26.9	10.0	–6.3	–8.9	7.8	–24.6	2.2	–5.2
Bihar	NA	–8.2	–4.0	1.7	–6.4	NA	–6.5	–16.0	2.0	–7.4
Gujarat	–0.8	–7.4	–11.4	0.8	0.3	–5.3	–10.0	–18.2	–0.9	–0.3
Haryana	–2.4	–3.0	–2.9	5.2	–10.0	–10.8	–9.3	–7.1	2.5	–7.2
Himachal Pradesh	–29.0	–5.6	–2.5	–4.2	–8.5	–29.0	14.4	–22.5	–4.2	–8.5
Karnataka	–4.4	8.4	2.0	–2.1	–12.1	–10.3	8.8	–1.0	–13.5	0.8
Kerala	0.9	–4.9	–4.3	–1.3	–2.3	–5.6	–5.3	–8.2	–0.2	–2.1
Madhya Pradesh	8.4	–12.9	5.2	1.4	–13.0	–0.2	–10.8	–2.3	–1.9	–11.8
Maharashtra	–7.3	–4.9	–2.1	–3.2	–5.6	–11.4	–6.0	–4.7	–8.0	–3.6
Orissa	2.1	–1.0	1.4	–2.9	–5.6	4.5	–2.9	–3.7	–12.5	–6.3
Punjab	–4.5	–5.5	–3.9	4.7	–3.0	–18.2	–7.8	–5.5	–0.7	2.5
Rajasthan	–9.1	4.5	–4.4	4.7	–12.7	–14.2	5.5	–14.8	3.5	–8.6
Tamil Nadu	–7.7	1.4	–7.3	–2.3	–12.6	–14.9	–5.4	–9.1	–5.0	–7.4
Uttar Pradesh	13.1	–25.0	–2.0	–2.5	–1.2	9.0	–25.8	–16.1	–8.9	47.2
West Bengal	NA	15.8	4.4	–2.9	–5.3	NA	–16.9	0.5	–6.0	–5.1
India	–3.6	–7.7	–2.2	1.1	–9.7	–11.6	–8.6	–9.4	–2.6	–6.4

Table 1d. Absolute change in components of under-five mortality rate according to five-year periods by States and India

	Absolute change in									
	Infant mortality					Under-five mortality				
State/India	1977–82	1982–87	1987–92	1992–97	1997–2002	1977–82	1982–87	1987–92	1992–97	1997–2002
Andhra Pradesh	–49.2	5.3	–14.5	–3.9	–0.1	–80.4	2.4	–42.9	–4.6	–9.4
Assam	–16.7	5.0	–28.4	1.2	–5.5	11.4	–10.3	–33.5	–18.5	–11.4
Bihar	NA	–3.6	–31.8	1.3	–10.7	NA	–16.8	–74.6	12.0	–44.4
Gujarat	–23.4	–9.8	–36.4	–0.3	–1.9	–52.6	–21.3	–54.6	–8.7	–8.5
Haryana	–16.6	–8.1	–18.6	1.0	–5.9	–60.8	–9.6	–33.7	7.2	–24.8
Himachal Pradesh	–29.0	14.5	–22.5	–4.2	–8.5	–38.8	4.9	–38.4	–2.9	–22.9
Karnataka	–18.5	8.7	–2.3	–19.1	3.5	–29.8	0.4	–17.1	–24.5	–4.5
Kerala	–14.8	–4.9	–13.2	–0.3	–3.5	–17.9	–15.7	–21.6	0.8	–6.7
Madhya Pradesh	–16.9	–13.3	–11.1	–13.0	–10.4	–56.5	–11.4	–48.9	–24.9	–27.0
Maharashtra	–22.1	–7.6	–9.5	–7.9	–3.2	–36.3	–17.3	–29.2	–12.7	–9.1
Orissa	–12.7	–7.6	–9.7	–19.3	–6.4	–22.9	7.5	–44.1	–20.8	–23.7
Punjab	–35.0	–12.2	–9.4	–3.0	–0.6	–67.6	–4.0	–30.3	–6.1	–2.7
Rajasthan	–33.5	4.6	–25.9	3.9	–8.3	–34.8	–7.0	–66.2	2.6	–31.1
Tamil Nadu	–20.8	–9.3	–20.6	–1.5	–8.2	–39.7	–39.2	–40.9	–5.6	–10.4
Uttar Pradesh	–17.7	–23.3	–37.2	–9.2	–4.0	–70.9	–21.9	–72.7	–3.4	–42.4
West Bengal	NA	–12.0	–7.5	–10.5	–5.3	NA	–36.1	–27.0	–10.9	–22.3
India	–25.2	–9.7	–19.4	–4.4	–7.8	–43.6	–16.8	–42.7	–5.9	–24.7

identified a set of 14 intermediate variables which directly influence the risk of morbidity and mortality. They grouped 14 variables into five factors: maternal factors, environmental contamination with infectious agents, nutrient deficiency, injury and personal illness. The effects of social, economic, cultural and geographical variables are said to operate through these biomedical factors to exert an impact on mortality. Maternal factors include mother's age, parity and birth interval. First-born children, children born to very young or very old mothers and those from closely spaced pregnancies generally have a higher mortality rate than others (Boerma 1987; Boerma and Bicego 1992; Fauveau *et al.* 1988; Hobcraft 1987; Pandey *et al.* 1998). Low birth-weight babies are subjected to a higher risk of dying than babies of normal birth weight. However, survival of such children could be affected through the quality of care—both prenatal and postnatal.

It is well documented that children belonging to a disadvantaged group, i.e. born in families or to women with low socioeconomic status are at greater risk of mortality

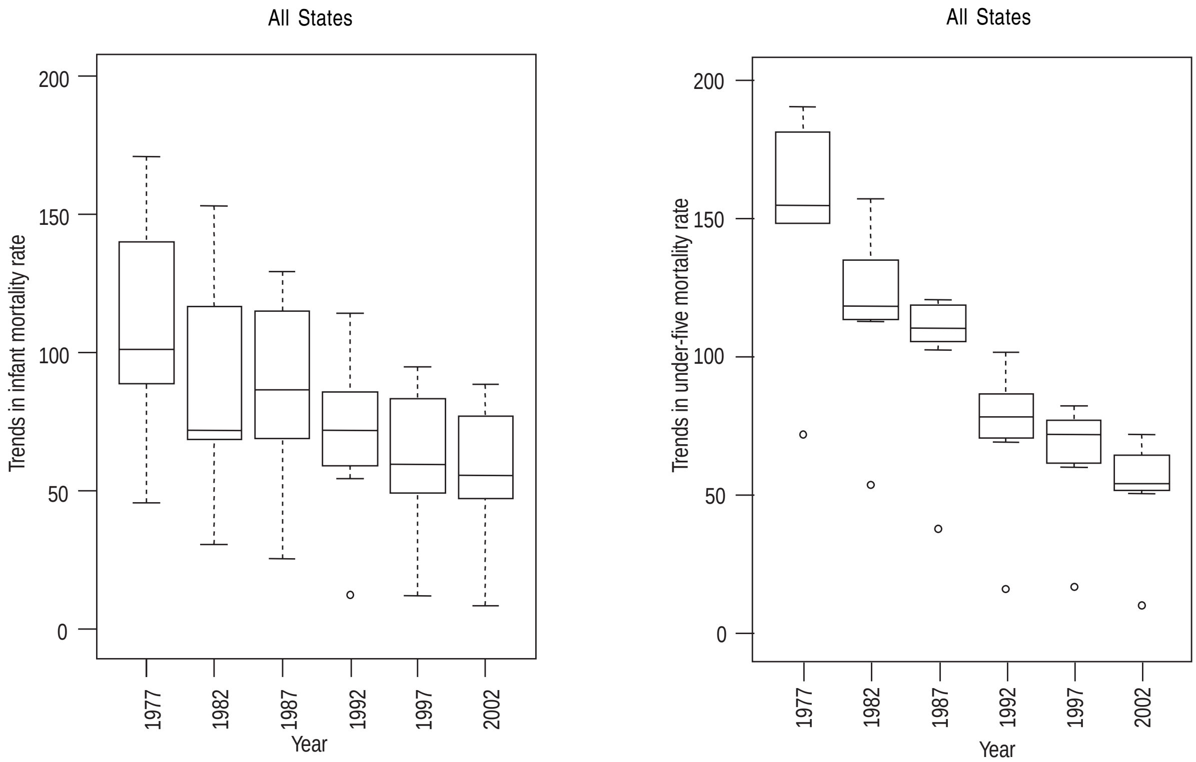

Fig. 3a Infant and under-five mortality rates by five-year periods, 1977–2002

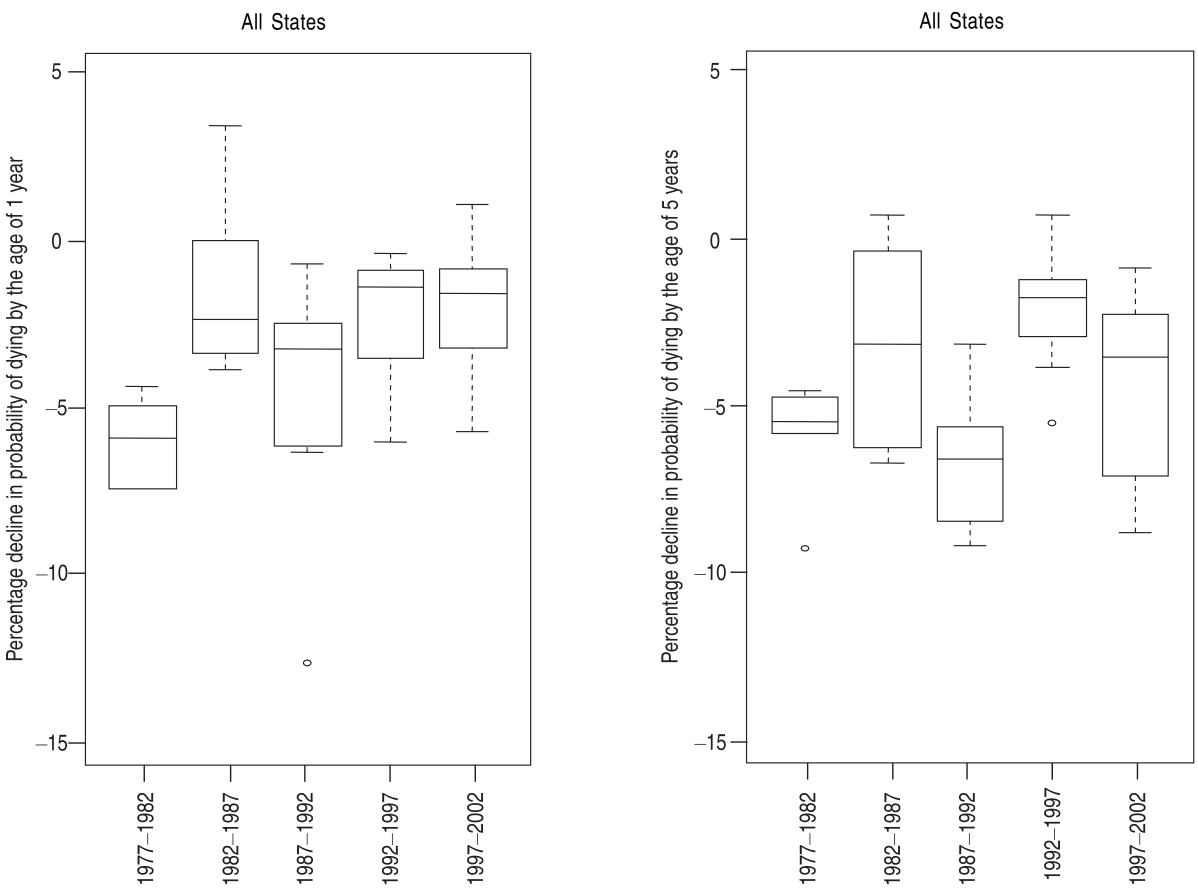

Fig. 3b Average annual rate of change in infant and under-five mortality rate by five-year periods, 1977–2002

