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Child Survival Progress in 194 Countries: 1990-2015

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Abstract: This paper analyses the progress towards child survival in the world during 1990-2015 on the basis of the estimates of under-five mortality rate prepared by the United Nations Inter-Agency Group on Child Mortality Estimation. The analysis reveals that in more than two-third countries of the world, the target of reducing the under-five mortality rate by two-third during 1990-2015 could not be achieved and there are countries where under-five mortality rate even increased during this period. A decomposition of the decrease of 6.8 million child deaths during 1990-2015 suggests that the decrease has been the result of both decrease in the number of live births as the result of the decrease in the birth rate and increase in the number of survivors as the result of the decrease in under-five mortality. The analysis suggests that in most of the countries of the world, the commitment made towards child survival by endorsing the United Nations Millennium Declaration could not be followed up by concrete efforts. The paper calls for a country specific approach to accelerating progress towards child survival to achieve targets set in the 2030 Sustainable Development Agenda.

Keywords: Child survival, Millennium Development Goals, Decomposition, Child deaths.

Introduction

The Millennium Development Goals (MDGs) set by the United Nations in 2000 as part of the United Nations Millennium Development Agenda have been the yardstick for measuring and monitoring global progress towards addressing different forms of extreme poverty (United Nations, 2000). These Goals have also been perceived as basic human rights. One of these Goals (MDG-4) is directed towards reducing child mortality with the target of reducing the under-five mortality rate (*U5MR*) by two-third between 1990 and 2015. However, a recent report based on consistent and internationally comparable country level estimates of *U5MR* prepared by the United Nations Inter-Agency Group for Child Mortality Estimation (UN IGME) has observed that, although, major progress has been made in the world towards reducing *U5MR* and the pace of decrease in *U5MR* has accelerated after 2000, yet the target of reducing *U5MR* by two-third between 1990 and 2015 could not be achieved (UNICEF, 2015). Many other studies have also observed that the progress towards reducing child mortality has been substantially slower than that required to achieve MDG-4 (Bhutta et al, 2010; Rajaratnam et al, 2010; You et al, 2010; Lozano et al, 2011). The very fact that child survival remains an unfinished agenda is recognised by the United Nations in its 2030 Sustainable Development Agenda which has set specific targets in terms of ending premature death of newborns and children below five years of age. The Agenda envisions that all countries should aim to reduce neonatal mortality to at least as low as 12 neonatal deaths and under-five mortality to at least as low as 25 under-five deaths for every 1000 live births by the year 2030 (United Nations, 2016). The essential difference between the goal set under the Millennium Development Agenda and the targets set under the 2030 Sustainable Development Agenda is that the goal set under the Millennium Development Agenda are defined in relative terms while the targets set under the 2030 Sustainable Development Agenda are global minimum standards, a level end goal. The relativeness of the goal set

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under the Millennium Development Agenda implies that every country, irrespective of the level of *U5MR*, should contribute to global reduction in *U5MR*. By contrast, the global minimum standards set under the 2030 Sustainable Development Agenda essentially means that countries which have already achieved these minimum standards are out of the purview of the 2030 Sustainable Development Agenda as far as reduction in child mortality is concerned. Estimates prepared by UN IGME suggest that 115 countries had already achieved *U5MR* at least as low as 25 under-five deaths for every 1000 live births by 2015 which means that these countries are out of the purview of the 2030 Sustainable Development Agenda in the context of child survival. The scope of the 2030 Sustainable Development Agenda in the context of reduction in *U5MR*, therefore, is actually limited to only those 79 countries where the*U5MR* was estimated to be more than 25 under-five deaths per 1000 live births in 2015.

The reduction in *U5MR*, it may be pointed out, is contingent upon the decrease in mortality during neonatal and post-neonatal periods and during 1-4 years of life. The relative contribution of neonatal mortality rate (*NMR*), post-neonatal mortality rate (*PNMR*) and 1-4 years' mortality rate (*CMR*) to *U5MR* depends upon the level of *U5MR*. With the decrease in *U5MR*, more and more under-five deaths get concentrated in infancy and in the neonatal period. Main causes of death during neonatal period, post neonatal period and 1-4 years are also different. More than 85 per cent of the deaths during the neonatal period are due to just four causes - prematurity, birth asphyxia, sepsis and congenital anomalies whereas almost 60 per cent deaths during the post-neonatal period are due to diarrhoea, acute respiratory infections, malaria and injuries. On the other hand, main causes of death during 1-4 years of life are accidents (unintended injuries). Interventions required for preventing neonatal deaths are, therefore, essentially different from interventions necessary to prevent post-neonatal deaths or deaths during1-4 years of life. This means that reduction in *U5MR* should be analysed in the context of the reduction in *NMR*, *PNMR* and *CMR*.

Moreover, at a given level of *U5MR*, total number of under-five deaths is also determined by the size of the population and the level of fertility. An increase in population results in an increase in the number of under-five deaths even if fertility and under-five mortality remain unchanged. Similarly, a decrease in fertility leads to a decrease in the number of under-five deaths even if there is no change in population and under-five mortality. This means that any analysis of the change in the number of under-five deaths should also take into account the change in population size and the transition in fertility in addition to the change in *U5MR* or change in *NMR*, *PNMR* and *CMR*.

The above considerations constitute the rationale for the present analysis which aims to analyze how the change in the number of under-five deaths in 194 countries of the world during 1990-2015 has been influenced by the change in population size, transition in fertility and the change in *NMR*, *PNMR* and *CMR*. The analysis contributes to our understanding of the transition path followed by different countries towards MDG-4 and in avoiding premature but preventable under-five deaths.

