Potential for Reducing Child and Maternal Mortality through Reproductive and Child Health Intervention Programmes: An Illustrative Case Study from India[1]

Some countries may have inadequate technical and financial resources for improving reproductive and maternal and child health services. International cooperation both within the Asian and Pacific region and the wider global community may be required to meet the challenges of the Millennium Development Goals at the regional level.

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In September 2000, at the United Nations Millennium Summit in New York, leaders of the world's Governments signed the Millennium Declaration and committed themselves to a series of goals and targets that came to be known as the

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Millennium Development Goals (MDGs). The Goals include reducing under-five mortality by two thirds (Goal 4) and reducing maternal mortality ratio by three quarters (Goal 5) between 1990 and 2015 (IMF, OECD, United Nations and World Bank Group, 2000). According to the assessment made in 2003 by ESCAP, UNDP and ADB, among 47 countries in the ESCAP region for which data are available, one half (24 countries) have already achieved Goal 4 and four additional countries are expected to achieve the Goal, leaving 19 countries (40 per cent) making slow progress or regressing. As for Goal 5 (improve maternal health), of the 42 countries for which data are available, seven have already achieved the Goal and another seven are expected to achieve it, leaving 28 countries (two thirds) either making slow progress or regressing. Goal 5 (reduction by three quarters) is more ambitious than Goal 4 (reduction by two thirds) and it is not surprising that fewer countries are progressing well towards the first than towards the latter. India is classified as progressing slowly towards Goal 4 and regressing in achieving Goal 5 as of 2003 (ESCAP, UNDP and ADB, 2005).

In this paper, the authors first examine patterns of major correlates of under-five mortality rate and maternal mortality ratios, as well as the progress towards meeting the Goals of reducing under-five mortality rate and maternal mortality ratio among the countries in the Asian and Pacific region. Doing so, one hopes to get a better understanding of why some countries are progressing well towards meeting some of the Goals while some are lagging behind. It is followed by an in-depth analysis of estimating potential for reducing under-five mortality through reproductive and child health intervention programmes including family planning, antenatal care and child immunization, using India as an illustrative example.

Correlates of under-five mortality rate and maternal mortality ratio

Recent studies of under-five mortality have identified its key determinants as poverty, mother's education, mother's fertility behaviour (such as age pattern of fertility, birth spacing and number of births), environmental conditions (such as source of drinking water and toilet facility), utilization of reproductive and child health services (such as prenatal care, delivery care and child immunization), and utilization of health-care services of sick children (Ahmed, Lopez and Inoue, 2000; Black, Morris and Bryce, 2003; Koenig, Philips, Campbell and D'Souza, 1990; Miller, Trussell, Pebley and Vaughan, 1992; Mosley and Chen, 1984; Setty-Venugopal and Upadhyay, 2002; Tulloch, 1999; WHO, 2002; Winikoff, 1983).

Studies on maternal mortality ratio are not as numerous. One of the difficulties associated with the study of maternal mortality ratio is that it is very

difficult to collect accurate data especially in countries with high levels of maternal mortality ratios (UNICEF, UNFPA and WHO, 2004). Limited studies document that the main causes of maternal mortality are the unexpected complications during pregnancy, childbirth and other terminations of pregnancy, and just after the termination of pregnancy, combined with inadequate medical treatment. Indirectly, knowledge of reproductive health, access to and utilization of reproductive health care, access to and utilization of medical care, and the socio-economic and cultural factors associated with knowledge, access and utilization have been identified as determinants of maternal mortality (UNICEF, UNFPA and WHO, 2004; Tsui, Wasserheit and Haaga, 1997).

Internationally comparable and accurate time series data on under-five mortality rates and maternal mortality ratios together with those determinants would provide an excellent opportunity for in-depth analysis of the causes of progress or lack of progress on those two Goals. But many countries in the Asian and Pacific region have limited data available and those are characterized by varying degrees of accuracy, especially on maternal mortality ratios (ESCAP, UNDP and ADB, 2005). Therefore, the authors examine the patterns of under-five mortality rates and maternal mortality ratios at country-level using simple descriptive statistics and correlation coefficients.

Under-five mortality rates and maternal mortality ratios in Asian countries: country-level analysis of the progress towards the Goals

Data

For this part of the analysis, the countries included in East and North-East Asia are: China; Hong Kong, China; Macao, China; the Democratic People's Republic of Korea; Japan; Mongolia and the Republic of Korea. In South-East Asia they are: Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste and Viet Nam, in South and South-West Asia: Afghanistan, Bangladesh, Bhutan, India, the Islamic Republic of Iran, Maldives, Nepal, Pakistan, Sri Lanka and Turkey, and in North and Central Asia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan, Turkmenistan and Uzbekistan.[2] Data from 37 countries are used for the country-level analysis. They come from compilations by the United Nations agencies and the Population Reference Bureau (ESCAP, UNDP and ADB, 2005; Population Reference Bureau, 2005) but it is to be noted that data are incomplete for many countries.

Descriptive statistics

Table 1 shows the mean values of indicators of poverty, women's education, environment, women's fertility behaviour, and utilization of reproductive and child health services for two groups of countries classified according to their progress towards or distance from Goal 4 of reducing under-five mortality rate. In general, countries that are not progressing well towards the Goal of reducing under-five mortality are characterized by high levels of mortality, high levels of poverty, low levels of education among women, and poor sanitary conditions. In addition, those countries tend to have high levels of fertility, low levels of contraceptive use, and early childbearing among women. They are also characterized by a low-level utilization of reproductive and child health services. But there are some interesting exceptions. In Bangladesh and Viet Nam, the per capita gross national income (GNI) is less than US$ 2,500 but the two countries are progressing well towards meeting the Goal 4 of reducing the child mortality. By contrast, Turkmenistan and Kazakhstan have relatively high per capita GNI (more than US$ 4,500) but the progression towards meeting Goal 4 is slow or regressing. Those exceptions suggest that it may not be necessary to change all determinants of under-five mortality to achieve Goal 4.

Table 2 shows the mean values of the same set of indicators as in table 1 for two groups of countries classified according to their progress towards or distance from Goal 5 of improving maternal health. Here, the pattern is less clear than in table 1. One of the indicators of poverty, the percentage of people with income less than one-dollar-a-day, for example, is larger in the group of countries that are progressing well than in the group of countries that are progressing slowly. This pattern may reflect that one-dollar-a-day may not be a good measure of poverty in some countries. Countries with small proportions of population with less than one-dollar-a-day and high maternal mortality include Kazakhstan, Kyrgyzstan and Viet Nam. It is notable that those countries are also characterized by high prevalence of induced abortions. In Kazakhstan and Kyrgyzstan, about half of pregnancies ended with induced abortions in recent years (Academy of Preventive Medicine, Kazakhstan and Macro International Inc., 1999; Research Institute of Obstetrics and Pediatrics, Kyrgyz Republic and Macro International Inc., 1998). The 2002 Viet Nam Demographic and Health Survey reports that about 22 per cent of pregnancies in the period 1999-2002 were terminated either by menstrual regulation or induced abortions but considers those to be severely under-reported (Committee for Population, Family and Children, Viet Nam and ORC Macro, 2003). The high prevalence of induced abortion is likely to be associated with poor reproductive health of women in general. A closer look at those countries also reveals that they have large proportions of slum residents among their urban population. It is likely that urban slum residents have exceptionally high levels of

maternal mortality. Because the overall level of maternal mortality is generally low, exceptionally high maternal mortality in a special group can result in high maternal mortality ratio at national level. Lastly, the authors note that data on maternal mortality are known to be deficient and inaccurate in many countries