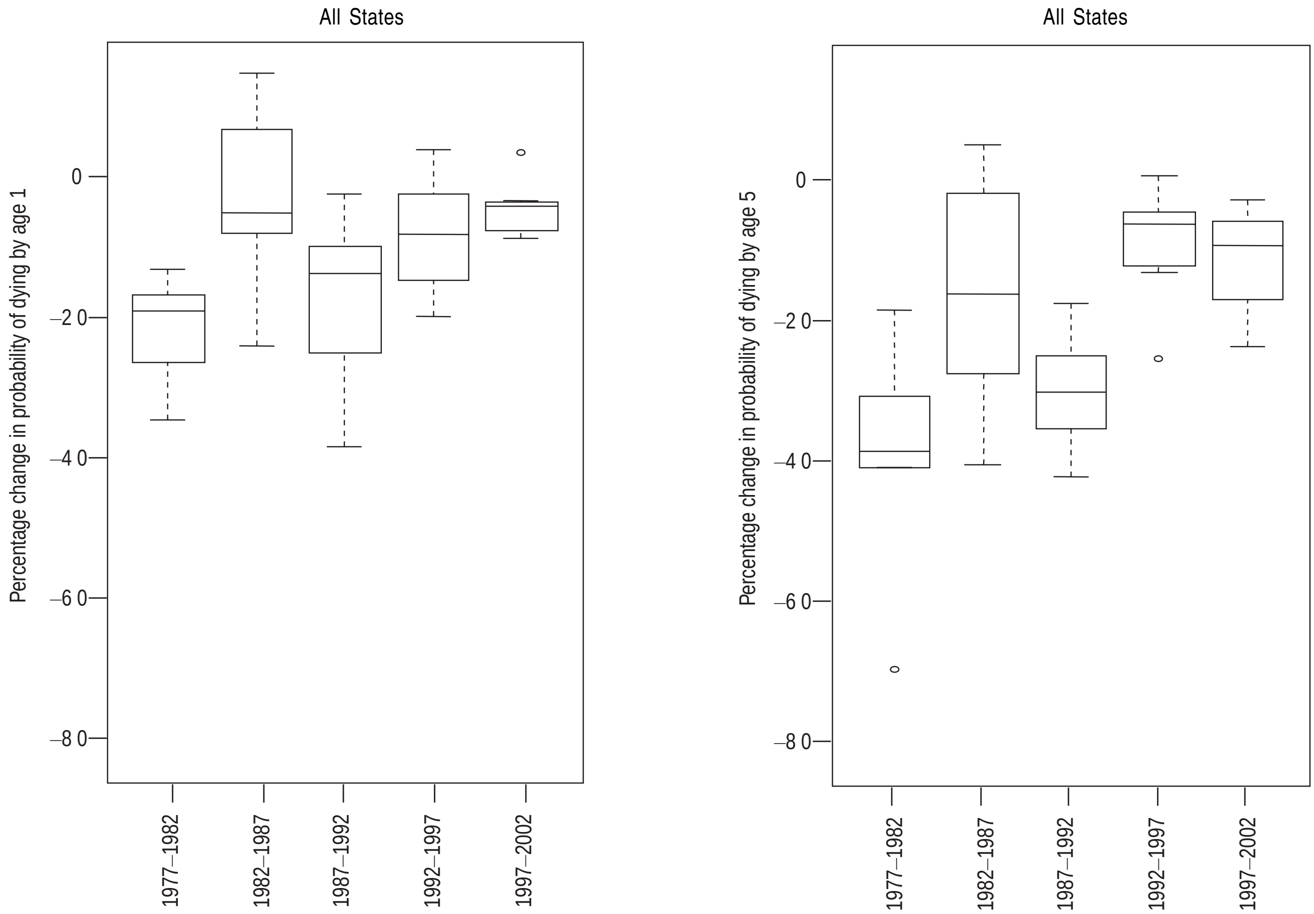

Fig. 3c Absolute change in infant and under-five mortality rate by five-year periods, 1977–2002

than those born in an advantaged group. Low socioeconomic status through intermediate variables leads to the proximal causes of death (nearer in time to the terminal event) such as undernutrition, infectious diseases and injury (Black *et al.* 2003). We focus here on the following:

- Levels of excess of child mortality among high-risk births
- Effect of socioeconomic status on components of child mortality. Four indicators—place of residence, caste, mother's education and standard of living index are considered to represent the social and economic status of a child. Place of residence is considered as an indicator because health services are more easily accessible in urban rather than in rural areas.
- Effects of breastfeeding practices on post-neonatal mortality
- Effects of the use of antenatal care services, immunization with tetanus toxoid and consumption of iron–folic acid during pregnancy on infant mortality.

The NFHS-2 data have been used to study the effects of high-risk births, social status and utilization of MCH on child mortality. The NFHS-1 data are used to study the effect of breastfeeding on post-neonatal mortality.

High-risk births and child mortality

As mentioned above, age of the mother at the time of birth has an important bearing on the survival of the child. Those mothers who give birth or become pregnant before they attain full physical growth tend to have a greater risk of complications during pregnancy or childbirth. Children born to mothers who were under the age of 20 years or 35 years and above are likely to have a higher risk of mortality. An analysis of the NFHS-2 estimates of the level of neonatal, post-neonatal and infant mortality by age of mothers at the time of birth has shown that too early or too late child-bearing has an effect on child mortality. Age of the mother at birth and birth order may have independent effects on neonatal and post-neonatal mortality. Children of birth order 2–3 have the lowest neonatal mortality rate whereas those of birth order 1 have the lowest post-neonatal and child mortality rates. Children of birth order 4 and above have the highest neonatal as well as post-neonatal and child mortality rates. The effect of length of preceding birth interval on infant survival is substantial—neonatal, post-neonatal and child mortality are almost double among children born after a birth interval of less than 2 years as compared to those born after two years (Pandey *et al.* 2004). Low birth-weight babies (less than 2500 g) are subjected to a higher risk of dying than babies of normal birth weight. In India, a large proportion (about 70%) of births is conducted at home and babies are not likely to be weighed. We have therefore taken the perceived size of the baby (large, average, small and very small) as a proxy for birth weight and estimated the neonatal and post-neonatal mortality according to the size of the baby. By and large, neonatal mortality among babies of small and very small sizes at birth is almost twice as high as that among babies whose size at birth was average. Estimated neonatal mortality by the size of the baby after adjusting for the sociodemographic and antenatal health care factors also shows the same pattern (Table 2).

Income/standard of living index

Income is considered to serve as an indicator of children's consumption of calories and nutrients, use of medical systems and adult supervision, all of which affect their health. WHO has acknowledged that the health status of an individual is influenced by social and economic circumstances, over which individuals have little control (Victora *et al.* 2003). Measham *et al.* (1999) have documented an inverse relationship between per capita income and IMR. Non-income factors are found to play a significant role in lowering the IMR, i.e. the effect of technological progress (including access to preventive and curative health services) on lowering the IMR has been found to be the strongest with the magnitude of decline being 20% between 1975 and 1990.

The NFHS did not collect information on income; instead, it collected information on a household's level of wealth, mainly in the form of a stock of assets of a particular type. The standard of living index (SLI) of households—a measure of socioeconomic status—is constructed based on the scores assigned to type of house, type of toilet facility, source of lighting, main fuel for cooking, source of drinking water, separate room for cooking, ownership of house, ownership of agricultural land, ownership of irrigated land, ownership of livestock and ownership of durable goods (IIPS and ORC Macro 2000). Households are classified into three categories according to the standard of living index score as low, medium and high. Children born in households belonging to a low SLI are more likely to have higher exposure to diseases than those born in households with a high standard of living. The level of neonatal mortality in households with low SLI is 19% higher than that in households with medium SLI, and it is 90% higher than that in households with high SLI (Table 2).

Post-neonatal mortality in low SLI households was 38% higher than that of medium SLI households and 175% higher than that of high SLI households. Similarly, child mortality in households with low SLI was 74% and 400% higher than that in medium and high SLI households. It may however be mentioned that SLI affects mortality through a number of intermediate variables and by including them in the hazard model will ultimately reduce the impact of SLI. The unadjusted mortality rates show a rapid decline across the three groups of SLI. However, the adjusted effects of SLI are much smaller: negligible in the case of neonatal mortality.

Place of residence

Research on child mortality in India has shown that mortality is lower in urban areas. One of the frequently mentioned possible causes is the relatively greater availability of medical services and their quality. Large differences in neonatal, post-neonatal and child mortality between rural and urban areas may be due to factors closely related to certain development activities and services available in urban and not in rural areas (Fig. 4). Urban populations benefit more from better health resources, but they also have a higher standard of living, more knowledge about seeking help when it is needed, and are better educated than rural dwellers. Also, the proportion of socially disadvantaged groups (SC/ST population) and high-risk births are lower in urban areas. When mother's education and mother's age at childbirth, standard of living of households, child's sex, preceding birth interval, mother's exposure to media and caste are controlled, the gap between urban and rural mortality is considerably reduced.