The paper is organized as follows. The next section describes the data used in the analysis. The analysis is based on the estimates of *U5MR* and under-five deaths prepared by UN IGME for 194 countries for different years of the period 1990-2015. The analytical framework used in the analysis is elaborated in section three. Section four presents an overview of inter-country variation and the trend in child mortality. Results of the analysis are presented in section five while the last section summarizes main conclusions of the analysis.

Data

The analysis is based on the estimates of under-five mortality rate (*U5MR*), infant mortality rate (*IMR*) and neonatal mortality rate (*NMR*) along with the estimates of the total number of under-five deaths, total number of infant deaths and the total number of neonatal deaths for different years of the period 1990-2015 prepared by UN IGME for 194 countries of the world (UNICEF, 2015). UN IGME was formed in 2004 to share data on child mortality, harmonise estimates within the United Nations system, improve methods for child mortality estimation, report on the progress towards child survival goals and enhance country capacity to produce timely and properly assessed estimates of child mortality. The estimates of *U5MR*, *IMR*, and *NMR* prepared by UN IGME are actually, respectively, the probability of death between birth and exactly 5 years of age, the probability of death between birth and exactly 1 year of age and the probability of death during the first 28 days of life and are expressed per 1000 live births. The methodology adopted by UNI GME for preparing these estimates is given elsewhere and is not repeated here (UNICEF, 2015). The estimation approach, essentially, involves fitting a statistical model, for each country, on the basis of the data available from different sources to generate a smooth trend curve that averages over possibly disparate estimates from the different data sources, and, then, extrapolating the model to the year 2015.

In addition to estimates of *U5MR*, *IMR*, and *NMR* prepared by UN IGME, estimates of the population of each country prepared by the United Nations Population Division for different years of the period 1990-2015 have also been used in the present paper to analyze how much of the change in the under-five deaths in each country is attributed to the change in the size of the population. These estimates refer to 1st July of every year (United Nations, 2017). The population estimates have also been used to estimate the birth rate for each country for different years on the basis of the number of live births estimated from the number of neonatal deaths in a year and estimated *NMR* for that year.

Methodology

Let

q_u=*U5MR*/1000

q_n=*NMR*/1000, and

q_i=*IMR*/1000.

Then, the probability of death during the postnatal period, q_p, can be estimated as

$q_p = 1-[(1-q_i)/(1-q_n)]$

Similarly, the probability of death during 1-4 years of life, q_c, can be estimated as

$q_c=1-[(1-q_u)/(1-q_i)]$

It is easy to show that

$1-q_u = (1-q_n)*(1-q_p)*(1-q_c)$

or

(1)

where p_u=1-q_u is the probability of survival during the first five years of life, p_n is the probability of survival during the neonatal period, p_p is the probability of survival during the post-neonatal period and p_c is the probability of survival during 1-4 years of life. The change in p_u over time can now be decomposed into the change in p_n, p_p and p_c in relative as well as in absolute terms. In relative terms, the probability of survival, p_u, at time 2, relative to time 1 can be decomposed as

$$\left(\frac{p_u^2}{p_u^1}\right) = \left(\frac{p_n^2}{p_n^1}\right) * \left(\frac{p_p^2}{p_p^1}\right) * \left(\frac{p_c^2}{p_c^1}\right)$$

or

$$ln\left(\frac{p_u^2}{p_u^1}\right) = ln\left(\frac{p_n^2}{p_n^1}\right) + ln\left(\frac{p_p^2}{p_p^1}\right) + ln\left(\frac{p_c^2}{p_c^1}\right)$$

or

$$\partial p_u = \partial p_n + \partial p_p + \partial p_c \qquad (2)$$

Equation (2) is true by definition and applies to every country so that naive regression or correlation approaches, which ignore the sum constraint, are potentially problematic in analyzing the relative contribution of the inter-country variation in the change in ∂p_n, ∂p_p and ∂p_c to the inter-country variation in the change in ∂p_u. An alternative approach (Preston, 1994; Poorter and van der Werf, 1998; Wright and Westoby, 2001) is to decompose the inter-country variance in the change in ∂p_u. It can be shown that

$$Var(\partial p_u) = \sum_j Var(\partial p_j) + \sum_{\substack{j,k \\ j\neq k}} Cov(\partial p_j, \partial p_k) \qquad (3)$$

where $j=n, p, c$. Here *Var* denotes the variance and *Cov* denotes the covariance. The relative contribution of the inter-country variance in the change in ∂p_n, ∂p_p and ∂p_c to the inter-country variance in the change in ∂p_u may now be obtained as

$$1 = C(\partial p_n) + C(\partial p_p) + C(\partial p_c) \qquad (4)$$

where

$$C(\partial p_n) = \frac{Var(\partial p_n) + Cov(\partial p_n, \partial p_p) + Cov(\partial p_n, \partial p_c)}{Var(\partial p_u)}$$

$$C(\partial p_p) = \frac{Var(\partial p_p) + Cov(\partial p_n, \partial p_p) + Cov(\partial p_p, \partial p_c)}{Var(\partial p_u)}$$

$$C(\partial p_c) = \frac{Var(\partial p_c) + Cov(\partial p_n, \partial p_c) + Cov(\partial p_p, \partial p_c)}{Var(\partial p_u)}$$