Table 1. Means of selected economic, social, environmental, demographic, and health-care indicators of countries classifed by their progress towards meeting Goal 4 (reduce child mortality), countries in the ESCAP region

	Source of data	Mean among countries that have met or are expected to meet the Goal	Mean among countries that are progressing slowly towards the Goal or regressing
Under-five mortality rate (deaths per 1,000 live births)	(a)	25	97
Maternal mortality ratio (deaths per 100,000 live births)	(a)	96	374
Per capita ppp gross national income, 2004 (US $)	(b)	11,750	2,945
Percentage of population whose income is less than one dollar a day	(a)	9	14
Slum population as percentage of urban population	(a)	22	43
Percentage literate, women aged 15-24	(c)	95	85
Secondary school enrollment rate, women (per cent)	(c)	78	60
Percentage with access to safe drinking water (urban)	(a)	95	86
Percentage with access to safe drinking water (rural)	(a)	81	61
Percentage with access to improved sanitation (urban)	(a)	88	72
Percentage with access to improved sanitation (rural)	(a)	65	40
Total fertility rate	(c)	2.0	3.4
Percentage giving birth in one year, women aged 15-19	(c)	3	5
Percentage using contraceptives, currently married women 15-49	(c)	67	44
Percentage using modern contraceptives, currently married women 15-49	(c)	51	35
Percentage immunized against measles, one-year old children	(a)	90	80
Percentage births attended by skilled health personnel	(a)	86	61
Number of countries		18	19

Sources: (a) ESCAP, UNDP and ADB (2005). *A Future Within Reach: Reshaping Institutions in a Region of Disparities to Meet the Millennium Development Goals in Asia and the Pacific;*
(b) Population Reference Bureau (2005). *2005 World Population Data Sheet;*
(c) Population Reference Bureau (2005). *Women of Our World.*

(UNICEF, UNFPA and WHO, 2004; Tsui, Wasserheit and Haaga, 1997). The change in maternal mortality ratio, which is the bases for classifying countries into two groups in the table, is likely to be even less accurate, having to rely on two possibly inaccurate measures.

Table 2. Means of selected economic, social, environmental, demographic, and health-care indicators of countries classifed by their progress towards meeting Goal 5 (improve maternal health), countries in the ESCAP region

	Source of data	Mean among countries that have met or are expected to meet the Goal	Mean among countries that are progressing slowly towards the Goal or regressing
Under-five mortality rate (deaths per 1,000 live births)	(a)	56	70
Maternal mortality ratio (deaths per 100,000 live births)	(a)	184	289
Per capita ppp gross national income, 2004 (US $)	(b)	11,769	4,579
Percentage of population whose income is less than one dollar a day	(a)	15	10
Slum population as percentage of urban population	(a)	29	36
Percentage literate, women aged 15-24	(c)	91	91
Secondary school enrollment rate, women (per cent)	(c)	68	71
Percentage with access to safe drinking water (urban)	(a)	91	89
Percentage with access to safe drinking water (rural)	(a)	72	68
Percentage with access to improved sanitation (urban)	(a)	80	77
Percentage with access to improved sanitation (rural)	(a)	51	50
Total fertility rate	(c)	2.5	2.9
Percentage giving birth in one year, women aged 15-19	(c)	4	4
Percentage using contraceptives, currently married women 15-49	(c)	58	53
Percentage using modern contraceptives, currently married women 15-49	(c)	48	37
Percentage immunized against measles, one-year old children	(a)	86	84
Percentage births attended by skilled health personnel	(a)	72	73
Number of countries		16	21

Sources: (a) ESCAP, UNDP and ADB (2005). *A Future Within Reach: Reshaping Institutions in a Region of Disparities to Meet the Millennium Development Goals in Asia and the Pacific;*
(b) Population Reference Bureau (2005). *2005 World Population Data Sheet;*
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Analysis of correlations

In table 3, the correlation coefficients of four dependent variables are examined (under-five mortality rate, maternal mortality ratio, progress towards the Goal of reducing under-five mortality, and progress towards the Goal of improving maternal health) with the determinants of under-five and maternal mortality. In order to maximize the use of available data, the correlation coefficients are computed one pair at a time.

Under-five mortality rate is correlated with the indicators of income, women's education, national level sanitary conditions in urban and rural parts, fertility behaviour, and utilization of maternal and child health programmes in a manner consistent with previous findings. Poverty, low levels of education among women, poor sanitary conditions, high levels of fertility, high levels of teenage fertility, low levels of contraceptive use, and low levels of utilization of reproductive and child health services are associated with high levels of under-five mortality rate. The magnitudes of the correlation coefficients are high for all correlates and they are all statistically significant ($p<0.05$). Similarly, maternal mortality ratio has high correlations with all the factors examined, in the same direction as the correlation coefficient with under-five mortality rate, and they are all statistically significant. The correlation between under-five mortality rate and maternal mortality ratio (not in the table) is very high (0.82) and statistically significant.

The last two columns in table 3 show correlation coefficients between whether countries have already met the Goal or are expected to meet it (coded as 1) or not (coded as 0) and the potential determinants. Most of the correlation coefficients between the indicator of progress on Goal 4 (reduce child mortality) and the potential determinants are large and statistically significant.[3]

By contrast, most of the correlation coefficients between the indicators of progress on Goal 5 (improve maternal health) and the potential determinants are small and statistically insignificant. Only one of the determinants, per-capita GNI has statistically significant correlation with whether the country is progressing well towards reducing maternal mortality ratio or not. The weak relationship between the indicator of progress to Goal 5 and the determinants of maternal mortality may be owing to the measurement problems of the maternal mortality ratio. As discussed, the statistics on maternal mortality ratio are often inaccurate, and the progress on maternal mortality, which involves measurements at two or more time points are much more likely to be inaccurate than the single measure.