Mother's education

In developing countries including India, mother's education has been considered to have a strong effect on the mortality of young children (Das and Dey 2003; Khasakhala 2003; Rama Rao *et al.* 1997). Educated mothers are more likely than non-literate mothers to ensure a healthy environment, nutritious food, and have better knowledge about reproductive health at conception and health care facilities for their children. As a result, literate mothers give birth to healthier babies because they themselves tend to be healthier and are likely to experience lower mortality among their children at all ages. The level of mother's education is inversely related to the level of child mortality. The higher the educational level of mother the lower the level of neonatal, post-neonatal and child morality. The IMR and the child mortality rate (CMR) are higher (44% and 112%, respectively) for children born to illiterate mothers than for children born to just-literate ones (who are literate but less than middle school completed) (Table 2). It is almost one-and-a-half times higher in case of IMR and five times higher in case of CMR among children born to illiterate mothers as compared to children born to mothers who have completed middle school and above. The differences in adjusted mortality rates between children born to mothers belonging to two consecutive educational levels remain high. Thus, it can be summarized that mother's education emerges as an important factor associated with U5MR and also has an effect on post-neonatal mortality rate (PNMR).

Caste

Membership of the head of the household to an SC/ST is known to affect many aspects of the life of their families, particularly survival of the newborn. Such effects reflect

Table 2. Per cent distribution of births during the 35 months preceding the reference date, and unadjusted and adjusted neonatal, post-neonatal, infant, and child mortality rates for the ten-year period preceding the reference date by selected background characteristics of mother, India

Characteristic	Percentage of births during the 35 months preceding the reference date	Unadjusted					Adjusted				
		NMR	PNMR	IMR	CMR	U5MR	NMR	PNMR	IMR	CMR	U5MR
Place of residence											
Rural	77.7	52	28	81	31	107	41	21	62	20	80
Urban	22.3	33	15	49	16	63	34	18	42	17	68
Mother's education (completed years of education)											
0	54.4	57	32	89	36	120	49	28	76	29	102
1–7	22.2	42	20	62	17	77	38	19	56	18	73
8+	23.4	27	11	37	6	43	28	15	43	9	51
Caste											
SC/ST	30.2	54	31	85	23	104	43	21	62	19	81
OBC/Others	69.8	46	24	69	37	103	39	10	59	21	69
Standard of living index of the households											
Low	36.3	57	33	90	40	125	42	25	66	28	92
Medium	47.5	48	24	72	23	92	40	21	60	18	77
High	16.2	30	12	42	8	49	38	17	55	11	65
Sex of the child											
Female	48.1	45	27	72	33	101	37	22	57	22	79
Male	51.9	51	24	75	22	94	43	20	62	17	78
Preceding birth interval for birth order two or more											
<24 months	24.4	67	37	104	39	144	63	35	95	34	126
24 months+	75.6	32	21	53	24	76	31	20	50	21	70
Birth order of the child											
1	29.2	53	22	75	17	90	46	17	63	11	73
2–3	43.5	42	23	64	26	91	36	20	55	21	75
4–5	17.4	47	28	75	35	110	37	24	60	26	84
6+	9.9	65	40	105	43	148	54	37	89	38	123
Mother's age at the time of first birth											
<20	51.7	62	29	91	23	110	49	21	68	13	81
20–34	48.1	40	14	54	11	64	40	14	53	9	62
35+	0.2	50	NC	NC	NC	NC	7	NC	NC	NC	NC
Mother's age at birth order two or more											
<20	12.0	66	32	98	37	129	35	28	62	24	85
20–34	82.4	42	25	67	29	93	38	22	59	23	81
35+	5.6	63	38	101	40	135	55	22	76	38	124
Mother's exposure to the media											
No	45.5	56	32	88	38	121	39	25	62	26	87
Yes	54.5	41	19	60	17	75	40	20	59	16	74

NMR: neonatal mortality rate; PNMR: post-neonatal mortality rate; IMR: infant mortality rate; CMR: child mortality rate; U5MR: under-5 mortality rate;
NC: Calculation not done because of small number of deaths

differences in lifestyle based on traditions or beliefs and practices related to childbearing, childbirth, childfeeding and health care. These may affect the child's health and accessibility of health facilities and services. Each of the components of under-five mortality is higher among SC/ST families than among families which belong to OBC or other castes. However, between caste groups, the differences in adjusted mortality rates are much smaller than the difference between the unadjusted mortality rates.

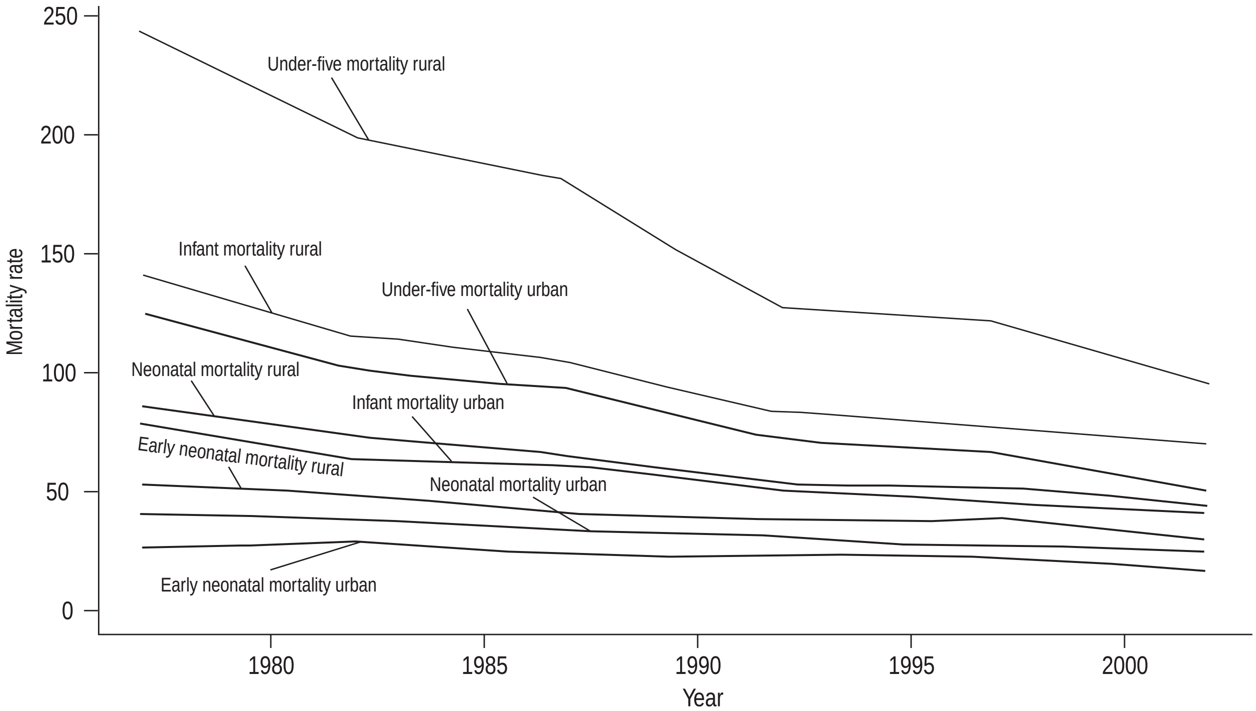

Fig. 4 Trends in early neonatal, neonatal, infant and under-five mortality rates by residence, India, 1977–2002

Mother's exposure to the media

Mother's exposure to the media should tend to reduce the mortality of children because such women are more likely to have access to information on ways of enhancing maternal and child health care. Exposure to the mass media is an indicator of the economic status of the household as well. The level of neonatal mortality exhibits the expected relationship; it is higher for children of mothers who are not exposed to the mass media. However, when the effects of other variables are controlled, the effect of the mass media is negligible. In fact, the neonatal mortality is likely to be affected by endogenous variables as well as biological factors. As expected, post-neonatal and child mortality is consistently higher for children whose mothers are not exposed to the mass media even after controlling for the effects of other variables.

Child's sex

Mortality during the neonatal period is expected to be higher among male children than among female children as during the neonatal stage males are more prone to death than females due to their biological constitution. The NMR is higher among male than among female children. Son preference in a patriarchal society like India affects it through parental care during infancy through postnatal care. The post-neonatal and child mortality rates among female children are 13% and 50% higher, respectively, than among male children (Table 2).

SRS data show that the ratio of female to male IMR for India was less than unity during 1981 (0.981) and 1991 (0.988), whereas during 1998 it exceeded unity. In other words, during 1981 and 1991 more male than female infants died whereas the reverse was true for the year 1998. The ratios of female to male mortality in India have not only been invariably in favour of males but they have also been larger than what was observed during infancy. Over time, these gaps have further widened. During the early 1980s, an additional 366 female children 1–4 years of age died for every 1000 deaths among male children. The excess of female child deaths increased by 405 in the next five years and widened further to 463 during 1993–97 (Usha 2004).

Prenatal care and child mortality reduction

Further, we examine the effect on neonatal and post-neonatal mortality of programmatic factors such as antenatal and delivery care, especially the number of antenatal check-ups during pregnancy, immunization of women against tetanus during pregnancy, full consumption of iron–folic acid (IFA) tablets or syrups during pregnancy, and delivery in a medical facility. Ideally, antenatal care (ANC) should monitor a pregnancy for signs of complications, detect and treat pre-existing and concurrent problems of pregnancy, and provide advice and counselling on preventive care, diet during pregnancy, delivery care, postnatal care and related issues (IIPS & ORC Macro 2000). Infant mortality is lower (48%) among children whose mothers received 3 or more ANC check-ups as compared to those children born to mothers who either did not receive any ANC check-up or received less than 3 (Table 3). The effect of ANC visits on survival during the post-neonatal period is more pronounced than during the neonatal period. The adjusted effect is a little

Table 3. Per cent distribution of births during the 35 months preceding the reference date, and unadjusted and adjusted neonatal, post-neonatal and infant mortality rates for the three-year period preceding the reference date by selected characteristics, India

Characteristic	Percentage of births during the 35 months preceding the reference date	Unadjusted			Adjusted		
		NMR	PNMR	IMR	NMR	PNMR	IMR
Antenatal care visits made by mothers during pregnancy							
0–2	55.3	45	29	73	35	26	60
3+	44.7	25	13	38	28	13	41
Full consumption of iron–folic acid tablets or syrups							
No	20.2	32	25	56	28	21	48
Yes	79.8	26	14	40	27	13	40
Mother received at least two injections during pregnancy							
No	31.9	52	33	83	49	20	68
Yes	68.1	26	16	42	27	15	42
Place of delivery							
Institutional	33.9	39	14	52	38	16	53
Home or others	66.1	31	25	55	32	19	50
Size of the baby at birth							
Large/very large	14.0	34	16	49	33	14	47
Average	61.3	27	20	46	26	17	43
Small/very small	24.6	54	28	80	50	18	67

lower than the unadjusted effect. Because utilization of ANC services is correlated with receipt of tetanus toxoid (TT) injections, consumption of IFA tablets or syrups and the socioeconomic background characteristics, these are included in the model for estimating adjusted effects (Table 3).