The contribution of the inter-country variance in any component of ∂p_u to the inter-country variance in ∂p_u based on equation (4) may be small for two reasons. First the change in the component of interest is not variable across countries so that variance and covariance terms in equation (4) are small. Second, the change in the component of interest varies across countries but the covariance terms are negative so that the algebraic sum of variance and covariance terms is small. In the second case, equation (4) may not reflect the true importance of the inter-country variance in ∂p_n or ∂p_p or ∂p_c in explaining the inter-country variance in ∂p_u. This problem may be addressed by using absolute values of the covariance terms (Horvitz et al, 1997; Rees et al, 2010: Rees et al, 1996) so that the importance of the inter-country variance in ∂p_n, ∂p_p and ∂p_c to the inter-country variance in ∂p_u may be obtained as

$$1 = Imp(\partial p_n) + Imp(\partial p_p) + Imp(\partial p_c) \qquad (5)$$

where

$$Imp(\partial p_n) = \frac{Var(\partial p_n) + |Cov(\partial p_n, \partial p_p)| + |Cov(\partial p_n, \partial p_c)|}{T}$$

$$Imp(\partial p_p) = \frac{Var(\partial p_p) + |Cov(\partial p_n, \partial p_p)| + |Cov(\partial p_p, \partial p_c)|}{T}$$

$$Imp(\partial p_c) = \frac{Var(\partial p_c) + |Cov(\partial p_n, \partial p_c)| + |Cov(\partial p_p, \partial p_c)|}{T}$$

where *T* is the sum of the absolute values of the terms on the right-hand side of equation (4) and is different from $Var(\partial p_u)$.

If P denotes population size and BR denotes the birth rate so that $b=(BR/1000)$ and $L=P*b$ is the total number of live births, then the total number of survivors S in the first five years of life is given by

$$S = P*b*p_n*p_p*p_c \tag{6}$$

The change in the total number of survivors during the first five years of life, over time, is now given by:

$$\nabla S = S^2 - S^1 = \left(P^2 * b^2 * p_n^2 * p_p^2 * p_c^2\right) - \left(P^1 * b^1 * p_n^1 * p_p^1 * p_c^1\right) \tag{7}$$

Now, following Ang (2016)

$$\nabla S = \frac{S^2 - S^1}{r_S} * r_S \tag{8}$$

where

$$r_S = ln\left(\frac{S^2}{S^1}\right) = ln\left(\frac{P^2*b^2*p_n^2*p_p^2*p_c^2}{P^1*b^1*p_n^1*p_p^1*p_c^1}\right) = r_P + r_b + r_{p_n} + r_{p_p} + r_{p_c} \tag{9}$$

Substituting from (8) in (7), we get

$$\nabla S = \nabla S * \left(\frac{r_P}{r_S}\right) + \nabla S * \left(\frac{r_b}{r_S}\right) + \nabla S * \left(\frac{r_{pn}}{r_S}\right) + \nabla S * \left(\frac{r_{pp}}{r_S}\right) \nabla S * \left(\frac{r_{pc}}{r_S}\right) \tag{10}$$

If D denotes the total number of under-five deaths, then the change the total number of survivors can also be expressed as

$$\nabla S = (L^2 - D^2) - (L^1 - D^1) = (L^2 - L^1) - (D^2 - D^1) = \nabla L - \nabla D \tag{11}$$

or

$$\nabla D = \nabla L - \nabla S \tag{12}$$

Now

$$\nabla L = L^2 - L^1 = P^2 * b^2 - P^1 * b^1 = \nabla L * \left(\frac{r_P}{r_L}\right) + \nabla L * \left(\frac{r_b}{r_L}\right) \tag{13}$$

So that

$$\nabla D = \nabla L * \left[\left(\frac{r_P}{r_L}\right) + \left(\frac{r_b}{r_L}\right)\right] - \nabla S * \left[\left(\frac{r_P}{r_S}\right) + \left(\frac{r_b}{r_S}\right) + \left(\frac{r_{pn}}{r_S}\right) + \left(\frac{r_{pp}}{r_S}\right) + \left(\frac{r_{pc}}{r_S}\right)\right] \tag{14}$$

$$\nabla D = \left(r_p \frac{\nabla L}{r_L} - r_p \frac{\nabla S}{r_S}\right) + \left(r_b \frac{\nabla L}{r_L} - r_b \frac{\nabla S}{r_S}\right) - r_{p_n}\left(\frac{\nabla S}{r_S}\right) - r_{p_p}\left(\frac{\nabla S}{r_S}\right) - r_{p_c}\left(\frac{\nabla S}{r_S}\right) \tag{15}$$

or

$$\nabla D = \left(dL_p - dS_p\right) + (dL_b - dS_b) - dS_{p_n} - dS_{p_p} - dS_{p_c} \tag{16}$$

Finally, the total number of under-five deaths in a country is determined by the level of under-five mortality, q_u, birth rate, b, and size of the population, P. In other words,

$$D = P * b * q_u \tag{17}$$

The change in the number of under-five deaths can, therefore, be decomposed as

$$\partial D = \partial P + \partial b + \partial q_u \tag{18}$$

The inter-country variance in the change in the number of under-five deaths can therefore be decomposed as

$$Var(\partial D) = \sum_j Var\left(\partial y_j\right) + \sum_{\substack{j,k \\ j \neq k}} Cov\left(\partial y_j, \partial y_k\right) \tag{19}$$

where $y=P$, b and q_u.

The importance of the inter-country variance in ∂P, ∂b and ∂q_u to the inter-country variance in ∂D may be obtained as

$$1 = Imp(\partial P) + Imp(\partial b) + Imp(\partial q_u) \tag{20}$$

where

$$Imp(\partial P) = \frac{Var(\partial P) + |Cov(\partial P, \partial b)| + |Cov(\partial P, \partial q_u)|}{K}$$

$$Imp(\partial b) = \frac{Var(\partial b) + |Cov(\partial b, \partial P)| + |Cov(\partial b, \partial q_u)|}{K}$$

$$Imp(\partial q_u) = \frac{Var(\partial q_u) + |Cov(\partial q_u, \partial P)| + |Cov(\partial q_u, \partial b)|}{K}$$

where K is the sum of the absolute values of variance and covariance terms on the right-hand side of equation (19) and is different from $Var(\partial D)$.

