7

SRI LANKA'S UNDER-FIVE MORTALITY ESTIMATION FOR MEASURING PROGRESS OF MILLENNIUM DEVELOPMENT GOAL (MDG): A COMMENT AND SUGGESTIONS FOR IMPROVEMENT

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Introduction

The Infant Mortality Rate (IMR) defined as deaths of children under the age of 1 year per 1,000 live births has been used as an indicator of the health of children and a measure of the level of socio-economic development of a country. In many countries, the number of deaths during infancy is generally higher, than those occurring in early childhood (1-4 years of age). However, in some developing countries deaths occurring in early childhood are also high, although, not exceeding deaths in infancy. This observation prompted the United Nations Children's Fund (UNICEF) to focus on 'under-five mortality' as an indicator of the cumulative exposure to the risk of death faced by both infants and those in early childhood. This measure has gained popularity since the 1990 World Summit of Children where, among other things, member nations of the United

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Nations (UN) agreed to implement strategies to reduce Under-five Mortality Rates (U5MR) in their countries (UNICEF, 1990). Later, use of under-five mortality, as an indicator of the health and well-being of children and socio-economic development, was recognized by the International Conference on Population and Development (ICPD) in 1994. This indicator gained greater acceptance when it was listed as a key indicator of Goal 4 of the Millennium Development Goals (MDG).

In order to assist member countries to maintain statistics on each MDG indicator, consistently and uniformly, the UN provided guidelines with details regarding the concepts, definitions and the computational methods (Department of Economic and Social Affairs, 2012). These guidelines are continually updated. The U5MR is defined as the probability for a child born in a specified year to die before reaching the age of five, if he or she were subject to the current age-specific mortality rates. In recommending suitable methodology for developing this indicator, MDG guidelines reviewed different data sources which can draw estimates of under-five mortality. These guidelines recognized the Vital Registration System (VRS) which covers the entire country with a high coverage of births and deaths to be the most appropriate source of data on infant and child mortality.

Counties with effectively functioning VRS use the life-table approach to produce relevant indicators of infant and under-five mortality. However, the fully functioning VRSs are confined to a few countries, mostly comprise the developed nations. In countries where the registration systems are not functioning effectively, the guidelines provided information on possible sources of data, such as household surveys that collect full birth histories and survival status of children, as well as surveys and censuses which collect summary birth histories of children for the estimation of infant and under-five mortality. These are briefly discussed later in this paper.

The guidelines recommended that in countries where the registration systems are not functioning properly, the U5MR for a calendar year should be calculated by dividing the total

number of under-five deaths recorded for the year by the total number of live births in the same year multiplied by 1,000. The Sri Lanka Vital Statistics Unit of the Department of Registrar Generals uses this method to compute U5MR for the country as a whole and for subnational areas. Other agencies, such as the Ministry of Health, use these rates for program monitoring and dissemination of U5MRs as well as other mortality indicators in their publications i.e Annual Health Bulletin of the Ministry of Health.

This paper comments on the method used for computing U5MR for Sri Lanka and suggests an alternative method of estimating U5MR. The alternative method proposed will be consistent with the definition of under-five mortality. The paper begins with a brief comment on the major sources of information on live births and under-five deaths that the MDG considered as alternative data sources for estimating of infant and under-five mortality rates.

Sources of Data to Estimate Under-five Mortality

The MDG indicator of under-five mortality rates could be calculated using the data from household surveys that are conducted on a representative sample, stratified by major socio-economic and regional areas. Such surveys normally collect information from ever-married women aged 15-49 years. The detailed data collected include dates of birth, sex and survival status of each live birth that the woman ever had, and the dates of death. Using these complete birth histories it is possible to compute the probability of dying for a child in infancy, early childhood and before the child reached his/her fifth birthday. To perform these calculations it is necessary to identify babies born in a specified period, say 5, 10 or 15 years before the survey date. The Sri Lanka Demographic and Health Survey (SLDHS) program which began in the 1980s and the Sri Lanka World Fertility Survey (SLWFS) program conducted in the 1970's, are examples of such household surveys.

The quality of household survey data can be affected by sampling and non-sampling errors. So-called 'structural issues' are among the non-sampling errors. For example, these surveys

collect birth history information from those surviving at the time of the survey, therefore, the mortality experience of children of mothers who had died by the survey date are excluded. This becomes a problem as the women who did not survive may have had children, who may also be at a higher risk of dying in childhood (Curtis, 1995). If the survey data are used to estimate infant and under-five mortality rates of children born many years prior to the survey date this could introduce bias. The bias may occur as the mortality estimates are based on younger women and thus the mortality experience of women currently over 49 years of age, who could have had live births in the reference period, are not included in estimation (Hill, *et al.*, 2012). There are also reporting errors in these surveys, including recall errors, age misstatement and potential omission of some early deaths. It has also been observed that when a survey questionnaire includes many question items on different modules such as those used in the Demographic and Health Survey series, interviewers may even misdate events to avoid completing detailed questions about many children (Arnold, 1990).