Tetanus is a major cause of neonatal mortality in developing countries. Pregnant women require two injections of TT to protect their newborns. It is observed that if the mother is immunized with TT during pregnancy, the likelihood of both neonatal and post-neonatal death is reduced to half. Even after controlling for sociodemographic characteristics and other ANC variables, the adjusted effect of TT immunization to pregnant women on neonatal mortality remained more or less the same. The finding reinforces the importance of TT immunization for pregnant women as this reduces infant and under-five mortality in general and neonatal mortality in particular.

Iron deficiency anaemia among mothers is a major threat to safe motherhood and to the health and survival of the infant because it contributes to low birth weight, lowered resistance to infection and impaired development. Supplementary iron in the form of tablets or syrup is the simplest method of preventing iron deficiency when the requirement is higher over a relative short period of time as in pregnancy and lactation. In India the provision of IFA tablets to pregnant and lactating mothers to prevent anaemia forms an integral part of the RCH Programme. Though the effect of consumption of IFA tablets or syrups is observed to be small during the neonatal period, it is quite high during the post-neonatal period. The adjusted post-neonatal mortality is 40% lower among children whose mothers consumed IFA tablets or syrups than those children whose mothers did not.

It is assumed that children born in institutions are likely to have a better sanitary environment and health care assistance, and thereby have lower neonatal, post-neonatal and infant mortality rates. In India, two-thirds of deliveries take place at home. Some States in India have a high percentage of institutional deliveries (93% in Kerala, 79% in Tamil Nadu and around 50% in Gujarat, Maharashtra, Andhra Pradesh and Karnataka). The effect of place of delivery on neonatal mortality is observed in States where institutional deliveries are higher. In States where facilities for institutional deliveries are lacking, women delivering in institutions are mostly from a high socioeconomic status.

Breastfeeding practices and child mortality

An analysis of the NFHS-1 (1992–93) was carried out to estimate the effect of breastfeeding practices on mortality over the period of infancy (IRMS 2004). It found that the risk of dying during the age segment (1, 6) months was lowest for children breastfeeding and having plain water only compared to the children who were given other types of breastfeeding (Table 4). In the age segment (1, 6) months breastfeeding and plain water only appear to be more

Table 4. Death rates (per 1000 person-years) in different age segments of the first year of life according to type of breastfeeding exposure by selected characteristics irrespective of the level of PNMR*, NFHS-1

Characteristics/ category	Age (in months)	Period of exposure (no. of months preceding the survey)	Death rate (per 1000 person-years) during the period child was under						
			Exclusive breast-feeding	Breast-feeding + water only	Full breast-feeding	Breast-feeding + supplements	Non-exclusive breast-feeding	No breast-feeding	Total
All	1–6	0–12	65.1	13.5	39.2	35.6	23.2	177.4	42.2
	6–12	0–24	114.4	14.9	35.5	11.6	12.4	44.7	21.2
Standard of living index									
Low	1–6	0–12	62.9	11.0	39.6	58.4	29.4	317.0	48.7
	6–12	0–24	87.6	16.1	33.5	13.9	14.5	81.1	24.9
Medium / high	1–6	0–12	70.1	15.6	40.5	25.3	20.2	114.2	38.4
	6–12	0–24	145.1	14.5	36.9	10.7	11.5	31.8	18.8
Residence									
Urban	1–6	0–12	53.8	3.8	23.5	25.4	13.8	81.7	27.3
	6–12	0–24	100.5	11.6	27.6	12.1	12.0	14.0	15.2
Rural	1–6	0–12	67.4	16.7	43.3	39.4	26.5	253.3	46.7
	6–12	0–24	116.6	15.6	37.0	11.5	12.5	64.1	23.0
Mother's education									
Illiterate	1–6	0–12	69.1	16.6	44.2	49.3	29.4	350.2	51.3
	6–12	0–24	126.5	18.7	42.5	12.8	14.5	69.4	26.2
Literate, < middle school	1–6	0–12	52.3	2.3	24.6	11.0	6.6	136.3	23.6
complete	6–12	0–24	61.1	2.3	11.2	10.2	8.7	32.7	13.0
Middle school complete	1–6	0–12	54.8	12.1	29.6	25.4	19.3	5.2	26.4
and above	6–12	0–24	29.6	0.0	4.8	9.1	8.0	18.4	10.5
Caste									
Scheduled caste	1–6	0–12	61.8	15.2	38.1	29.9	22.0	154.0	39.3
	6–12	0–24	109.6	12.2	31.9	10.8	11.1	37.4	18.7
Scheduled tribe	1–6	0–12	55.2	6.2	30.5	29.9	12.3	431.7	37.2
	6–12	0–24	88.3	17.9	33.1	6.6	10.3	110.3	23.9
Others	1–6	0–12	88.9	9.7	51.0	81.2	37.7	243.7	62.3
	6–12	0–24	154.0	25.5	54.2	20.3	21.8	63.9	34.2

*North-eastern States are excluded

beneficial than breastfeeding with supplements, which contradicts the concluding remarks of Anandiah and Choe (2000). The results show that any type of breastfeeding during [1, 6) months and non-exclusive breastfeeding[1] during [6, 12) months reduces the instantaneous risk of mortality. However, during the age segment [1, 6) months the risk of death of children receiving breast milk with plain water only was lower compared to children receiving only breast milk, as well as children receiving breast milk with supplementary food.

A large number of factors other than breastfeeding may affect the post-neonatal mortality rate. The multivariate hazard model with provision of time-dependent covariates was used to compare the effects of exclusive breastfeeding, breastfeeding and water only, and not breastfeeding with respect to breastfeeding with supplements after controlling for the effects on mortality of potentially confounding variables. The results of the hazard analysis revealed that though the relative risk of death of children currently receiving only breast milk at any given age 'a' ($1 \leq a < 6$ months) compared to children currently receiving breast milk plus food supplements at that age is higher, the relative risk of death of children currently receiving breast milk plus plain water only at any given age between 1 and 6 months was much lower compared to children currently receiving breast milk and food supplements (Table 5).

UNICEF and WHO recommend that children should be exclusively breastfed for about 6 months, and complementary foods should begin at around 6 months of age, and that breastfeeding should continue well into the second year of life and beyond. Analysis of the NFHS-1 data revealed that during the early post-neonatal period, if breastfeeding was supplemented with plain water then the mortality was lowest compared to other types of breastfeeding practices. One of

[1]A breastfeeding child given plain water only was also considered as non-exclusively breastfeeding.

Table 5. Proportional hazards analysis of different types of breastfeeding practices on mortality for the age groups 1–4 and 4–6 months for births with an exposure in the aforesaid age group during 12 months and for age groups 6–9, 9–12 months for births with an exposure in the aforesaid age group during 24 months preceding the survey by different background characteristics, NFHS-1

			Children belonging to the age group (in months) Hazard ratio			
Variable	Reference category	Category	1–4	4–6	6–9	9–12
Type of breastfeeding	Breastfeeding + supplements	Exclusive breastfeeding indicator	0.90	1.65	4.78*	10.80*
		(Breastfeeding + water) indicator	0.29*	0.64	0.69	1.33
		Not breastfeeding indicator	5.54*	3.94*	6.36*	3.82*
Place of residence	Rural	Urban	1.14	0.58	0.85	1.19
Mother's age at birth	20–34 years	Less than 20 years	1.58*	0.48	0.79	0.91
		35 years or more	1.49	1.39	1.95*	2.37*
Mother's education	Illiterate	Literate, <middle school complete	0.50*	0.41**	0.66	0.95
		Middle school complete and above	0.35*	0.57	0.38*	0.62
Mother's occupation	Non-gainful occupation	Gainful occupation	1.72*	0.96	1.14	1.51
Interval since last birth	First birth/preceding birth interval 2 years or more	Preceding birth interval less than 2 years	2.01*	1.60	1.69*	1.59†
Antenatal and natal care	No	Yes	0.63*	0.73	0.49*	0.33*
Size of the baby	Medium/large	Small	1.92*	2.54*	1.65*	1.33
Standard of living index	Low	Medium/high	1.05	1.95†	1.02	0.99

Note: Statistical significance: *p<0.05, **0.05<p<0.10, unmarked coefficients are not significant

the possible reasons could be that children on exclusive breastfeeding were possibly not getting the minimum required water that is essential for maintaining body fluids and they might get dehydrated thus leading to death whereas children on water supplements were able to maintain the fluid level leading to better survival. Mortality among young post-neonates receiving food supplements along with breast milk was higher than those who were exclusively breastfed. This reflects the fact that supplementary food given to children is neither sufficient in quantity nor nutritive enough in relation to the requirement. Studies conducted in different parts of the country reported that dehydration following diarrhoea was a major cause of post-neonatal mortality. Transmission of bacilli causing diarrhoea and related illnesses is primarily through food and water. Solid foods given during the second half of the post-neonatal age become a major cause of diarrhoea.

Inequalities in utilization of RCH services

Evaluating the impact of the RCH Programme is a daunting task. With increasing resources being spent to hasten improvement in maternal and child health conditions, there is a need to evaluate these efforts on a regular basis. The most common approach to the evaluation of MCH programmes is to measure the services reported by these programmes and their complementary activities—number of pregnant women who received ANC check-ups, were immunized against TT and received an adequate quantity of iron; number of children immunized, age at immunizations, awareness among mothers about the causes and treatment of diarrhoea, knowledge of mothers about the symptoms of ARI, place of treatment, etc. Such knowledge is essential to reformulate the intervention strategies and their implementation, identify new thrust areas and introduce new approaches to achieve optimum results. Service statistics generate data on a yearly basis on programme inputs and outputs such as immunizations, institutional deliveries, care-seeking indicators, etc. These data are generated from institutions which are covered under the Programme and do not include the inputs and outputs, and the outcomes of the private and voluntary sectors. Thus, most of the published indicators have limited value in assessing outputs and outcomes. Furthermore, outcomes and outputs are sometimes overstated. For example, throughout the 1990s, the reported DPT3 rate for India as a whole was around 90% (Claeson *et al.* 1999), but the DPT3 coverage was found to be only 52% in the NFHS-1 and NFHS-2 (IIPS 1995, IIPS & ORC Macro 2000). Similarly, the Multi-indicator Cluster Survey in 2000 (MICS 2000) gave the DPT3 coverage as 47%.