Results

Transition in Under-five Mortality

UN IGME estimates suggest that *U5MR* varied widely across 194 countries circa 2015. It was the lowest in Luxembourg (1.9 under five deaths per 1000 live births) but the highest in Angola (155.9 under five deaths per 1000 live births). The inter-country variation in *U5MR* is presented in Table 1 for the period 1990 through 2015. There were only seven countries – Nigeria, Mali, Sierra Leone, Central African Republic, Somalia, Chad and Angola – where *U5MR* was more than 100 under-five deaths per 1000 live births in 2015 whereas 115 countries had *U5MR* less than or equal to 25 under-five deaths per 1000 live births, the target set under the United Nations 2030 Sustainable Development Agenda to be achieved by 2030. In 1990, *U5MR* was less than or equal to 25 in 66 countries but more than 100 in 53 countries. The median *U5MR* across 194 countries decreased from 46.7 in 1990 to 17.0 under-five deaths per 1000 live births in 2015. The decrease in *U5MR* has, however, not been associated with the decrease in the inter-country dispersion in *U5MR* or σ-convergence.as the inter-country coefficient of variation increased from 0.953 in 1990 to 1.021 in 2015. In 1990, the highest *U5MR* was around 52 per cent times the lowest *U5MR* but, in 2015, the highest *U5MR* was almost 83 times the lowest *U5MR*. Despite reduction, the inter-country dissimilarity in*U5MR* has increased in the world. *U5MR* also varied widely across countries categorized as developed, developing and the least developed by the United Nations. In 2015, *U5MR* was the lowest in developed countries with a median of 4.2 but the highest in the least developed countries with a median of 69.6 under-five deaths per 1000 live births. In developing countries, median *U5MR* in 2015 was estimated to be 17.0 under-five deaths for every 1000 live births. There was no developed country in 2015 where *U5MR* was more than 25 under-five deaths per 1000 live births but *U5MR* was more than 25 in all least developed countries. The inter-country dispersion in *U5MR*, however, increased in all the three groups of countries. The σ-divergence is found to be quite marked in the least developed countries where inter-country coefficient of variation in *U5MR* increased from 0.330 in 1990 to 0.408 in 2015. The inter-country coefficient of variation in the developing countries increased from 0.745 to 0.797 and from 0.685 to 0.726 in the developed countries.

One condition that is necessary for σ-convergence is the β-convergence which means that the rate of decrease in *U5MR* is relatively faster in countries with high *U5MR* than in countries with low *U5MR*, although β-convergence is not a sufficient condition for σ-convergence. There is however no evidence of β-convergence in *U5MR* across the 194 countries included in the present analysis. There is also no evidence of inter-country β-convergence across either developed or developing or least developed countries.

The rate of decrease in *U5MR* was the most rapid in Maldives whereas there are three countries – Niue, Dominica and Lesotho – where *U5MR* increased, instead decreased between 1990 and 2015. There are only 11countries – 4 developed, 5 developing and 2 least developed - where *U5MR* decreased at an average annual rate of decrease of more than 6 per cent per year. In 68 countries – 21 developed, 31 developing and 16 least developed - the average annual rate of decrease in *U5MR* ranged 4-6 per cent per year whereas in 28 countries–2 developed, 18 developing and 8 least developed -*U5MR* decreased at a rate of less than 2 per cent per year (Table 2).

Table 1: Inter-country variation in *U5MR*, 1990-2015

Year	**Number of countries having *U5MR***					**Median *U5MR***
	<25	**25-50**	**50-75**	**75-100**	**>=100**	
1990	66	35	26	14	53	47
1991	67	36	23	15	53	46
1992	68	34	27	13	52	45
1993	70	35	26	10	53	43
1994	70	41	20	11	52	42
1995	72	41	19	10	52	40
1996	74	40	17	11	52	39
1997	76	42	12	12	52	38
1998	79	41	14	14	48	36
1999	80	42	11	15	46	34
2000	82	42	9	16	46	32
2001	85	41	6	19	43	30
2002	86	41	8	20	39	29
2003	88	39	11	18	38	28
2004	92	37	14	15	36	27
2005	97	32	18	15	32	25
2006	98	32	19	16	29	24
2007	100	30	21	18	25	23
2008	102	30	21	16	25	22
2009	104	31	21	15	23	22
2010	107	29	21	16	21	20
2011	108	29	23	16	18	20
2012	110	31	22	15	16	19
2013	112	32	24	13	13	18
2014	113	34	22	16	9	18
2015	115	35	20	17	7	17

Source: Author's calculations

In Dominica, Lesotho and Niue, *U5MR* increased during 1990-2015 according to UN IGME estimates and the contributing factors to the increase have been different in the three countries. In Dominica, *U5MR* decreased during 1990-2000 but increased consistently after 2000. The increase in *U5MR* in Lesotho was the result of almost doubling of *CMR* during 1990-2000. In Niue, on the other hand, all three *NMR*, *PNMR* and *CMR* increased during the period 1990-2010 so that *U5MR* almost doubled between 1990 and 2010. Country-specific factors appear to be responsible for the increase in *U5MR* in these countries, although the magnitude of the increase in *U5MR* has been small.