When countries are grouped by their level of per capita income, most countries with ppp (adjusted for purchasing power parity) per-capita Gross National Income under US$ 4,000 in 2004 are progressing slowly or regressing in

Table 3. Correlation coefficients of selected economic, social, environmental, demographic and health-care indicators with under-five mortality rate, maternal mortality ratio, and progress to Goals of reducing them, countries in the ESCAP region

	Under-five mortality rate (deaths per 1,000 live births	Maternal mortality ratio (deaths per 100,000 live births)	Progress towards Goal of reducing child mortality	Progress towards Goal of improving maternal health
Per capita ppp gross national income, 2004 (US$)	-0.61*	-0.42*	0.50*	0.41*
Percentage of population whose income is less than one dollar a day	0.54*	0.74*	-0.20	0.20
Slum population as percentage of urban population	0.56*	0.63*	-0.35*	-0.11
Percentage literate, women aged 15-24	-0.43*	-0.80*	0.28	0.00
Secondary school enrollment rate, women (per cent)	-0.67*	-0.84*	0.38*	-0.05
Percentage with access to safe drinking water (urban)	-0.79*	-0.86*	0.30*	0.05
Percentage with access to safe drinking water (rural)	-0.72*	-0.56*	0.46*	0.09
Percentage with access to improved sanitation (urban)	-0.76*	-0.74*	0.45*	0.10
Percentage with access to improved sanitation (rural)	-0.67*	-0.59*	0.50*	0.03
Total fertility rate	0.79*	0.81*	-0.53*	-0.14
Percentage giving birth in one year, women aged 15-19	0.58*	0.73*	-0.37*	-0.01
Percentage using contraceptives, currently married women 15-49	-0.79*	-0.73*	0.62*	0.13
Percentage using modern contraceptives, currently married women 15-49	-0.59*	-0.51*	0.44*	0.30
Percentage immunized against measles, one-year old children	-0.59*	-0.74*	0.31	0.07
Percentage births attended by skilled health personnel	-0.66*	-0.77*	0.40*	-0.02

Sources: (a) ESCAP, UNDP and ADB (2005). *A Future Within Reach: Reshaping Institutions in a Region of Disparities to Meet the Millennium Development Goals in Asia and the Pacific;*
(b) Population Reference Bureau (2005). *2005 World Population Data Sheet;*
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Note: * indicates $p<0.05$.

both under-five mortality (Goal 4) and maternal mortality (Goal 5), while countries with ppp per-capita Gross National Income of US$ 4,000 or over in 2004 are progressing well. However, it is notable that among countries with low levels of income, Indonesia and Bangladesh are progressing well towards the two Goals (see appendix tables A1 and A2). A closer look reveals that the characteristics that separate those countries from other low-income countries are high level of contraceptive use and low level of fertility. Viet Nam also has low-income, high level of contraceptive use, low level of fertility. Yet it is progressing well towards Goal 4. However, despite this remarkable progress on this latest Goal, distance from Goal 5 is increasing. As speculated earlier, progress towards Goal 5 may be lagging in Viet Nam owing to the high prevalence of unsafe induced abortion. Those exceptions suggest that high contraceptive prevalence and low level of fertility can reduce child mortality by decreasing high-risk births and unwanted births (Setty-Venugopal and Upadhyay, 2002). This can be achieved even when economic and development conditions are not favourable to low level of child mortality and despite the fact that reduction of maternal mortality may be hindered if the rate of unsafe induced abortion is high.

An attempt was made to conduct country-level multivariate statistical analysis of progress towards Goals 4 and 5 such as fitting regression models in order to estimate the "net effects" of each determinant, controlling for the effects of other determinants. But because many countries have incomplete data (less than 20 countries have complete data available) the estimates become quite unstable. Obviously, in-depth statistical analysis leading to the estimation of the "net effects" of the determinants of under-five mortality rate and maternal mortality ratio or their progresses requires more comprehensive data sources.

Summary of country-level analysis

In summary, country-level analyses show that levels of under-five mortality and maternal mortality are very highly correlated. Poverty, low level of education among women, poor sanitary conditions, high level of fertility, high level of teenage fertility, low level of contraceptive use, and low level of utilization of reproductive and child health services are associated with high level of under-five mortality rate and maternal mortality ratio. The cases of Indonesia and Bangladesh suggest that reduction of under-five mortality rate and maternal mortality ratio can be achieved by altering some determinants through intervention programmes aimed at reducing unwanted and high-risk births.

Although most of the determinants of under-five mortality rate and maternal mortality ratio are correlated, it is likely that reduction of under-five mortality rate and maternal mortality ratio can be achieved by altering some determinants

through increased levels of utilization of reproductive and child health programmes. Estimating the potential contribution of intervention programmes, one needs to have better measures of the "net effects" of the determinants. Such estimates can be computed from multivariate statistical models as illustrated in the following case study of India.

Estimating potential for reducing early childhood mortality: an illustrative case study of India

The case of India

India offers an excellent opportunity for an illustrative analysis to study determinants of under-five mortality and potential for its reduction for at least three reasons. The first reason is related to the level of under-five mortality. At national level, under-five mortality is moderately high and India is progressing slowly towards meeting the corresponding Goal. According to the assessment made by the United Nations agencies, India's under-five mortality in 2003 was 87 per 1,000 live births. This corresponds to the medial level mortality among the 19 countries in the ESCAP region that are making slow progress towards or regressing on Goal 4 (ESCAP, UNDP and ADB, 2005). However, India is a large and complex country and there has been large variations at state level in both the level of mortality and the rate of reduction in mortality in recent years as shown below. The second reason is related to the state-level variations in factors associated with under-five mortality. In India, the state government is largely responsible for implementing reproductive and child health programmes and the utilization of those programmes vary greatly among states. Similarly, other conditions affecting under-five mortality such as the level of poverty, sanitary conditions and mother's education, vary also greatly among states as shown below. Indeed, the variations among states of India in terms of under-five mortality and the major determinants resemble much the cross-national variations among countries observed in the ESCAP region. Third, the National Family Health Surveys (NFHS) conducted in the 1990s offer an excellent data source for rigorous statistical analysis. The data availability is especially important because many of the countries that are making slow progress towards Goal 4 do not have high quality data that would allow in-depth analysis.

Under-five mortality in India

In India, the under-five mortality rate was 123 in 1990. Two thirds reduction to meet Goal 4 means reaching an under-five mortality rate of 41 by 2015. In 2003, this same rate was estimated at 87, which means that it was reduced by 29 per cent in 13 years. In order to meet the Goal of reducing the rate by two thirds in 25 years,

the under-five mortality should have fallen by 35 per cent in 13 years.[4] In summary, in more than half of the time required to achieve the Goal, less than half of the necessary reduction has been achieved.

Table 4. Child mortality during 1994-1998 and percentage decline in child mortality during the periods between 1988-1992 and 1994-1998

State/Union Territory	Child mortality in 1994-1998	Percentage decline in child mortality in six years	Population in 1991 census (1,000s)
Decline >=16 per cent			
Kerala	18.8	41	29,099
Himachal Pradesh	42.4	39	5,171
Assam	89.5	37	22,414
Delhi	55.4	33	9,421
West Bengal	67.6	32	68,078
Tamil Nadu	63.3	27	55,859
Haryana	76.8	22	16,464
Orissa	104.0	20	31,660
Karnataka	70.0	20	44,977
Gujarat	85.1	18	41,310
Bihar	105.1	18	86,374
Maharashtra	58.1	17	78,937
Decline < 16 per cent			
Uttar Pradesh	123.0	13	139,112
Andhra Pradesh	85.5	6	66,506
Madhya Pradesh	137.6	-6	66,181
Punjab	72.1	-6	20,282
Rajasthan	114.9	-12	44,006

Sources: IIPS (1995, p. 221) and IIPS and ORC Macro (2000, p. 194) for child mortality; Office of the Registrar General (2005) for population.