In the absence of reliable service statistics on the utilization and quality of health care services, it was somewhat difficult to attribute the trends in improvement in child health conditions and reduction in child mortality to programme inputs. Two rounds of the NFHS conducted in 1992–93 (NFHS-1) and 1998–99 (NFHS-2) created a landmark in the field of data collection on various aspects of health and family welfare. The main objective was to provide reliable and high-quality data on a number of issues required for the development, monitoring and evaluation of programmes. To explore the possible reasons for the slowing down of the decline in child mortality we have analysed the extent of utilization of antenatal, natal and postnatal care services among children who were born during the three years preceding the survey for NFHS-2 and four years preceding the survey for NFHS-1. We have also analysed the differentials in the nutritional status, family planning acceptance and reproductive health problems among women in the study population. The effect of programmatic factors, such as antenatal and delivery care, immunization of pregnant women against tetanus, full consumption of IFA tablets or syrups and delivery in a medical facility on neonatal mortality have been estimated using the NFHS-2 data. Table 6 presents the differentials of prenatal, natal and postnatal care, nutritional status, knowledge of mothers about treatment of diarrhoea, etc. Table 7 presents the status of fertility, family planning and nutrition, and the reproductive health problems of mothers, etc.

ANC check-ups

According to NFHS-2, in India only about two-thirds of mothers received ANC during pregnancy, and only 44% received 3 or more check-ups. The above figure has not undergone any change since NFHS-1. Women who did not receive antenatal check-ups are mostly older women, those having high parity, from rural areas, ST, illiterate and poor women. Check-ups during the first trimester were about twice as common in urban areas as in rural areas (IIPS, 1995; IIPS & ORC Macro 2000). The effectiveness of antenatal check-ups in ensuring safe motherhood depends in part on the tests and measurements done and the advice given during the check-ups. The NFHS-2 results show that most of these tests were performed at least 1.5 times more frequently for mothers living in urban areas than for those living in rural areas.

Tetanus toxoid

The proportion of mothers who received two or more TT injections during their pregnancy rose from 55% to 67% between the NFHS-1 to NFHS-2. Coverage (two or more injections) was found to be lower for births to women 35 years of age and above than to younger women; varying inversely by birth order, literacy level of the mother, standard of living; rural and urban areas, and for births to SC mothers.

Institutional deliveries

Deliveries in health facilities in India have increased from 26% during NFHS-1 to 34% during NFHS-2. It is largely assumed that children born in health care institutions are more likely to get a better sanitary environment and receive the required health care assistance, and thereby tend to have lower neonatal mortality than those born at home.

Iron and folic acid supplements

For India as a whole, iron–folic acid (IFA) coverage improved slightly from 52% in NFHS-1 to 58% in NFHS-2. Some of this improvement may be due to the fact that IFA syrup was included in the measurement of IFA coverage in NFHS-2 but not in NFHS-1. Only 66% of mothers received an adequate supply and consumed all of it, 16% received but did not consume all that was supplied.

Vaccinations

The percentage of children fully vaccinated in the age group of 12–23 months in NFHS-1 and NFHS-2 were 35.4% and 42.0%, respectively. The percentage of those vaccinated was higher among urban than rural children. A strong positive relationship of children's immunization coverage was observed with mother's education and standard of living. ST children were less likely to be fully vaccinated than SC children and those of other castes.

Diarrhoea

Deaths from acute diarrhoea are most often due to dehydration and loss of water and electrolytes. Nearly all dehydration-related deaths can be prevented by prompt administration of rehydration solutions. One major goal of the 'Oral Rehydration Therapy Programme' is to increase awareness among mothers and communities about the cause and treatment of diarrhoea. The percentage of children under 3 years of age who suffered from diarrhoea in the two-week period before the survey was 10% in the NFHS-1 and 19% in NFHS-2. However, because of seasonal variations in the prevalence of diarrhoea, the NFHS-1 and NFHS-2 rates cannot be compared. The prevalence among children of mothers with high school or higher education and children living in households with a high standard of living (NFHS-2) was lesser than that among other children. Sixty-two per cent of mothers who had given birth during the three years preceding the survey (NFHS-2) knew about ORS packets; against only 43% in NFHS-1. Knowledge was considerably low among rural, illiterate and ST mothers. However, ORT is a stop-gap measure that does not always manage to compensate for the lack of safe drinking water and clean living conditions, which in many places appear to remain unattainable goals. To assess the possible impact of ORT in reducing deaths due to diarrhoea, it is equally important to know the practices with regard to the food and fluids usually given to children during diarrhoea. Rural, illiterate and ST mothers were much less likely to report correctly (NFHS-2) that children with diarrhoea should be given more to drink. Among children who suffered from diarrhoea during the two weeks preceding the survey, 61.2% in NFHS-1 and 63.2% in NFHS-2 were taken to a health facility. Again, the percentage taken to a health facility was much higher for urban than rural children, and children of more educated mothers. The percentage was particularly low for ST children and for children living in households with a low SLI.

Table 6. Description of ANC care, natal and PNC, prevalance of ARI and diarrhoea and their treatment, India

Characteristic	NFHS round	Place of residence: All	Place of residence: Urban	Place of residence: Rural	Mother's education: Illiterate	Mother's education: Literate, <Middle school complete	Mother's education: Middle school complete	Mother's education: High school complete and above	Caste: SC	Caste: ST	Caste: Other than SC, ST	Standard of living index: Low	Standard of living index: Medium	Standard of living index: High
Antenatal check-ups														
Percentage of mothers who received three or more antenatal check-ups during pregnancy	1	43.6	66.0	37.0	29.0	57.0	79.0		32.0	32.0	48.0	28.0	66.0	69.0
	2	43.8	69.0	37.0	26.0	55.0	77.0		35.0	35.0	48.0	31.0	45.0	71.0
Percentage of mothers who received no antenatal check-ups during pregnancy	1	36.8	17.8	42.4	48.8	19.9	9.8	4.2	42.2	52.3	34.0			
	2	34.0	13.6	39.8	48.4	19.3	13.5	5.8	38.2	43.1	31.1	45.1	32.8	12.4
Tetanus toxoid vaccinations														
Percentage of mothers who received two or more TT injections during pregnancy	1	53.8	74.4	47.7	40.3	71.9	84.3	91.5	47.4	34.1	57.3	39.0	75.0	78.0
	2	66.8	81.9	62.5	54.7	78.4	84.2	91.2	64.8	46.4	70.5	55.4	68.7	87.5
Percentage of mothers who received no TT injections during pregnancy	1	39.0	19.4	44.7	51.7	20.9	10.0	4.4	45.4	56.2	35.7			
	2	24.1	9.9	28.2	35.3	12.5	7.5	3.0	25.8	38.7	21.2	34.1	22.3	6.4
Place of delivery and birth attendent at time of delivery														
Percentage of institutional deliveries	1	35.5	17.0	56.0	11.8	37.8	55.4	75.3	16.0	9.1	29.2	11.0	48.0	23.0
	2	33.6	65.0	25.0	17.4	43.4	55.1	75.0	26.8	17.1	38.0	18.5	34.9	64.6
Percentage of home deliveries attended by trained birth attendent	1	35.2	22.0	39.1	41.8	30.2	20.4	10.5	39.5	41.8	33.7	—	—	—
	2	35.0	18.8	39.6	44.7	28.4	21.0	11.8	37.7	44.4	33.0	43.5	34.3	17.5
Consumption of iron–folic acid tablets or syrups														
Percentage of mothers given IFA tablets during pregnancy														
During four years preceding the survey	1	50.5	68.7	45.1	38.3	66.6	77.2	85.6	44.2	40.2	52.8	51.0	49.0	59.0
During three years preceding the survey	2	57.6	75.7	52.5	43.6	70.4	78.5	86.5	54.6	48.6	60.2	46.0	59.4	79.2
Among those who received IFA during pregnancy percentage who consumed all the supply	2	80.5	83.2	79.4	76.3	80.7	81.5	88.7	76.2	82.0	81.5	77.1	80.2	86.1
Percentage of children age 12–23 months who received all vaccinations														
All*	1	35.4	50.7	30.9	24.0	46.9	60.3	70.0	26.8	24.8	38.2	—	—	—
	2	42.0	60.5	36.6	27.8	52.3	62.7	72.7	40.2	26.4	45.1	30.4	43.2	64.7
None	1	30.0	16.4	34.0	40.1	16.9	8.2	4.2	36.9	41.8	27.4			
	2	14.4	6.40	16.7	21.2	8.0	4.6	1.4	15.1	24.2	12.5	20.8	13.1	4.0
Percentage of children who were ill with diarrhoea† during the two weeks preceding the survey														
Among all children under four years of age	1	10.0	8.80	10.4	10.3	10.4	9.6	8.3	11.4	9.9	9.8	—	—	—
Among all children under three years of age	2	19.2	19.6	19.0	20.1	19.8	18.6	15.0	19.8	21.1	18.7	19.9	19.7	16.1
Percentage of diarrhoea cases taken to a health facility or provider														
Among all children under four years of age	1	61.2	68.7	59.3	58.0	66.0	67.5	70.9	61.2	51.5	62.4	—	—	—
Among all children under three years of age	2	63.4	75.2	59.9	58.5	65.2	74.2	78.2	54.6	52.2	65.1	55.5	65.1	77.2
Percentage of children who were ill with ARI during the two weeks preceding the survey														
Among all children under four years of age	1	6.5	5.1	6.9	6.5	7.7	5.9	4.6	6.8	6.1	6.5	—	—	—

(Cont.)