In the context of MDG-4, there are only 60 (30.9 per cent) countries – 17 developed, 29 developing and 14 least developed - where *U5MR* decreased by at least two-third between 1990 and 2015. This means that as many as 134 countries – 30 developed, 72 developing and 32 developing - failed to achieve MDG-4. In majority of developed and developing countries, the decrease in *U5MR* ranged between 50-67 per cent whereas *U5MR* decreased by at least two-third in majority of the least developed countries, although in 15 least developed countries, *U5MR* decreased by less than 50 per cent between 1990 and 2015. In the context of 2030 Sustainable Development Agenda, *U5MR* was at least as low as 25 in 114 countries in 2015 which means that the onus of achieving the target of reducing *U5MR* at least as low as

25 rests with only 80 countries- 34 developing and all 46 least developed. The developed countries are out of the purview of the 2030 Sustainable Development Agenda as far as reduction in *U5MR* is concerned.

Table 2: Decrease in *U5MR*, *NMR*, *PNMR* and *CMR* in 191 countries, 1990-2015

Decrease during 1990-2015 relative to 1990	**All**	**Developed**	**Developing**	**Least developed**
		U5MR		
< 0	3	0	2	1
0-33 per cent	16	0	11	5
33-50 per cent	40	3	26	11
50-66 per cent	75	27	32	16
≥66 per cent	60	17	30	13
Median decrease	58.4	63.5	55.2	56.2
		NMR		
< 0	2	0	2	0
0-33 per cent	39	2	25	12
33-50 per cent	51	9	22	20
50-66 per cent	67	18	36	14
≥66 per cent	35	18	16	0
Median decrease	51.3	62.9	51.5	41.0
		PNMR		
< 0	6	1	4	1
0-33 per cent	21	0	14	7
33-50 per cent	27	5	13	9
50-66 per cent	63	14	36	13
≥66 per cent	77	27	34	16
Median decrease	62.3	68.1	57.8	59.1
		CMR		
< 0	2	1	0	1
0-33 per cent	15	5	8	2
33-50 per cent	25	6	14	5
50-66 per cent	68	19	38	11
≥66 per cent	84	16	41	27
Median decrease	63.5	62.1	62.8	70.0
N	191	47	101	46

Source: Author's calculations
Note: Median decrease is calculated for those countries only, where child mortality decreased between 1990 and 2015.

The Millennium Development Agenda was launched in 2000, although, the year1990 was set as the reference year for monitoring the progress of the targets set under the Agenda. It may be argued that the pace of decrease in *U5MR* might have accelerated after the launch of the Millennium Development Agenda. To test this hypothesis, piecewise regression model was fitted to the time series of *U5MR* assuming that the pace of decrease in *U5MR* during 2000-2010 was different from that during 1990-2000 and the pace of decrease during 2010-

2015 was different from that during 2000-2010.The piecewise regression analysis revealed that, compared to 1990-2000, the pace of decrease in *U5MR* accelerated during 2000-2015 in only 105 countries – 16 developed, 49 developing and 40 least developed. On the other hand, compared to 2000-2010, the pace of decrease in *U5MR* accelerated during 2010-15 in only 82 countries. Interestingly, in 68 countries, the pace of the decrease in *U5MR* was the most rapid during 1990-2000, the period before the launch of the Millennium Development Agenda in the year 2000. In these countries, there is little evidence of acceleration in the decrease in *U5MR* after the launch of United Nations Millennium Development Agenda.

Decomposition of the Change in U5MR

Table 3 decomposes the change in *U5MR* during 1990-2015 into the change in *NMR*, *PNMR* and *CMR* for each of the 194 countries in conjunction with equation (2). At the global level, the change in *NMR*, *PNMR* and *CMR* appears to have contributed almost equally to the change in *U5MR*. The relative contribution of the change in *NMR*, *PNMR* and *CMR* to the change in *U5MR* has however been different in different development regions of the world. In the developed region, change in *U5MR* has mainly been the result of the change in *NMR* whereas the change in *U5MR* in the least developed countries may primarily be attributed to the change in *CMR*. In the developing countries, the contribution of the change in *NMR* has been substantially higher than that of *PNMR* whereas, in the least developed countries, the contribution of the change in *NMR* to the change in *U5MR* has relatively been the smallest among the three regions.

Table 3: Decomposition of the change in *U5MR* into changes in *NMR*, *PNMR* and *CMR* during 1990-2015 in the world and in its major development regions

Absolute change	**World**	**Developed countries**	**Developing countries**	**Least developed countries**
Change in *U5MR*	48.0	8.8	46.9	101.0
Change in *NMR*	16.4	4.4	17.9	22.0
Change in *PNMR*	14.5	2.9	14.0	32.3
Change in *CMR*	17.1	1.5	15.0	46.7

Source: Author's calculations

Table 4: Relative importance of inter-country variance in ∂p_n, ∂p_p and ∂p_c to inter-country variance in∂p_u

Variance estimates	**World**	**Developed countries**	**Developing countries**	**Least developed countries**
Var(∂p_u)x10^6	2617.12	61.21	1010.67	3204.04
Imp(∂p_n) (per cent)	14.37	33.53	18.56	10.98
Imp(∂p_p) (per cent)	33.64	46.38	41.22	30.15
Imp(∂p_c) (per cent)	51.99	20.09	40.22	58.87
N	194	47	101	46

Source: Author's calculations

Table 4 decomposes the inter-country variance in ∂p_u into inter-country variance in ∂p_n, ∂p_p and ∂p_c. More than half of the inter-country variance in ∂p_u is accounted by ∂p_c while ∂p_n accounts for less than 15 per cent of the inter-country variance in ∂p_u. In the developed countries, however, inter-country variance in ∂p_u is accounted almost equally by ∂p_p and ∂p_n. The contribution of ∂p_c to ∂p_u has not found to be large in these countries. In the developing countries, the main contributors to the inter-country variance in ∂p_u have been ∂p_p and ∂p_c. The contribution of ∂p_n has not been substantial in these countries. Finally, in the least developed countries, inter-country variance in ∂p_c is the most important contributor to the inter-country variance in ∂p_u while the contribution of ∂p_n is the least important. This shows that the path followed by developed, developing and the least developed countries towards MDG-4 has been different. This is expected as child mortality levels vary widely across three development regions.