Note: Small states in the north-eastern region are not included in the table.

According to the estimates based on National Family Health Surveys of 1992-1993 (NFHS-1) and 1998-1999 (NFHS-2), all India experienced a 13 per cent reduction in under-five mortality from 109.3 in 1992-1993 to 94.9 in 1998-1999, falling somewhat short of the amount of decline required to achieve Goal 4 (a 16 per cent decline in six years is required) and at about the same rate as estimated by ESCAP, UNDP and ADB in 2005. However, 12 out of 17 major states with data show decline in under-five mortality by more than 16 per cent, the level required to achieve the Goal, as shown in table 4.[5] The statistics from Kerala are

most impressive. In this south-western state, not only did the under-five mortality decline impressively by 41 per cent, it had also reached the level of developed countries by 1998-1999. This achievement is remarkable considering that the per capita Gross State Product in Kerala was only Rs. 16,029[6] in 1998-1999 (current prices), far below some other states such as Delhi (34,332 rupees), Goa (40,248 rupees), Punjab (21,194 rupees), and Maharashtra (20,148 rupees) (Ministry of Statistics and Programme Implementation, 2005). Another noteworthy fact is that the states that have achieved sufficient amount of reduction in under-five mortality have varying levels of mortality. Under-five mortality in some states are under 50 per 1,000 live births in the 1994-1998 period, but it is between 50 and 100 in a number of states, while in Orissa and Bihar under-five mortality is over 100. States making slow progress or regressing on this Goal also have wide ranging levels of under-five mortality, from 72 to 138. From this pattern one can conclude that the slow progress in reducing under-five mortality at the national level is due to slow progress in some large states which have high levels of under-five mortality such as Uttar Pradesh, Madhya Pradesh and Rajasthan.

India's health programmes

The Government of India's effort to strengthen maternal and child health services began during the First and Second Five-Year Plans (1951-1956 and 1956-1961) under the Ministry of Health, and continued with the Minimum Needs Programmes initiated during the Fifth Five-Year Plan (1974-1979). The primary objective of the effort was to provide basic public health services to vulnerable groups of pregnant women, lactating mothers and pre-school children. In 1992-1993, the Child Survival and Safe Motherhood Programme continued the process of integration by bringing together several key child survival interventions with safe motherhood and family planning activities.

More recently, efforts to improve maternal and child health have been enhanced by the activities implemented by the Family Welfare Programme (Ministry of Health and Family Welfare, 1992). Special schemes included the programme of Oral Rehydration Therapy and the development of Regional Institutes of Maternal and Child Health in states where infant mortality rates are high. The Universal Immunization Programme and the Maternal and Child Health Supplemental Programme within the Post-Partum Programme were also implemented (IIPS, 1995).

In 1996, the integrated Reproductive and Child Health Programme was launched incorporating safe motherhood and child health services (IIPS and ORC Macro, 2000). This new programme seeks to integrate maternal health, child health, and fertility regulation interventions with reproductive health programmes

for both women and men. Important elements of reproductive health programmes include: (a) provision of antenatal care including at least three antenatal visits and two doses of tetanus toxoid vaccine; (b) encouragement of institutional deliveries or home deliveries assisted by trained health personnel; (c) provision of postnatal care; and (d) identification and management of reproductive tract and sexually transmitted infections.

State-level variations in socio-economic, demographic and health indicators

As discussed in the previous section, the health and welfare programmes in India are operated jointly by the federal and state governments yet the state governments play preponderant roles in their implementation. Partly because of this institutional arrangement and owing also to differing historical and cultural backgrounds, Indian states vary greatly in socio-economic, demographic, and health conditions as seen in table 5.

Economic conditions are generally good in the northern states (except Rajasthan) where less than 10 per cent of households were classified as having low standard of living index according to the NFHS-2 survey. Eastern states are economically least advanced with about half of the households classified as having low standard of living index. Women's illiteracy varies greatly according to states, from a low of 10 per cent in Mizoram and 13 per cent in Kerala to a high of 77 per cent in Bihar and 76 per cent in Rajasthan. Other states in central and eastern regions show high levels of illiteracy among women.

In terms of fertility, Goa, Kerala, Himachal Pradesh, Punjab and Tamil Nadu show very low fertility and relatively late ages at marriage. In some states in the southern region such as Karnataka and Andhra Pradesh, total fertility rate is low but early marriage is quite common. By contrast, in some states in the north-eastern region such as Mizoram, Nagaland and Manipur, fertility is high but early marriage is uncommon. In many large states such as Rajasthan, Madhya Pradesh, Uttar Pradesh, and Bihar, fertility is high and early marriage is widespread.

In most of the states in the north, west and south, the prevalence of antenatal tetanus toxoid vaccine (two or more times)[7] is quite high, reaching 95 per cent in Tamil Nadu and more than 85 per cent in Delhi, Punjab, Goa and Kerala. States in central, eastern and north-eastern areas lag behind substantially. Among big states, it is only 51 per cent in Uttar Pradesh and 52 per cent in Rajasthan. Similar patterns are observed in childhood immunizations,[8] but the gap is wider ranging from more than 80 per cent in Himachal Pradesh, Goa, Kerala and Tamil Nadu to less than 25 per cent prevalence in Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, Arunachal Pradesh, Assam, Meghalaya and Nagaland.

Table 5. Selected socio-economic, demographic and health indicators, major states/unions territories of India, 1998-1999

State/Union Territory	Percentage of households with low standard of living index	Percentage illiterate, ever-married women aged 15-49	Total fertility rate	Percentage of women aged 25-49 married before age 18	Percentage of women receiving two antenatal tetanus toxoid innoculations (a)	Percentage of one-year olds with full immunization (b)
North						
Delhi	3	29	2.4	38	85	70
Haryana	10	55	2.9	60	80	63
Himachal Pradesh	8	36	2.1	38	66	83
Jammu & Kashmir	9	70	2.7	48	78	57
Punjab	4	39	2.2	23	90	72
Rajasthan	23	76	3.8	82	52	17
Central						
Madhya Pradesh	31	69	3.3	79	55	22
Uttar Pradesh	29	70	4.0	80	51	21
East						
Bihar	53	77	3.5	84	58	11
Orissa	51	60	2.5	58	74	44
West Bengal	46	50	2.3	62	82	44
North-east						
Arunachal Pradesh	23	53	2.5	40	46	21
Assam	39	54	2.3	49	52	17
Manipur	34	43	3.0	21	64	42
Meghalaya	44	38	4.6	35	31	14
Mizoram	13	10	2.9	13	38	60
Nagaland	25	40	3.8	24	51	14
Sikkim	13	49	2.8	35	53	47
West						
Goa	15	29	1.8	15	86	83
Gujarat	22	50	2.7	54	73	53
Maharashtra	23	45	2.5	65	75	78
South						
Andhra Pradesh	36	64	2.3	80	82	59
Karnataka	30	55	2.1	61	75	60
Kerala	15	13	2.0	27	86	80
Tamil Nadu	34	48	2.2	42	95	89

Source: IIPS and ORC Macro (2000).