Table 6 *(cont.)*. Description of ANC care, natal and PNC, prevalance of ARI and diarrhoea and their treatment, India

Characteristic	NFHS round	All	Place of residence: Urban	Place of residence: Rural	Mother's education: Illiterate	Mother's education: Literate, <Middle school complete	Mother's education: Middle school complete	Mother's education: High school complete and above	Caste: SC	Caste: ST	Caste: Other than SC, ST	Standard of living index: Low	Standard of living index: Medium	Standard of living index: High
Among all children under three years of age	2	19.3	16.2	20.3	20.6	20.3	18.8	13.8	19.6	22.4	18.9	21.0	19.4	15.7
Percentage with ARI taken to a health facility or provider														
Among all children under four years of age	1	66.3	77.1	63.9	62.4	70.4	72.0	84.9	64.0	59.1	67.6	—	—	—
Among all children under three years of age	2	64.0	75.1	61.4	58.3	69.5	76.3	77.0	60.3	50.4	67.5	55.1	67.4	76.9
Percentage of children who were classified as undernourished according weight for age														
Weight - for - height														
Among children under under four years of age Percentage below –3 SD ***	1	20.6	14.8	22.4	24.7	16.7	12.4	7.8	23.7	25.3	19.5	—	—	—
Among children under under three years of age Percentage below –3 SD ***	2	18.0	11.6	19.9	24.1	13.1	10.8	5.8	21.2	26.0	15.6	25.3	16.5	6.7
Percentage of having iron-deficiency anaemia by degree of anaemia														
Children age 6–35 months with any anaemia	2	74.3	70.8	75.3	78.2	74.6	69.7	61.9	78.3	79.8	72.4	78.7	73.5	67.3
Percentage of births during three years preceding the survey														
Birth order														
4+	1	31.0	24.1	32.9	38.5	23.6	12.4	7.4	—	—	—	—	—	—
	2	27.5	19.2	29.9	38.2	19.6	9.3	4.6	31.5	34.0	25.3	36.7	25.7	11.7
Preceding birth interval														
Less than 24 months	1	26.9	28.8	26.3	25.8	28.7	30.6	30.3	27.2	26.5	—	—	—	—
	2	28.3	29.4	27.9	27.5	30.0	31.3	27.8	27.3	29.3	28.4	27.2	28.9	29.3

Note:

*Children who were fully vaccinated, i.e. those who received BCG, measles and three doses of DPT and polio vaccine (excluding polio 0)

†Diarrhoea includes blood also

***Includes children who were below –3 SD from the International Reference Population Median.

Sources: International Institute for Population Sciences (IIPS). National Family Health Survey India, 1992–93 (NFHS-1), International Institute for Population Sciences, Mumbai, 1995
International Institute for Population Sciences (IIPS) and ORC Macro. National Family Health Survey (NFHS-2), India, 1998–99. Mumbai: IIPS; and Maryland, USA: ORC Macro; 2000

Table 7. Description of various characteristics of fertlity, family planning, nuitritional and reproductive health problems among mothers, India

Characteristic	NFHS round	All	Place of residence		Mother's education				Caste			Standard of living index		
			Urban	Rural	Illiterate	Literate, <middle school complete	Middle school complete	High school complete and above	SC	ST	OBC/ others	Low	Medium	High
Median age at first marriage among women age 20–49 years														
Current age														
20–49 years	1	16.1	18.1	15.5	15.0	16.8	18.4	21.3	15.0	15.8	16.3	—	—	—
	2	16.4	18.4	15.8	—	—	—	—	—	—	—	—	—	—
Total fertility rate														
During three years preceding the survey	1	3.4	2.7	3.7	4.0	3.0	2.5	2.2	3.9	3.6	3.3	—	—	—
	2	2.9	2.3	3.1	3.5	2.6	2.3	2.0	3.2	3.1	—	3.4	2.9	2.1
Contraceptive method														
Percentage of currently married women using any modern method	1	36.3	45.3	33.1	31.5	44.8	42.4	45.0	31.7	30.8	37.6	—	—	—
	2	42.8	51.2	39.9	39.2	49.7	44.6	47.1	40.1	35.2	44.7	35.5	43.35	3.1
Percentage of ever married women with BMI below 18.5 kg/m²														
Among ever married women[2]	2	35.8	22.6	40.6	42.6	32.6	28.0	17.8	42.1	46.3	32.9	48.1	35.6	17.3
Percentage of having iron-deficiency anaemia by degree of anaemia														
Percentage of ever married women with any anaemia	2	51.8	45.7	53.9	55.8	50.1	48.0	40.3	56.0	64.9	49.0	60.2	50.3	41.9
Symptoms of reproductive health problem														
Percentage of ever married women reporting any abnormal vaginal dischage or symptoms of urinary tract infection[1]	2	35.5	33.1	36.4	37.3	36.2	34.3	28.0	36.1	39.2	35.1	37.4	36.3	30.6
Percentage of currently married women reporting any reproductive health problem	2	39.2	36.7	40.1	40.8	39.9	38.6	32.4	39.9	42.0	38.7	41.3	40.1	34.0
Home visits by a health or famiy planning worker														
Percentage of ever married women who had at least one visit in the 12 months preceding the survey	2	13.0	10.0	14.0	11.5	15.9	17.0	12.6	13.4	17.9	12.4	14.2	13.3	10.3
*Percentage who know two or more signs for medical treatment of diarhoea**														
Among mothers with births during the three years preceding the survey	2	37.1	37.1	37.1	34.9	38.3	42.1	41.4	37.5	35.1	37.2	—	—	—
Percentage of mothers with births who know about ORS packets														
At least one birth during the four years preceding the survey	1	42.7	55.6	38.9	31.8	56.4	62.7	75.4	35.3	26.8	45.9	—	—	—
At least one birth during the three years preceding the survey	2	62.4	75.8	58.6	51.2	72.3	77.2	86.5	59.3	51.3	64.8	—	—	—
Reported quantity (of ORS) to be given to drink during diarrhoea														
More amount	2	29.4	36.8	27.3	22.2	32.0	51.1	26.5	22.0	31.3	—	—	—	—

*Diarrhoea includes blood also

[1]Includes pain or burning while urinating or more frequent or difficult urination. [2] Excluded women who were pregnant and women with a birth in the preceding two months

Sources: International Institute for Population Sciences (IIPS). National Family Health Survey India, 1992–93 (NFHS-1), International Institute for Population Sciences, Mumbai, 1995
International Institute for Population Sciences (IIPS) and ORC Macro. National Family Health Survey (NFHS-2), India, 1998–99. Mumbai: IIPS; and Maryland, USA: ORC Macro; 2000

Acute respiratory infection

Small variations in the prevalence of ARI by most of the background characteristics was observed. ARI was somewhat more common among children living in rural areas than those living in urban areas. Children of mothers with at least middle school education seemed to have a lower occurrence of ARI than children of those educated below middle school. The prevalence of ARI was higher among children in ST households and those having a low standard of living. The percentage of children with ARI taken to a health facility or provider has a strong positive relationship with the mother's educational attainment and household standard of living. By caste/tribe, this percentage is lower for SC and ST than other backward classes or 'others'. By place of residence, urban children were taken more often to a health facility or provider than rural children.

Low birth weight

The NFHS-1 and NFHS-2 had taken the perceived size of the baby (large/very large, average and small/very small), as the proxy for birth weight, and provided estimates of NMR, PNMR and IMR according to the size of the baby. The percentage of children with a small size or who were very small at birth was found to be higher among mothers belonging to socioeconomically disadvantaged households than among socioeconomically advantaged ones.

Nutritional status of the children

Nutrition has an important bearing on maternal and child health. Inadequate or unbalanced diets and chronic illness are associated with poor nutrition among children. Diarrhoea and dehydration may be underlying causes of death among children who have low levels of nutrition than among better-nourished children. Malnutrition is precipitated and aggravated by diarrhoea through inadequate absorption of nutrients from the food. The proportion of children under 4 years of age in NFHS-1 and under 3 years of age in NFHS-2 who were severely undernourished was 20.6% (according to weight for age) and 18.0%, respectively. Further, anaemia among young children can result in impaired cognitive performance, behavioural and motor development and scholastic achievement, as well as increased morbidity from infectious diseases (Seshadri 1997). According to NFHS-2, among children 6–24 months of age, 74% had some level of anaemia; 23% were mildly anaemic, 46% were moderately anaemic and 5% severely anaemic, confirming the findings of Stoltzfus and Deyfuss (1998) that one of the most vulnerable groups among children is the age group of 6–24 months. Undernutrition and a high level of anaemia were found to be higher among rural children, children whose mothers were illiterate, children belonging to the SC and ST and poor children.

Family planning

The reduction in maternal and child mortality can be achieved by promoting family planning spacing methods, which help in reducing high-risk pregnancies (pregnancy at younger ages and closely spaced pregnancies), while terminal methods, which greatly help in reducing pregnancies of a higher order and in older women. Comparison of the results of the NFHS-2 with NFHS-1 for current contraceptive use revealed an 18% increase in the use of modern methods of contraceptives in 6–7 years' time. A low rate of increase between the two surveys could be due to a shift from traditional target systems of family planning to a target-free approach and integrating such services into health programmes. The percentage of couples currently using contraceptives was found to increase with education and standard of living; it was lowest among women from the SC and highest among women who did not belong to the SC and ST; and higher among urban women as compared to rural women.

Nutritional status of women

The nutritional status of and level anaemia in children were strongly related to the nutritional status of and level of anaemia in the mother. The NFHS-2 provided information on body mass index (BMI), a measure of nutritional status, and prevalence of anaemia among ever-married women 15–49 years of age. The BMI, which is used to assess both thinness and obesity (defined as the weight in kilograms divided by the height in meters squared [kg/m^2]), was obtained for ever-married women who were non-pregnant at the time of the survey and those who had not given birth during the two months preceding the survey. Chronic energy deficiency is usually indicated by a BMI of less than 18.5. Thirty-six per cent of women had a BMI below 18.5, indicating a high prevalence of nutritional deficiency.

Anaemia among women may have detrimental effects on their health and that of their children, and may become an underlying cause of maternal and perinatal mortality. Anaemia results in an increased risk of premature delivery and low birth weight. The overall prevalence of anaemia among women, as reported in NFHS-2, was 52%. The prevalence of mild, moderate and severe anaemia was, respectively, 35%, 15% and 2%. The prevalence of anaemia and low BMI were both considerably higher for rural women, for SC/ST women and inversely related to educational level and SLI. Though differences in the prevalence of anaemia by background characteristics was observed, it was substantial for every population group.

Disadvantaged and advantaged groups

Inequalities in child health are well documented in NFHS-1 and NFHS-2. Data reveal that disadvantaged/vulnerable groups are less likely to receive child survival interventions that can prevent the most common diseases. It is well-documented (Victora *et al.* 2003) that children from poor households are more likely to be exposed to many disease agents and have lower resistance to those risks and become sick vis-à-vis children from richer households.

The disadvantaged group consists of people belonging to the lowest socioeconomic rungs of society. They have low levels of literacy, a low standard of living, are less exposed to media, and thus have low concern about health care. This gets reflected in under-usage of proper medical services, low nutritional imbalance and poor personal hygiene. Thus higher rate of mortality among the disadvantaged may be due to inequalities in coverage of preventive interventions. These reasons may also be responsible for the slowing down/stagnation of the decline in infant and child mortality. The differentials in the level of child mortality within and between States may be due to varying proportions of disadvantaged groups. Therefore, further reduction in IMR and CMR can be realized by improving the delivery of RCH services in communities with a relatively high IMR. A healthy child requires many coordinated preventive and therapeutic interventions and these demand renewed action.