Table 5: Likely year of achieving MDG-4 by countries

Countries	**World**	**Developed countries**	**Developing countries**	**Least developed countries**
Total number of countries	194	47	101	46
Countries which achieved MDG-4 by 2015	60	17	30	13
Countries likely to achieve MDG-4 by				
2016	9	3	3	3
2017	4	2	2	0
2018	6	3	3	0
2019	0	0	0	0
2020	4	1	2	1
2021	6	3	2	1
2022	6	3	2	1
2023	3	2	1	0
2024	6	2	3	1
2025	9	3	5	1
2026	7	1	3	3
2027	7	1	3	3
2028	7	1	5	1
2029	3	0	1	2
2030	4	0	3	1
Beyond 2030	53	5	33	15
Total	134	28	72	32

Source: Author's calculations

Distance to MDG-4

Although, child mortality estimates prepared by UN IGME suggest that *U5MR* has decreased in all but three countries, yet, the decrease in child mortality has not been large enough to achieve the MDG-4 either globally or separately in the three development regions.

MDG-4 could not be achieved because decrease in *U5MR* has been slower than required in 134 countries which include developed, developing and least developed countries. A pertinent question, therefore, is to forecast the year by when the world would be able to reduce *U5MR* by two-third from the level that prevailed in 1990 under the assumption that the trend in *U5MR* observed during 1990-2015 will continue in the coming years. The time series forecasting technique has been used for the purpose. The Expert Modeler option of the Forecasting Routine of Statistical Package for Social Sciences (SPSS) was used to select the most appropriate time series model. The advantage of using Expert Modeler option is that it eliminates, to a significant extent, the cumbersome trial and error process associated with the time series modeling (IBM, *no date*). The Expert Modeler automatically identifies that time series model which best fits the data. The time series forecasting exercise has been carried out for the world, for three major development regions and for each of the 134 countries where *U5MR*did not decrease by two-third between 1990 and 2015.

Results of the time series forecasting exercise are presented in Table 5 which suggests that *U5MR* in the world is likely to reduce by two-third from the level in 1990 some times during 2026 or more than 10 years behind the target year set in MDG-4. MDG-4 is likely to be achieved by year 2022 in developed and least developed regions but by 2027 only in the developing region. Moreover, without additional efforts, 53 countries of the world - 5 developed, 33 developing and 15 least developed - will not be able to reduce *U5MR* by two-third from the level in 1990 even by 2030. It is also evident from Table 5 that only 21 of the 134 countries which could not achieve MDG-4 would be able to achieve MDG-4 by 2020 while another 30 are likely to achieve MDG-4 sometimes during 2021-2025.

Transition in the Number of Child Deaths

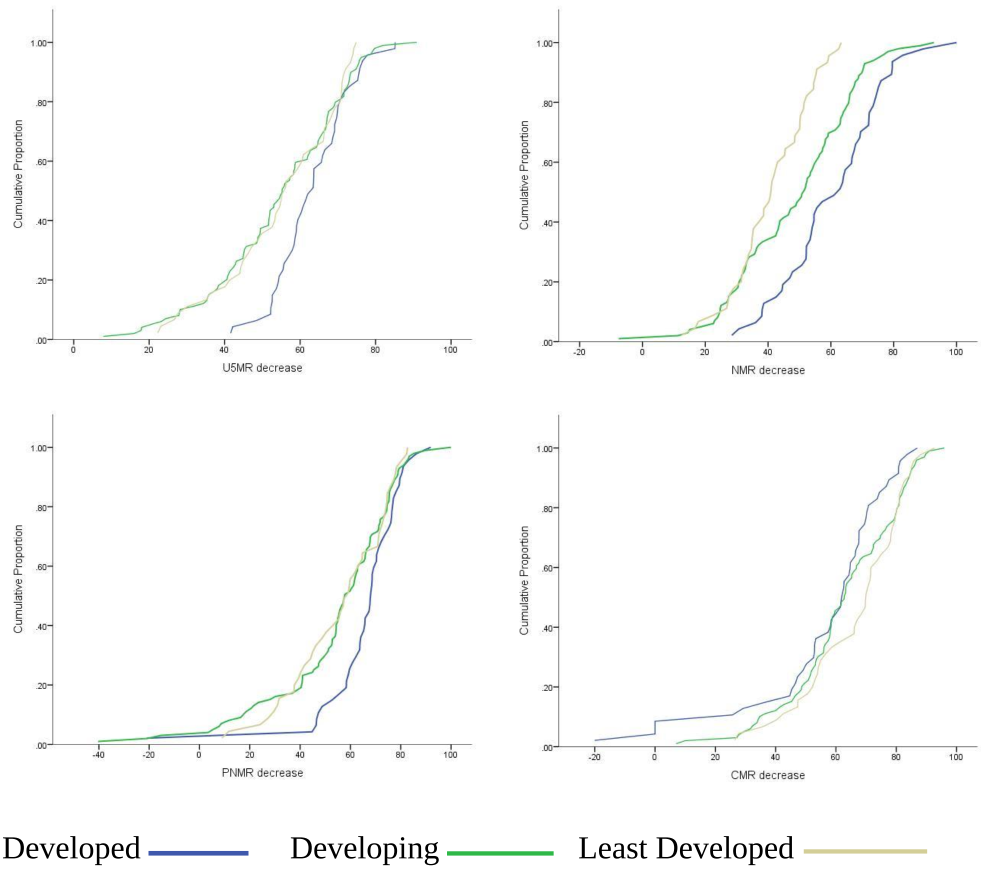
The estimates prepared by UN IGME suggest that total number of under-five deaths in the world decreased by around 6.804 million from around 12.75 million in 1990 to around 5.95 million in 2015 (Table 6). This decrease has been the result of both decrease in the number of live births as the result of the decrease in birth rate and increase in the number of survivors as the result of the decrease in *U5MR*. The number of live births in the world decreased by around 1.128 million between 1990 and 2015 whereas the number of survivors during the first five years of life increased by around 5.676 million. The proportionate decrease in the number of under-five deaths during 1990-2015 was relatively the highest in the least developed region of the world (64.7 per cent) but the lowest in the developed region (38.6 per cent) with the number of under-five deaths in the developing region reducing by around 59.1 per cent. The difference in the proportionate reduction in the number of under-five deaths across the three development regions of the world has resulted in an increase in the concentration of the global under-five deaths in the least developed countries from around 28.5 per cent in 1990 to 37.5 per cent in 2015. On the other hand, the proportion of under-five deaths in the developed countries to the total number of under-five deaths in the world decreased from 1.7 per cent in 1990 to 1.3 per cent in 2015 whereas under-five deaths in the developing countries as proportion to the total number of under-five deaths in the world decreased from 69.8 per cent in 1990 to 61.2 per cent in 2015.