Notes: (a) Among women who gave births during the five-year period before the survey, for the last and next-to-last births.
(b) Among one-year olds at the time of survey.

Analytical strategy

Using data from the National Family Health Survey (NFHS-2) conducted in 1998-1999, the authors first estimated a statistical model to estimate effects of major determinants of early childhood mortality (ages 0-24 months). The estimated statistical models of early childhood was then used for simulation by altering the values of major determinants. Most of the simulation consisted of estimating the reduction of mortality under the hypothetical situation specified by the conditions in Kerala, the state with the lowest level of infant and child mortality in all India. Some additional simulations, involving additional changes in fertility behaviour and reductions of sex differentials in childhood mortality were also undertaken. The simulation exercises showed the extent of potential reduction in early childhood mortality through reproductive and child health intervention programmes.

Data

To estimate the effects of major determinants of early childhood mortality, data from National Family Health Survey (NFHS-2) conducted in 1998-1999 were used. The survey is based on a nationally representative sample of 91,196 households and on all ever-married women aged 15-49 within the households (89,199 women). The sampling fraction varies from state to state, in order to assure that the sample size in each state is large enough to provide statistically meaningful estimates (IIPS and ORC Macro, 2000).

In each state, the rural sample was selected in two stages. The first stage consists of the selection of the primary sampling units (PSUs), which are villages, with probability proportional to population size (PPS). The second stage consists of the random selection of about 30 households within each PSU. In urban areas, a three-stage procedure was followed. In the first stage, wards were selected with PPS sampling. In the next stage, one census enumeration block (CEB) was randomly selected from each sampling ward. In the final stage, households were randomly selected within each sample CEB. On average, 30 households were targeted for selection in each selected enumeration area (IIPS and ORC Macro, 2000).

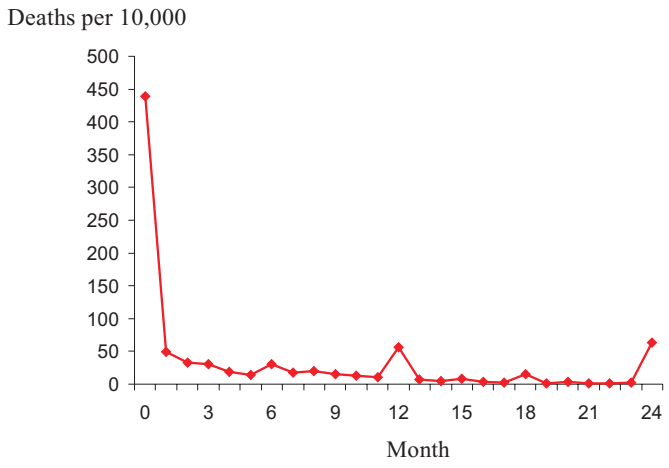
Each household is assigned a state-level weight and an all-India weight. Weights are needed to correct for over-sampling of some groups and under-sampling of others. The all-India weights take into account variability in sampling fractions among the states. The calculation of weights takes into account non-responses as well. In the analysis in the paper, all-India weights, normalized so that the sum of weights is equal to the number of observations in the sample, are used.

Statistical model for early childhood mortality

The survey collected full birth histories of women, including information on birth order, date of birth, sex, whether child was alive at the time of survey and for the children who have died, age at death. For the last and next-to-last births occurring since January 1995, the survey collected information on antenatal care including antenatal visits, tetanus toxoid vaccine, place of delivery, and birth attendance. For the surviving children among those, information on feeding, children's vaccination, morbidity, and care of sick children were also collected.

The authors first created the children file consisting of one record for each child born to women in the survey during the five-year period preceding the survey, extracting information from birth histories of women. Then the child record was used as the unit of analysis. The analysis was limited to children born during the five-year period before the survey because many of the household-level and community-level factors examined were measured at the time of the survey and would not have been accurate for children born long before the survey. Some child-specific factors such as year of birth, survival status of the child, age at death, sex, birth order, mother's age at birth, previous birth interval, sex combination of surviving older siblings at the time of birth, whether any of the older siblings have died at the time of birth of the index child, and previous birth interval are computed and added to the child record.

Figure 1. Monthly probability of dying estimated from NFHS-2 among children born during the five-year period before survey



To estimate the effects of factors on early childhood mortality, the hazard model (Cox model) for the month-specific probability of dying during the first 25 months (months 0 through 24) of life was used. Hazard model is chosen so that the analysis does not have to be limited to children who have been observed for the full 25 months since birth. The hazard model allows for the inclusion of children who were born less than 25 months before the survey (censored cases). The mortality during first 25 months rather than a more usual 24 months was used in order to include reported deaths at age 24 months. Age at death data in India tend to heap at 6, 12, 18 and 24 months as shown in figure 1. Limiting analysis to deaths at 0-23 months, one would be excluding some deaths that occurred at age 19-23 months but reported as occurring at age 24 months. According to the NFHS-2 data, about 90 per cent of under-five mortality in India takes place at ages 0-24 months. Thus, the present analysis should include most of the under-five mortality.

Hazard model requires two dependent variables: survival status and exposure time. The survival status is measured at the end of age 24 months or at the time of survey for those who were born less than 25 months before the survey. The exposure time is the age at death for those who died by the end of age 24 months, and age at survey for those who were surviving.

Three sets of factors were examined: household/mother-level factors, child-level factors, and community-level factors. Our choice of factors is determined on the basis of major literature on under-five mortality in general, and in India (Black, Morris and Bryce, 2003; Mosley and Chen, 1984; Pandey and others, 1998). The household/mother-level factors include the standard of living index of the household created by IIPS (low or not), and the level of mother's education (none, primary and more).

The child-level factors include year of birth, sex of child, and mother's age at birth for all children. For children of birth order two or higher sex combination of surviving older siblings was also included, along with preceding birth interval, birth order, and the dummy variable indicating whether any of the older siblings have died before the birth of the index child. All child-level factors are created to reflect the condition at the time of birth of the index child.

The first community-level factor is the urban-rural designation of the community. Two community-level factors were also included indicating sanitary conditions: percentage of households with piped water and percentages of households with toilet facility. Lastly, two factors indicating the level of utilization of reproductive and child health programmes were included: percentages of women in the community who received at least two tetanus toxoid vaccines among those who gave birth during the five-year period before the survey,[9] and

percentages of one-year olds in the community who received full childhood vaccinations.[10] It would have been ideal to include the utilization of reproductive and child health programmes as child-level variables as well. Unfortunately, however, this information was collected only for last or next-to-last births, and for childhood vaccination, only for the children who were still surviving at the time of survey, making it impossible to treat them as potential factors of early childhood mortality.

By contrast, using those measures at community-level have benefits. Estimating the effects of the utilization of reproductive and child health programmes at the community-level is sensible because many of the programmes are related to the control of infectious diseases at the community level. The primary sampling units (PSUs) are identified as communities. Usually, one PSU in rural area consists of one village and one PSU in urban area consists of one census enumeration block.