Projection

The National Population Policy (2000) has set the goal to reduce the IMR to less than 30 by the year 2010. This necessitates projecting the IMR and U5MR for India up to 2016. Assuming that in the immediate future, the mortality will continue to follow the prevailing trend, the projected figures and values of IMR and U5MR up to 2016 for India are presented in Figs 5 and 6 (Tables 8 and 9), respectively. It appears that without further intervention, India will not be able to achieve the set target of an IMR of less than 30 by 2010. However, despite the inherent limitations of SRS data, the declining trend observed for IMR in the present study can be considered valid.

Mortality forecasts largely depend on the factors associated with child mortality. Therefore, one way to improve the mortality forecasts is to gain insight into the causes and predictors of mortality. If the risk profile of the current cohort compared to previous cohorts is determined, then the forecasts will improve. Mortality projections based on several covariate alternatives should be obtained. These alternatives should cover a realistic future-related range of variation in programme-related aspects. However, the number of alternatives should not be so large that it creates confusion and complications in using the mortality projections.

Conclusion

The foregoing analysis shows that the under-five mortality in India and its States has declined during the period 1978–2002. However, the pace of decline has not been constant, it has sometimes been slow and stagnated, and at times even increased. Such a scenario generates curiosity to unearth the factors that might have played a role in the decline of child mortality in the country and in some of the major States. Disparities observed in child mortality might be explained, to some extent, by the differences in the socio-economic status of mothers and households. Analysis of two rounds of the NFHS-1 and NFHS-2 depicted an inverse relationship between child mortality and socioeconomic factors including education of mother and standard of living of the household. However, a keen observation of child mortality data revealed that the differences in child mortality continued even after controlling for the effect of socio-economic status of the household. Such a scenario necessitates examination of the differences in child mortality among the socially and economically vulnerable/disadvantaged groups. We can attribute the differences in child mortality to complex set of social, economical and biological factors affecting the same. In addition, the decline in child mortality could also be a result of programme factors such as public health

Fig. 5 Forecast of infant mortality rate of India for 2003–2016

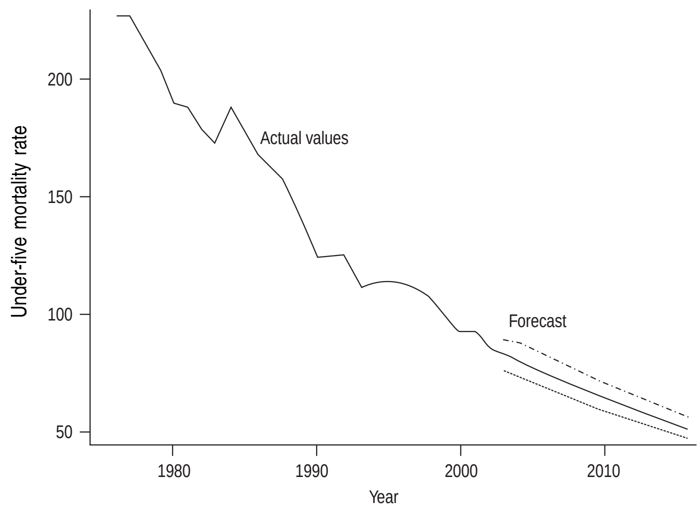

Fig. 6 Forecast of under-five mortality rate of India for 2003–2016

Table 8. Predicted values of infant mortality rates and associated 95% confidence intervals using the ARIMA model by States and India, 2003–2016

State	Fitted ARIMA model	IMR Values	Years													
			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Andhra Pradesh	(0,1,1)	Predicted	59	58	56	55	53	51	50	49	47	46	45	43	42	41
		LCL	53	48	45	42	39	37	35	33	31	30	28	27	25	24
		UCL	66	69	70	71	72	72	72	72	71	71	70	70	9	69
Assam	(0,1,1)	Predicted	69	67	66	65	64	62	61	60	59	57	56	55	54	53
		LCL	61	57	55	52	50	48	46	44	42	41	39	38	37	36
		UCL	78	79	80	81	81	81	1	81	81	81	0	80	80	9
Bihar	(0,1,1)	Predicted	57	56	54	53	51	50	49	47	46	45	44	43	41	40
		LCL	50	46	43	40	38	35	34	32	30	29	27	26	25	24
		UCL	65	67	69	70	70	70	70	70	70	70	70	69	69	68
Gujarat	(0,1,1)	Predicted	58	56	54	52	50	49	47	46	44	43	41	40	39	37
		LCL	51	48	45	42	40	38	36	34	32	31	29	28	27	25
		UCL	65	65	65	65	64	63	0	61	60	9	58	57	6	55
Haryana	(0,1,1)	Predicted	61	60	59	57	56	55	53	52	51	50	49	48	47	46
		LCL	54	53	51	49	48	47	45	44	43	41	40	39	38	37
		UCL	69	68	67	66	65	64	63	62	61	60	59	58	57	56
Himachal Pradesh	(0,1,1)	Predicted	51	49	48	47	45	44	43	42	41	40	39	37	36	35
		LCL	42	39	36	34	32	30	28	27	25	24	23	22	21	20
		UCL	61	63	64	64	65	65	65	65	65	65	65	65	64	64
Karnataka	(0,1,1)	Predicted	54	54	53	52	51	50	49	48	48	47	46	45	45	44
		LCL	47	45	43	41	39	38	36	35	34	33	32	31	30	29
		UCL	62	64	65	66	66	67	67	67	67	67	67	67	67	67
Kerala	(0,1,1)	Predicted	10	9	9	8	8	7	7	6	6	6	5	5	5	4
		LCL	8	7	6	6	5	5	4	4	4	3	3	3	3	3
		UCL	13	12	12	12	11	11	10	10	10	9	9	8	8	8
Madhya Pradesh	(0,1,1)	Predicted	81	79	77	75	74	72	70	69	67	66	64	63	62	60
		LCL	74	72	70	68	66	64	62	61	59	57	56	54	53	51
		UCL	87	86	85	83	82	81	80	78	77	76	74	73	72	71
Maharashtra	(0,1,1)	Predicted	42	41	40	38	37	36	35	34	33	32	32	31	30	29
		LCL	37	36	35	34	33	32	31	30	29	28	28	27	26	25
		UCL	48	47	45	44	43	42	40	39	38	37	36	35	34	33
Orissa	(0,1,1)	Predicted	86	85	84	82	80	78	77	75	74	72	70	69	68	66
		LCL	80	78	76	75	73	71	70	68	67	66	64	63	61	60
		UCL	94	93	92	90	88	86	84	83	81	79	77	76	74	73
Punjab	(0,1,1)	Predicted	49	47	46	45	43	42	41	40	38	37	36	35	34	33
		LCL	42	40	38	36	35	33	32	30	29	28	27	26	25	24
		UCL	56	56	55	55	54	53	52	51	51	50	49	48	47	46
Rajasthan	(0,1,1)	Predicted	76	74	72	71	69	67	66	64	63	61	60	58	57	56
		LCL	65	61	57	54	52	49	47	45	43	41	39	38	36	35
		UCL	89	90	91	92	92	92	92	92	92	91	91	90	90	89

(Cont.)

Table 8 (*cont.*). Predicted values of infant mortality rates and associated 95% confidence intervals using the ARIMA model by States and India, 2003–2016

State	Fitted ARIMA model	IMR Values	Years													
			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tamil Nadu	(0,1,1)	Predicted	43	42	41	39	38	37	36	34	33	32	31	30	29	28
		LCL	39	37	35	34	32	31	29	28	27	26	24	23	22	22
		UCL	48	47	47	46	45	44	43	42	41	40	39	38	38	37
Uttar Pradesh	(0,1,1)	Predicted	77	74	72	70	68	66	64	62	60	58	57	55	53	52
		LCL	70	66	62	59	56	53	51	48	46	44	42	41	39	37
		UCL	84	84	84	83	82	81	80	79	78	7	75	74	73	71
West Bengal	(0,1,1)	Predicted	47	46	44	43	42	41	40	39	37	36	35	34	34	33
		LCL	43	42	40	39	38	37	36	35	34	33	32	31	31	30
		UCL	51	50	48	47	46	45	43	42	41	40	39	38	37	36
India	(0,1,1)	Predicted	61	60	58	56	55	53	52	50	49	48	46	45	44	42
		LCL	58	55	53	51	49	47	45	44	42	41	39	38	37	35
		UCL	65	64	63	62	61	60	59	58	57	55	54	53	52	51

ARIMA: autoregressive integrated moving averages; LCL: lower confidence level; UCL: upper confidence level

Table 9. Predicted values of under-five mortality rates and associated 95% confidence intervals using the ARIMA model, India, 2003–2016

Fitted ARIMA model	U5MR values	Year													
		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
(0,1,2)	Predicted	82	81	78	75	72	69	67	64	62	60	58	55	53	51
	LCL	76	74	71	68	66	64	61	59	57	55	53	51	49	47
	UCL	89	88	85	82	79	76	73	70	68	65	63	61	58	56

ARIMA: autoregressive integrated moving averages; LCL: lower confidence level; UCL: upper confidence level reforms, access and quality of health care services and community mobilization. Several studies indicate that health care interventions are determinants of the variations in infant and child mortality.

The trend in IMR for the country over the past 25 years revealed that the share of neonatal morality has remained more or less constant but an appreciable decline is observed in case of post-neonatal mortality. Usually any intervention programme targeted at reducing child mortality shows its impact first on post-neonatal mortality and later on early and late neonatal mortality. This is expected as most of our programmes, such as the EPI (Expanded Immunization Programme) started in 1978 to combat infectious diseases such as polio, etc. among children were targeted at reducing child mortality during the post-neonatal stage. Thus, new intervention programmes need to focus more on lowering neonatal mortality. This could be done to a large extent by strengthening antenatal, natal and delivery care interventions. During the 1970s, 40% of neonatal deaths in rural areas and 25% in urban areas were due to tetanus. By focusing on strategies to increase institutional deliveries, births attended by trained birth attendants and coverage of two doses of TT immunization to pregnant mothers, deaths due to tetanus have declined from 14% in 1978 to less than 5% in the early 1990s and 1% in the late 1990s.