Table 6: Transition in the number of under-five deaths (million) in the world and in its major development regions

Deaths (Million)	World	Developed countries	Developing countries	Least developed countries
		1990		
Under-five deaths	12.749	0.219	8.896	3.634
Neonatal deaths	5.106	0.114	3.914	1.078
Post-neonatal deaths	3.817	0.069	2.560	1.189
Deaths 1-4 years	3.825	0.036	2.423	1.366
		2015		
Under-five deaths	5.945	0.077	3.636	2.231
Neonatal deaths	2.682	0.042	1.800	0.840
Post-neonatal deaths	1.768	0.023	1.009	0.736
Deaths 1-4 years	1.494	0.012	0.826	0.656
Number of countries	194	47	101	46

Source: Author's calculations

Figure 1: Cumulative distribution of the proportionate change in *U5MR*, *NMR*, *PNMR* and *CMR* in developed, developing and least developed countries



Among different countries of the world, Estonia recorded the most rapid decrease in the number of under-five deaths followed by Maldives - the only two countries where the number of under-five deaths decreased by more than 90 per cent between 1990 and 2015. In addition, there are only 19 countries where the number of under-five deaths decreased by 80-

90 per cent during this period. In China, the most populous country of the world, the number of under-five deaths decreased by more than 80 per cent. By contrast, the number of under-five deaths decreased by only about 64 per cent in India, the second most populous country of the world. On the other hand, there are 14 countries where the total number of under-five deaths increased, instead decreased, during the period under reference with the increase being the most rapid in Angola where the number of under-five deaths increased by more than 38 per cent between 1990 and 2015. In Chad and Zimbabwe also, the number of under-five deaths increased by more than 30 per cent. Moreover, there are two countries - Niue and Monaco - where there has been no change in the number of under-five deaths in 2015 as compared to the number of under-five deaths in 1990.

Decomposition of the Change in Under-five Deaths

Table 7 decomposes the decrease in the number of under-five deaths into the decrease attributed to the change in population size, birth rate and the number of survivors during neonatal and post-neonatal periods and during 1-4 years of life. The number of under-five deaths in the world decreased by 6.804 million between 1990 and 2015. About 17 per cent of this decrease is attributed to the decrease in the number of live births whereas around 83 per cent of the decrease is attributed to the increase in the number of survivors during the first five years of life. The birth rate decreased from around 26.7 births per 1000 population in 1990 to around 19.1 in 2015 which resulted in a decrease of around 47.643 million live births between 1990 and 2015. However, world population increased from around 5276 million in 1990 to around 7310 million in 2015 which resulted in an increase in the number of live births by almost 46.515 million so that the net decrease in the number of live births between 1990 and 2015 was around 1.128 million.

The decrease in the birth rate also resulted in a decrease of 44.525 million survivors whereas the increase in population resulted in an increase of around 43.349 million survivors during the first five years of life so that the net decrease in the number of survivors due to the increase in population and decrease in birth rate was 1.176 million. At the same time, decrease in mortality during the first five years of life resulted in an increase of 6.852 million survivors so that the net increase in the number of survivors was 5.676 million. The increase in the number of survivors was 2.339 million during the neonatal period, 2.071 million during the post-neonatal period, and 2.442 million during 1-4 years of life. In other words, world population growth during 1990-2015 resulted in an increase of 3.160 million under-five deaths but the decrease in the birth rate resulted in a decrease of 3.112 million under-five deaths while the decrease in mortality in the first five years of life resulted in a decrease of 6.852 million under-five deaths. In the developed and developing regions, decrease in the number of under-five deaths as the result of the decrease in the birth rate more than compensated the increase in the number of under-five deaths as the result of the increase in population. In the least developed region, however, decrease in the number of under-five deaths as the result of the decrease in the birth rate has been substantially smaller than the increase in the number of under-five deaths as the result of the increase in population so that the decrease in the number of under-five deaths has been substantially smaller than the decrease attributed to the decrease in the risk of death during the first five years of life. The increase in the concentration of global under-five deaths in the least developed countries in 2015 as compared to that in 1990 may be attributed to slow fertility transition as reflected by the decrease in birth rate.