Statistical models were estimated separately for first-born children and children of higher birth order. This allowed authors to estimate the effects of factors such as previous birth interval, death among previous children, and sex combination of older siblings in a straightforward way. Table 6 shows the descriptive statistics of the factors for the two groups of children by birth order.

Standard of living index was created by IIPS based on house type, toilet facility, source of lighting, main fuel for cooking, source of drinking water, whether the house has separate room for cooking, ownership of house, ownership of agricultural land, ownership of irrigated land, ownership of livestock, and ownership of 20 durable goods, classified as low, medium or high. Thirty per cent of children of first-born children and 41 per cent of higher-order children were born to households with low standard of living. The observed difference in the standard of living by birth order is probably owing to the tendency for women in poor families to have more children than women in better-off families.

Mothers' level of education was classified in three categories: no formal education, primary, or higher. Table 6 shows that mothers' education is lower among high-order births (63 per cent with no formal education) than among first births (41 per cent with no formal education). This pattern is not surprising because women with low level of education tend to have more children and thus, more high-order births than the first births. In addition, mothers who gave first birth during the five-year period before the survey are likely to be younger and have higher level of education than those who gave birth to higher-order births.

Table 6. Descriptive statistics of the covariates, Indian children born five years before 1998-1999 NFHS-2 survey

Covariates	Birth order 1	Birth order 2 and over	All children
Household/mother-level factors			
Standard of living index of household is low (per cent)	30	41	38
Mother had no formal education (per cent)	43	63	56
Mother's education is primary (per cent)	16	15	16
Mother's education is more than primary (per cent)	43	22	28
Child-level factors			
Year of birth (mean)	96.19	96.07	96.1
Child is a girl (per cent)	48	--	48
Child is a girl and has no brothers (per cent)	--	14	--
Child is a girl and has at least one brother (per cent)	--	34	--
Mother's age at birth <18 (per cent)	28	--	--
Mother's age at birth <20 (per cent)	--	13	--
Preceding birth interval <24 months (per cent)	--	28	--
Birth order >4 (per cent)	--	25	--
Any death among older siblings (per cent)	--	10	--
Community factors			
Urban community	27	20	22
Percentage households with piped water (mean)	37	29	32
Percentage households with toilet facility (mean)	35	27	29
Percentage mothers with 2 tetanus vaccinations (mean)	72	65	67
Percentage children age 1 with full immunization (mean)	43	33	36

Note: -- indicates not applicable

Indian women begin to have children at a very young age. Twenty-eight per cent of first-born children were born to women below age 18. Among higher-order births, 13 per cent were born to women below 20 years. Indian women also tend to have short birth intervals. Twenty-eight per cent of children of birth order 2 or higher were born less than 24 months after the birth of previous child. Substantial proportion of births is of order 5 or higher reflecting high level of fertility. Ten per cent of second or higher-order children are born to families with some experience of child death.

At the community level, the average prevalence of piped water and toilet facility are about one third. The difference between first-born children and higher-order births are probably owing to the fact that fertility tends to be higher in less developed communities than in more developed communities. Community-level prevalence of antenatal tetanus vaccinations averages about two thirds at 67 per cent. By contrast, the average community-level prevalence of early childhood vaccinations is only slightly over one third at 36 per cent.

Results

The hazard ratios (relative risk) estimated by the hazard model are shown in table 7. Low standard of living increases early childhood mortality only for children of birth order 2 or higher but not for first-born children. It is possible that first-born children, being very precious to the family, receive special care from parents and the standard of living has little effect on their survival during the first two years of life after controlling for the effects of other factors such as mother's education, mother's age at birth, and community factors. Mother's education above primary school level lowers early childhood mortality substantially but primary school level education has no statistically significant effect on children's early childhood mortality. Relatively weak effect of primary level education of mother on child mortality is commonly found in other studies as well (see for example, Desai and Alva, 1998).

Many previous studies have documented high level of son preference and consequent excess female child mortality in India (Arnold, Choe and Roy, 1998; Das Gupta, 1987; Basu, 1989). Results from the present analysis are consistent with these earlier studies: among the first-born children, early childhood mortality is lower among girls as in most other populations, showing no evidence of discrimination against daughters. Among higher-order births, girls experience higher early childhood mortality, and the excess female mortality is more evident if the girl has no surviving brothers, reflecting discrimination against daughters especially when there are other daughters in the family.

Indian women begin their childbearing early as shown in table 6. The results indicate that early childbearing is associated with increased early childhood mortality. First-born children to mothers under age 18 experience 45 per cent higher early childhood mortality risk than children born to older mothers. The adverse effect of early childbearing continues with higher-order births as well, although the relative risk is lower. Other factors associated with fertility behaviour – previous birth interval and high birth order both have statistically significant positive association with early childhood mortality as well. The relative risk of early childhood mortality associated with short birth interval is especially high.

Children born to women who already experienced a death of children have higher risks of early childhood mortality than those born to mothers who have not experience any child death, consistent with findings from earlier studies.

Table 7. Relative risks of dying associated with covariates among Indian children born five years before 1998-1999 NFHS-2 survey, estimated from Cox model by birth order

Covariates	Birth order 1	Birth order 2 and over
Household/mother level factors		
Standard of living index of family is low	1.00	1.24*
Mother's education is primary	0.87	0.92
Mother's education is more than primary	0.62*	0.65*
Child-level factors		
Year of birth	0.98*	0.98*
Child is a girl	0.84*	--
Child is a girl and has no brothers	--	1.35*
Child is a girl and has at least one brother	--	1.16*
Mother's age at birth <18	1.45*	--
Mother's age at birth <20	--	1.15*
Preceding birth interval <24 months	--	1.83*
Birth order >4	--	1.22*
Any death among older siblings	--	1.59*
Community factors		
Urban community	1.09	1.07
Percentage households with piped water	0.78	1.02
Percentage households with toilet facility	0.67*	0.69*
Percentage mothers with 2 tetanus vaccinations	0.94	0.76*
Percentage children age 1 with full immunization	0.54*	0.67*

Notes: -- indicates not applicable
* indicates p<0.05

Turning now to the community-level factors, urbanity of the community and proportion of children born in households with piped water have no effect on early childhood mortality in India. The community-level prevalence of access to toilet facility, however, has large statistically significant negative effect on early childhood mortality. In the present models, community-level prevalence of antenatal tetanus toxoid vaccine has statistically significant effect on early

childhood mortality only for children of birth order two or higher. As discussed earlier, this variable was used as a proxy for the utilization of preventive reproductive health programmes. In India, utilization of antenatal care is often related with complications associated with pregnancies, women experiencing such complications being more likely to seek care. Thus, it may not be a good measure for preventive reproductive health programmes. As expected, child immunization coverage has strong negative effect on early childhood mortality.

Simulation

The impact of the factors on early childhood mortality can be seen clearly when the predicted values of mortality are computed under different scenarios specified by different hypothetical values. In table 8, cumulative predicted probabilities of dying before the end of the 24th month are computed under a selected set of scenarios. The scenarios consist of changing values of statistically significant factors to the level observed in Kerala, where the under-five mortality is lowest among the states of India.