Further, a rapid decline observed in IMR and under-five mortality during 1980–90 was followed by a period of stagnation from 1993, as it was hovering around 72 per thousand live-births (GOI 2000). The stagnation during this period may indicate that the programmes addressing reduction in child mortality were not effective in reducing the IMR as a large proportion of infants were dying in the neonatal stage. Thus, programmes such as RCH Programme, immunization programme and ICDS were not really oriented towards capturing infants dying during the neonatal stage. The other reason for the stagnation in IMR could be the lack of access to health and other types of services by disadvantaged/vulnerable groups.

The IMR and child mortality projected up to 2016 show that India might not be able to achieve the set target of an IMR of 30 by 2010 without making concerted efforts to improve the content and quality of RCH services and concentrate on community mobilization strategies. In addition, economic and social reforms should be commensurate with programme interventions bringing about an appreciable reduction in IMR and child mortality in the near future.

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Appendix 1

Table A1.1 Stillbirth rate and components of infant mortality rate, India, 1970–2002

	Stillbirth rate			Early neonatal mortality rate			Neonatal mortality rate			Postneonatal mortality rate		
Year	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
1970	NA	NA	NA	NA	NA	NA	69	72	46	61	64	45
1971	18	18	13	37	39	23	75	81	45	54	57	37
1972	18	19	14	33	35	23	72	77	45	68	73	40
1973	18	18	15	34	36	23	68	72	48	66	71	41
1974	17	18	13	36	38	24	70	76	41	56	60	33
1975	18	19	13	38	41	24	78	84	46	62	67	38
1976	18	19	11	50	59	33	77	83	49	52	56	31
1977	16	17	9	49	54	27	80	88	42	50	52	39
1978	15	16	10	48	53	23	77	85	38	50	52	36
1979	13	13	9	47	50	30	72	78	42	48	52	30
1980	11	12	8	45	48	28	69	76	39	45	48	26
1981	11	11	6	44	48	25	70	76	39	41	44	24
1982	9	10	5	45	48	28	67	73	39	38	41	26
1983	9	9	8	45	49	27	67	74	39	38	40	27
1984	10	11	8	44	48	28	66	72	40	38	41	26
1985	10	11	9	38	42	22	60	67	33	37	40	26
1986	10	11	9	38	42	24	60	66	36	37	39	26
1987	13	14	10	38	41	23	58	64	33	38	41	27
1988	14	14	12	37	40	23	57	62	35	38	40	28
1989	13	13	11	35	38	20	56	62	31	35	36	26
1990	12	12	11	37	40	23	53	57	31	27	29	20
1991	11	11	10	36	39	23	51	55	32	29	31	21
1992	12	12	10	36	39	24	50	54	33	29	31	20
1993	11	11	9	34	38	22	47	52	28	26	28	16
1994	9	7	15	34	36	24	48	52	33	26	28	20
1995	9	9	9	36	39	23	48	52	29	26	28	19
1996	9	9	9	35	37	23	47	50	28	25	27	17
1997	9	9	9	35	38	20	46	51	26	25	26	19
1998	9	9	8	34	37	22	45	49	27	27	28	18
1999	10	11	8	34	37	22	45	49	28	24	26	16
2000	8	9	7	32	35	19	44	49	27	23	25	16
2001	9	10	8	27	30	17	40	44	25	26	28	17
2002	9	9	7	25	29	16	40	44	24	24	26	16

Source: Sample Registration System, 1970–2002

Table A1.2 Selected indicators of under-five mortality by residence, India, 1970–2002

	Infant mortality rate			Child mortality rate ($1000^*{}_4q_1$)			Under-five mortality rage ($1000^*{}_5q_0$)		
Year	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
1970	129	136	90	122	137	66	235	255	150
1971	129	138	82	117	127	74	231	247	150
1972	139	150	85	131	144	71	252	272	150
1973	134	143	89	113	124	63	232	250	146
1974	126	136	74	111	123	59	223	242	128
1975	140	151	84	119	132	69	243	263	147
1976	129	139	80	113	121	64	227	243	139
1977	130	140	81	111	124	50	227	247	127
1978	127	137	74	102	114	54	216	236	124
1979	120	130	72	98	110	44	206	226	113
1980	114	124	65	86	96	43	190	208	106
1981	110	119	63	87	98	37	188	205	97
1982	105	114	65	83	96	37	179	199	100
1983	105	114	66	76	86	39	173	190	102
1984	104	113	66	93	107	47	188	208	110
1985	97	107	59	87	100	42	176	196	99
1986	96	105	62	80	91	40	168	186	100
1987	95	104	61	74	86	28	162	181	87
1988	94	102	62	67	70	29	154	165	90
1989	91	98	58	53	62	25	140	154	81
1990	80	86	50	48	55	24	124	136	73
1991	80	87	53	49	54	25	125	136	77
1992	79	85	53	50	56	24	125	136	75
1993	74	82	45	41	47	21	112	125	65
1994	74	80	52	42	47	25	113	123	76
1995	74	80	48	44	49	26	114	125	72
1996	72	77	46	44	50	24	113	123	69
1997	71	77	45	42	47	19	110	121	64
1998	72	77	45	38	44	18	107	117	62
1999	70	75	44	29	36	14	97	109	57
2000	68	74	43	27	32	14	93	103	56
2001	66	72	42	28	33	13	93	102	54
2002	63	69	40	24	27	11	85	94	50

Source: Sample Registration System, 1970–2002

Table A1.3 Percentage of early neonatal deaths among neonates, percentage of neonatal deaths among infants and percentage of infant deaths among under-five deaths, India, 1970–2002

	Early neonatal mortality as a percentage of NMR			NMR as a percentage of IMR (1000* $_4q_1$)			IMR as a percentage of under-five mortality		
Year	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
1970	NA	NA	NA	53.1	53.2	51.1	54.9	53.4	60.0
1971	48.6	48.5	50.7	58.3	58.4	55.4	55.9	55.8	54.8
1972	46.8	46.3	50.2	51.5	51.1	52.8	55.3	55.2	56.8
1973	49.5	49.9	47.7	50.9	50.4	53.4	57.7	57.3	60.9
1974	50.9	50.0	58.8	55.6	55.7	55.4	56.5	56.2	57.7
1975	48.9	48.6	51.7	55.9	55.8	55.0	57.7	57.4	57.0
1976	65.2	71.1	67.3	59.7	59.7	61.3	56.8	57.1	57.7
1977	61.0	60.9	64.1	61.7	62.9	51.9	57.3	56.7	63.6
1978	61.9	61.9	61.7	60.9	62.2	51.4	58.7	58.1	59.8
1979	65.5	65.0	70.5	59.8	59.9	58.7	58.3	57.5	63.8
1980	64.8	64.1	70.6	60.8	61.0	60.0	59.9	59.6	61.8
1981	63.6	63.4	66.1	63.3	63.5	61.6	58.9	58.1	64.2
1982	67.0	66.4	72.3	63.6	64.1	59.5	58.6	57.2	65.4
1983	66.5	66.2	69.3	64.1	64.7	59.7	60.8	59.9	64.6
1984	66.7	66.2	70.6	63.3	63.7	60.1	55.5	54.5	60.1
1985	63.4	63.1	65.1	61.8	62.5	56.5	55.3	54.3	59.7
1986	64.0	63.7	66.1	62.0	62.6	58.4	57.3	56.3	62.2
1987	65.3	65.0	68.5	60.7	61.2	54.6	58.5	57.4	69.9
1988	64.4	64.1	66.7	60.4	60.8	55.8	60.9	62.0	69.2
1989	62.0	61.7	63.8	62.0	63.4	54.1	65.2	63.7	71.3
1990	70.5	70.2	75.3	65.6	66.7	61.8	64.6	63.2	68.6
1991	69.8	69.7	72.4	63.9	63.7	60.8	64.1	63.9	68.7
1992	72.6	72.3	73.2	63.3	63.1	62.3	63.3	62.4	70.4
1993	72.3	71.7	77.1	63.6	63.8	63.1	65.9	65.5	69.3
1994	71.1	69.9	73.2	64.5	65.0	62.7	65.4	65.1	68.7
1995	74.4	74.3	77.9	64.9	65.0	60.4	64.6	64.1	66.2
1996	75.1	74.7	82.9	65.3	64.9	60.9	63.6	62.4	66.9
1997	75.7	74.6	78.0	64.8	66.2	57.8	64.8	63.8	70.8
1998	75.6	75.5	81.5	62.5	63.6	60.0	67.4	65.7	72.4
1999	75.6	75.5	78.6	64.3	65.3	63.6	71.9	69.0	77.3
2000	72.7	71.4	70.4	64.7	66.2	62.8	72.7	71.6	76.7
2001	67.5	68.2	68.0	60.6	61.1	59.5	71.3	70.4	77.2
2002	67.5	65.9	66.7	63.5	63.8	60.0	74.1	73.4	80.0

Calculated values

Table A1.4 Percentage distribution of mothers according to selected characteristics, NFHS-1 and NFHS-2

				Mother's education							
		Place of residence					Caste		Standard of living index		
Characteristics	NFHS round	Rural	Urban	Illiterate	Literate, <middle school complete	Middle school complete and above	SC/ST	OBC/ Others	Low	Medium	High
Percentage of mothers who received any iron–folic acid tablets or syrups during pregnancy	1	53	47	43	57	70	54	46	51	49	59
	2	53	76	42	71	83	54	60	47	60	79
Percentage of mothers who received 3 or more antenatal check-ups during pregnancy	1	37	66	29	57	79	32	48	28	66	69
	2	37	69	26	55	77	35	48	31	45	71
Percentage of babies having very small/small size at time of birth	1	22	20	22	23	26	21	21	22	20	25
	2	25	22	26	25	19	26	24	26	25	19
Percentage of mothers received 2 or more tetanus toxoid injections during pregnancy	1	48	73	40	68	86	41	59	39	75	78
	2	63	82	54	78	88	59	71	56	69	87
Percentage of mothers whose age was <20 years at time of birth	1	22	16	23	23	14	23	20	23	18	19
	2	25	18	24	29	17	25	23	25	25	15
Percentage of births of order two or more and the length of the preceding birth interval <24 months	1	38	35	40	35	30	39	36	40	33	32
	2	17	17	17	18	14	17	16	16	17	16
Percentage of births of order four or more	1	32	23	38	24	9	34	28	38	19	13
	2	30	19	39	20	7	32	25	36	26	12

Sources: International Institute for Population Sciences (IIPS). National Family Health Survey India, 1992–93 (NFHS-1), International Institute for Population Sciences, Mumbai, 1995

International Institute for Population Sciences (IIPS) and ORC Macro. National Family Health Survey (NFHS-2), India, 1998–99. Mumbai: IIPS; and Maryland, USA: ORC Macro; 2000