More than 76 per cent of the decrease in the under-five deaths in the world between 1990 and 2015 was confined to only seven countries - Bangladesh, Brazil, China, Ethiopia, India, Indonesia and Pakistan - with China and India, alone, accounting for more than half of the global decrease. On the other hand, in 14 countries - 5 developing and 9 least developed - number of under-five deaths increased accounting for an increase of 0.106 million under-five deaths. In these 14 countries, *U5MR* increased in only two countries while birth rate decreased in all countries. In these countries, decrease in the number of live births and increase in the number of survivors as the result of the decrease in the birth rate and *U5MR* has not been able to compensate for the increase in the number of live births and number of under-five deaths as the result of the increase in population. In order to ensure a decrease in the total number of under-five deaths, a certain minimum decrease in the birth rate and in *U5MR* is necessary to compensate for the increase in the number of live births and the number of under-five deaths as the result of population growth.

Table 7: Decomposition of the change in the under-five deaths in the world and major development regions, 1990-2015 (Million)

Components	**World**	**Regions**		
		Developed	**Developing**	**Least developed**
Change in the number of under-five deaths (∇D)	-6.804	-0.142	-5.260	-1.402
Change in the number of live births (∇L)	-1.128	-1.769	-8.942	9.583
Change in the number of survivors due to decrease in *U5MR* (∇S)	5.676	-1.627	-3.682	10.985
Change in the number of live births due to increase in population(dL_P)	46.515	1.249	35.472	16.141
Change in the number of live births due to decrease in birth rate(dL_b)	-47.643	-3.018	-44.414	-6.558
Change in survivors due to population increase(dS_P)	43.349	1.236	33.235	14.099
Change in survivors due to decrease in birth rate(dS_b)	-44.525	-2.987	-41.745	-5.776
Change in survivors due to decrease in *NMR*(dSp_n)	2.339	0.062	1.844	0.579
Change in survivors due to decrease in *PNMR*(dSp_p)	2.071	0.040	1.438	0.852
Change in survivors due to decrease in *CMR*(dSp_c)	2.442	0.021	1.546	1.231
Change in survivors due to decrease in *U5MR*(dSp_u)	6.852	0.123	4.828	2.662

Source: Author’s calculations

Table 8: Relative importance (per cent) of inter-country variance in change in P, change in b and change in q_u to the inter-country variance in the change in the number of under-five deaths

Particulars	World	Developed countries	Developing countries	Least developed countries
$Imp(\partial P)$	24.29	8.55	23.55	33.41
$Imp(\partial b)$	24.48	18.09	25.14	15.96
$Imp(\partial q_u)$	51.24	73.36	51.31	50.62

Source: Author's calculations

The relative importance of the inter-country variance in the change in population size, birth rate and *U5MR* to the inter-country variance in the change in the number of under-five deaths is shown in table 8. For the world, inter-country variance in the change in *U5MR* is found to be twice as important as the inter-country variance in population change and change in the birth rate in explaining the inter-country variance in the change in the number of under-five deaths. In the developed countries, inter-country variance in the decrease in the number of under-five deaths is very heavily influenced by the inter-country variance in the change in *U5MR*. In the least developed countries, the importance of the inter-country variance in the change in the birth rate is very low compared to that in *U5MR* and population change. Finally, in the developing countries, the importance of the inter-country variance in the three components is found to be nearly the same as that in the world.

Conclusions

The progress in child survival in the world is contingent upon the criteria used for measuring progress. If the goal set under the United Nations Millennium Development Agenda is the criteria, then child survival progress during 1990-2015 has definitely been unsatisfactory in most of the countries of the world, whether developed or developing or the least developed. However, if the targets set under the United Nations 2030 Sustainable Development Agenda is the criteria, then the scenario appears to be comparatively better as there were only 80 countries where *U5MR* in 2015 was higher than the target set under the Agenda. In any case, the failure of 134 countries to reduce *U5MR* by two-third between 1990 and 2015 implies that, around 1.7 million deaths of children below five years of age could not be saved in the world between 1990 and 2015. These countries, appear to have failed to mobilise resources necessary to prevent premature but avoidable deaths in children below five years of age irrespective of whether they are developed, developing or the least developed.

The decrease in the number of under-five deaths has particularly been slow in the least developed countries of the world. The comparatively slow decrease in the number of under-five deaths in these countries is not because of a slow decrease in *U5MR* but also because fertility transition in these countries has been slow so that the decrease in the number of under-five deaths as the result of the decrease in the birth rate could not compensate for the increase in the number of under-five deaths as the result of the increase in population which has been rapid because of slow fertility transition. Hastening the pace of fertility transition in these countries is necessary so as to prevent an increasing number of premature yet avoidable child deaths.

Efforts to reduce under-five mortality and prevent premature yet avoidable deaths of children are primarily built around the integrated management of childhood illness (IMCI) strategy launched by WHO and UNICEF in 1995 and which was later expanded to include neonatal care in 2003 and renamed as integrated management of neonatal and childhood illness (IMNCI). A review of the impact of this strategy in reducing child mortality by WHO has concluded that over a period of 20 years, the interest and funding for IMNCI have waned, implementation has proved problematic and coverage at scale could be achieved by only a few countries (WHO, 2016). The review has also observed that a holistic view of child health has been lost inside the continuum of reproductive, maternal, newborn, child and adolescent health (RMNCAH) care, although specific child survival interventions such as immunisation continued to be the focus of attention. The review has argued that every country should embark upon an integrated, well-funded child survival programme that aligns, maternal, newborn, and child health programming under a common national vision. Given the diverse child survival path followed by different countries, a country specific tailored response, as recommended in the WHO, is the need of the time to accelerate progress towards preventing premature child deaths. An accelerated progress towards child survival can be achieved only by sustaining a strong political will, investing adequately in children, and evidence-based planning, programming and monitoring of the action to promote child survival in each country.

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