For example, the following question can be raised: What would be the level of early childhood mortality in all India if the proportion of women with more than primary school education were equal to the level observed in Kerala? The mortality from the estimated hazard model in table 7 can be estimated by changing the value of "mother's education is more than primary" to the value observed in Kerala, leaving all other factors as observed. The results are shown in table 8, scenario (1). The table shows that the cumulative mortality at the end of 24^{th} month would be 64 among first-born children, a 20 per cent reduction from 80. It would be 65 among higher-order births, a 22 per cent reduction from 83. Combining the first- and higher-order births, as the weighted average using the observed distribution of children by birth order, mortality for all children would be 65; that is a 21 per cent reduction from 82. Similar exercises can be carried out by either changing the value of one factor at a time, or a number of factors simultaneously. Separate estimates can be calculated for children of birth order one and higher and for all children using the weighted average of mortality estimated for first- and higher-order births. If the scenario includes changes in fertility behaviour, the weighted average is computed using the observed distribution of children by birth order, or implied distribution as appropriate.

Table 8 shows that if the proportion of women with more than primary school education in all India increased to the level of Kerala, the cumulative mortality at the end of 24^{th} month would be 21 per cent lower than the observed mortality (scenario 1). According to the present data, 43 per cent of mothers of first-born children in all India had more than primary school education compared to 92 per

cent in Kerala. It would be an enormous task to increase women's education in all India to match the level reached in Kerala. But if this could be achieved, the early childhood mortality would fall substantially.

Table 8. Cummulative probability of dying by the end of 24th month under selected scenarios, predicted by the estimated hazard models

	Scenario (a)	Predicted cumulative probability of dying by end of 24th month			Per cent reduction in mortality relative to "no change" scenario		
		First births	Other births	All births	First births	Other births	All births
(0)	No change	80	83	82	NA	NA	NA
(1)	Percentage of women with more than primary education	64	65	65	20	22	21
(2)	Percentage of children born in households with low standard of living index	80	79	79	NA	5	4
(3)	Percentage of chidlren whose mothers age at birth was very young (< 18 for birth order 1, <20 for birth order 2 and over)	74	80	78	8	4	5
(4)	Percentage of children birth order >2 with preceding birth interval <24 months	80	82	81	NA	5	1
(5)	Percentage of children birth order >4	80	76	77	NA	8	6
(6)	Community-level prevalence of households with toilet facility	66	68	67	18	19	18
(7)	Community-level prevalnece of more than 2 antenatal tetanus vaccinations	80	79	79	NA	6	4
(8)	Community-level prevalence of complete childhood immunization	67	72	71	17	14	14
(9)	**All fertility factors**	**74**	**73**	**73**	**8**	**12**	**11**
(10)	**All MCH factors**	**67**	**68**	**68**	**17**	**18**	**18**
(11)	**All fertility and MCH factors**	**62**	**62**	**62**	**23**	**25**	**24**
(12)	**All statistically significant factors except year of birth, sex of child, and sex combination of older siblings**	**42**	**36**	**38**	**47**	**56**	**54**

Notes: (a) Changes to match the situation in the state of Kerala, India.
NA: indicates not applicable

Reducing the proportion of households with low standard of living from the level observed across India to the level of Kerala would result in some reduction of early childhood mortality but only by 4 per cent (scenario 2). This is not surprising because, as discussed earlier, the economic status of Kerala state is not drastically different from that of India as a whole.

Altering fertility behaviour of all Indian women to the pattern observed in Kerala by reducing early childbearing, short birth intervals, and high order births could reduce early childhood mortality by 5 per cent, 1 per cent and 6 per cent, respectively (scenarios 3, 4 and 5). Altering all fertility behaviour simultaneously would result in a 11 per cent reduction (scenario 9) in early childhood mortality, according to this analysis.

Improving sanitary conditions of communities by increasing the proportion of households with toilet facility to the level of Kerala could reduce early childhood mortality by 18 per cent (scenario 6). Reducing early childhood mortality through improving the sanitary conditions would take as long as increasing mothers' level of education.

Increasing utilization of reproductive and child health programmes by increasing antenatal tetanus toxoid vaccines and child immunizations in all India to the level observed in Kerala would reduce early childhood mortality by 4 per cent and 14 per cent, respectively (scenarios 7 and 8). Changing both would result in 18 per cent reduction (scenario 10) in early childhood mortality.

Changing fertility behaviour and utilization of reproductive and child health programmes simultaneously would reduce early childhood mortality by 24 per cent (scenario 11). In addition, altering all of the factors that affect early childhood mortality to the level observed in Kerala would result in a 54 per cent reduction in early childhood mortality (scenario 12).

Discussion

The simulation exercises discussed in the previous section did not include one major factor of early childhood mortality: sex of child and sex combination of surviving older siblings of children of birth order two or higher. The sex of children cannot be altered easily by population and health programmes. However, those programmes can work towards eliminating son preference behaviour of parents in taking care of their children through community-based communication and education programmes. Eliminating mortality differentials by sex of children and sex combination of older siblings would result in a 11 per cent reduction in early childhood mortality.[11]

Although many conditions in Kerala are conducive to low level of under-five mortality, there are some exceptions. One of them is the level of poverty as discussed earlier. Another is the supply of piped water. In all India, average percentage of households with piped water in a community is 40 per cent. In Kerala, it is less than 20 per cent. It is worthwhile to note, however, that 61 per cent of households in this state purify the water before drinking it, 77 per cent of them

using boiling as a purifying method (IIPS and ORC Macro, 2001). By contrast, only 39 per cent of households in all India purify the water before drinking it, the most common method of purifying being straining water by cloth (59 per cent). Only 26 per cent of households in all India boil water for purification (IIPS and ORC Macro, 2000). Those differences in the way water is treated before drinking may explain why in the present analysis, the community-level prevalence of piped water was not found to have a statistically significant effect on early childhood mortality. Another possible explanation for the weak association is that an important variable was omitted because data were not available (the variations in personal hygiene behaviour such as washing hands before cooking/eating) may interact with the prevalence of piped water.

In Kerala, although fertility level is below replacement, some aspects of fertility behaviour are not conducive to low level of childhood mortality. One is the prevalence of short birth interval. In all India, 28 per cent of children of birth order two or higher were born in less than 24 months of the birth of the previous child. In Kerala, the proportion is 21 per cent. This analysis found that short preceding birth interval is a statistically significant factor associated with increased early childhood mortality. Our simulation exercise on birth intervals (changing the prevalence of short birth interval to the level of Kerala) does not show full potential for reducing early childhood mortality through altering the child spacing behaviour. How would early childhood mortality change if the short previous birth intervals were eliminated? Table 9 shows the results of simulations from scenarios including this hypothesis. If previous birth intervals of less than 24 months were prevented (set the proportion to zero), the early childhood mortality would be reduced by 6 per cent. If this scenario were combined with fertility behaviour changes regarding early childbearing and prevalence of high order birth that matched the levels of Kerala, the early childhood mortality would be reduced by 16 per cent. Those changes, combined with the improved coverage of antenatal tetanus toxoid vaccines and child immunizations at the level observed in Kerala would reduce early childhood mortality by 30 per cent.

According to the present statistical model, the standard of living index of household has a weak association with early childhood mortality. Most studies, especially those based on country-level analysis document that poverty is probably the most important factor associated with high under-five mortality. Are the present results contrary to this common pattern? The weak association between standard of living index and early childhood mortality the authors found in India is likely to be caused by the measurement of poverty that used the standard of living index. Poverty leads to high level of mortality through malnutrition, poor access to medical care in addition to the factors examined here. The standard of living index, based mostly on

durable goods of the household is likely to be a poor measure of household expenditure which would be more directly associated with those intermediate variables. Furthermore, the standard of living index may have different meanings for urban and rural households and in summary, may be a poor measure of poverty. When a better measure of household-level poverty or expenditure is used, a stronger association with the early childhood mortality may be found.

Table 9. Probability of dying at ages 0-24 under the assumption of eliminating birth intervals < 24 months, predicted by the estimated hazard models

	Scenario (a)	Predicted cummulative probability of dying at ages 0-24 months	Per cent reduction in mortality relative to "no change" scenario
(0)	No change	82	NA
(1)	Eliminate of children birth order >2 with preceding birth interval <24 months	77	6
(2)	Reduce children born to young mothers and children of birth order >4 to the level observed in Kerala, and eliminate children of birth order >1 with preceding birth interval <24 months	69	16
(3)	Reduce children born to young mothers and children of birth order >4 to the level observed in Kerala, and eliminate children of birth order >2 with preceding birth interval <24 months, and increase antenatal tetanus toxoid innoculation and children's immunization to the level oberved in Kerala	58	30

Notes: (a) Changes to match the situation in the state of Kerala, India.
NA: indicates not applicable.

Goal 4 calls for a reduction of under-five mortality by two thirds (67 per cent) by 2015. If the current trend in under-five mortality in India (13 per cent reduction in six years) continues, one can expect a 54 per cent reduction by 2015; about 13 per cent short of the Goal. The present analysis shows that this gap can be closed by effective family planning programmes resulting in reduction of early childbearing, short birth intervals and high-order births, combined with increased utilization of reproductive and child health programmes including antenatal tetanus vaccination and child immunizations. Eliminating discrimination against girl children can reduce early childhood mortality even further.

Whether findings based on the analysis of Indian data will apply in other countries that need to improve child survival substantially remains to be validated by additional evidences. In the meantime, it is encouraging to have an evidence that early childhood mortality can be reduced substantially by family planning and reproductive and child health programmes even under unfavourable conditions in terms of poverty, women's education and community-level sanitary conditions.

The country-level analysis showed that under-five mortality rate and maternal mortality ratios are highly correlated and that they share common set of determinants. Thus, the intervention programmes designed for reducing under-five mortality rate are likely to reduce maternal mortality ratio as well.

Some countries may have inadequate technical and financial resources for improving reproductive and maternal and child health services. International cooperation both within the Asian and Pacific region and wider global community may be required to meet the challenges of the Millennium Development Goals at the regional level.

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Endnotes

1. This article has been submitted to ESCAP as a theme study on Health and Millennium Development Goals: Policies and Strategies to Meet the Millennium Development Goals of Reducing Child Mortality and improving maternal health as part of the ESCAP-UNFPA project on Population, Poverty and Development implemented in 2005.

2. The designation of regions follows the convention used by ESCAP, UNDP and ADB in this report *A Future Within Reach* (2005). Thus, the analysis excludes countries in the Pacific region.

3. It should be noted here that because the indicator of progress towards the Goal is binary (0 or 1), the correlation coefficients are not very large.

4. The constant rate of decline (equivalent to simple-interest approach) was used rather than the constant relative rate of decline (equivalent to the compound-interest approach).

5. Some states show negative reduction in under-five mortality, indicating increase in the under-five mortality. The reasons for the increase in mortality is not clear but the inaccuracy of data may explain part of the unexpected result.

6. Equivalent to approximately US$ 376. As of January 1999, one U.S. dollar was equivalent to 42.6 Indian rupees.

7. Among women who gave births during the five-year period before the survey, for the last and next-to-last births.

8. Among one-year olds at the time of survey.

9. Based on information of last birth and next-to-last birth for each woman.

10. Based on information from children born during the five-year period before the survey and surviving at the time of survey.

11. The computation, not shown here, assumes that the early childhood mortality of female children would be the same as that of male children, regardless of the sex combination of older siblings.

Appendix A1. Progress towards meeting Goals 4 and 5 as assessed in 2003 by ESCAP, UNDP and ADB: countries in the ESCAP region with 2004 GNI ppp per capita < US$ 4,000

Country	Goal 4 (under-5 and infant mortality)		Goal 5 (improve maternal health)	
	Already achieved or expected to achieve	Making slow progress or regressing	Already achieved or expected to achieve	Making slow progress or regressing
East and North-East Asia				
Democratic People's Republic of Korea		X		X
Mongolia		X		X
South-East Asia				
Cambodia		X	X	
Indonesia	X		X	
Lao People's Democratic Republic		X		X
Myanmar		X		X
Timor-Leste		X		X
Viet Nam	X			X
South and South-West Asia				
Afghanistan		X		X
Bangladesh	X		X	
Bhutan		X	X	
India		X		X
Maldives		X	X	
Nepal		X	X	
Pakistan		X		X
North and Central Asia				
Azerbajian		X		X
Georgia		X		X
Kyrgyzstan		X		X
Tajikstan		X		X
Uzbekistan		X	X	

Sources: ESCAP, UNDP and ADB, 2005 (p. 13 for progress); PRB, 2005 for GNI ppp per capita.

Notes:
1. The table excludes the countries for which data on either Goal 4 progress or Goal 5 progress are not available.
2. The table includes Myanmar, Timor-Leste, Afghanistan, Bhutan, and Maldives for which per capita income is unknown.

Appendix A2. Progress towards meeting Goals 4 and 5 as assessed in 2003 by ESCAP, UNDP and ADB: countries and areas in the ESCAP region with 2004 GNI ppp per capita >= US$ 4,000

Country/area	Goal 4 (under-5 and infant mortality)		Goal 5 (improve maternal health)	
	Already achieved or expected to achieve	Making slow progress or regressing	Already achieved or expected to achieve	Making slow progress or regressing
East and North-East Asia				
China	X			X
Hong Kong, China	X		X	
Macao, China	X		X	
Japan	X		X	
Republic of Korea	X		X	
South-East Asia				
Brunei Darussalam	X			X
Malaysia	X			X
Philippines	X			X
Singapore	X			X
Thailand	X		X	
South and South-West Asia				
Iran (Islamic Republic of)	X			X
Sri Lanka	X			X
Turkey	X			X
North and Central Asia				
Armenia	X			X
Kazakhstan		X		X
Russian Federation	X			X
Turkmenistan		X	X	

Sources: ESCAP, UNDP and ADB, 2005 (p. 13 for progress); PRB, 2005 for GNI ppp per capita.

Notes: 1. The table excludes the countries for which data on either Goal 4 progress or Goal 5 progress are not available.

2. The table includes Brunei Darussalam for which per capita income is not available.

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