Another source of error arises from age misstatement of children and recording of dates of their deceased children. If the age misreporting results in shifting the year of death into another age bracket then it could introduce a serious bias in the estimated mortality rates (Ahmad, et al., 2000; Child Mortality Coordinating Group, 2006). The other issue is that detailed questionnaires used in the surveys are normally restricted to small samples. Therefore, the samples selected allow estimates only at the national level, and for a few broad socio-economic subgroups. These surveys are expensive to carry out and demand personnel with advanced skills in all aspects of the survey program, from planning of the surveys to drafting the report and evaluation of data quality.

The Multiple Indicator Cluster Survey of UNICEF uses the 'summary birth history approach' to generate infant and child mortality data. These surveys question ever-married women about the children they ever had and the number of their children who have died by the survey date. These data have

been used to generate infant and child mortality estimates for the country as a whole and for socio-economic subgroups using indirect methods such as those proposed by Brass. The mortality estimates derived from the summary birth history information is considered as low-cost method of obtaining mortality estimates for children. This is because a response to only two survey questions is necessary to estimate child mortality and these questions can be easily included in surveys. The mortality estimates derived from the summary birth history data is particularly useful if included in regular censuses, as the data collected allow computation of child mortality rates for smaller geographic areas. However, these estimates are based on younger women of 15-19 and 20-24 years of age. These younger women are expected to have reliable recall when reporting the number of children they have had and those that may have died. However, the mortality experiences of children of these younger cohorts of women are expected to be relatively higher than those of middle-aged women, which may result in overestimating child mortality.

The SLDHS survey experience suggests that the accuracy of the information on children ever born and children surviving is likely to be under-reported in surveys. The SLDHS experience also suggests that the accuracy of reporting could be improved if the surveys included additional questions to obtain details of the number of sons and daughters living with the mother and numbers of her sons and daughters living elsewhere. Also, mothers should be queried for any births and deaths she may have missed reporting (Arnold, 1990).

Of the main sources of information to assess under-five mortality in Sri Lanka comes from the Vital Registration System, which compute detailed data on births and deaths on an annual basis. Household surveys in Sri Lanka which collected complete birth histories from ever-married women in the reproductive ages, such as the World Sri Lanka component of the SLWFS in 1974 and SLDHS series, have provided information on infant and early childhood mortality. For example, Meegama (1980), used SLWFS data to analyse infant and early childhood deaths according to several socio-economic characteristics, and

highlighted the population sub-groups that were vulnerable to the risk of infant and child mortality. Subsequent to SLWFS Sri Lanka has conducted four DHS surveys in, 1987, 1993, 2000, and 2006/7. These surveys prided a estimates of infant and under-five mortality for the country as a whole, and particularly for major socio-economic subgroups that the Vital Registration System in Sri Lanka cannot provide.

Vital Registration System in Sri Lanka

The VRS covering the entire country dates backs to 1867. The registration of births and deaths was made compulsory in 1887. The coverage of registration has gradually improved over the years, and this is demonstrated by the 1967 survey that measured the coverage of births and death registration. The survey revealed that the death registration was 94 percent complete and the coverage of birth registration was estimated to be 98 percent (Aponso, 1971). This survey also showed that the coverage of registration of both births and deaths was 100 percent complete in urban and estate areas and the under-registration was found to be in rural areas only. Over a 50 year period from 1995 death registration in Sri Lanka was considered to be over 90 percent complete (Mathers, *et al.*, 2005).

The increasing literacy rate of the Sri Lankan population has no doubt resulted in rapid improvements in the coverage of registration of vital events. It is to be noted that there was a belief that the low infant mortality rates observed in some remote regions in Sri Lanka were probably due to underreporting of deaths. This was thought to occur especially in remote regions where the population is widely dispersed such as the non-irrigated dry zone districts. It was assumed that if a newborn baby dies soon after birth in these remote regions, there was likelihood of both the birth and death not being reported to local registrars. This aspect was investigated in a Longitudinal Study of Mothers and Children conducted in early 1980s which covered three dry zone districts in Sri Lanka. The survey results revealed that the infant and neonatal (deaths to infants in the first 28 days after birth) mortality rates estimated from the study did not differ significantly from those derived from the VRS for those districts (Meegama and Gaminiratne, 1986).

It was also suspected that since the mid 1980s there were some vital events that were incompletely covered in some conflict-prone districts in the Northern and Eastern provinces. Since the Sri Lanka Government re-established administrative control over these areas in 2002 it can be concluded that coverage of births and deaths there has returned to normal, as there has been an increase in the number of vital events reported in the past few years as can b e seen in the vital statistics (Registrar Generals' Department, 2011).

The characteristics of a good VRS, that serves the measurement needs of childhood mortality, include complete registration of births and deaths with minimum delayed registration; reliable reporting of age at death; adequate identification of cause of death through medical certification; and the provision of data at a high degree of geographic disaggregation (Hill, 1991: 378). Very few VRSs in the world qualify for a good registration system, if these criteria were applied, and Sri Lankan VRS is no exception. It is, however, expected that the coverage of births and death registration in Sri Lanka is near to universal although there has been no systematic study conducted in Sri Lanka to measure it.

Conventional Method of Estimating Infant and Early Childhood Mortality

In the analysis of mortality, it is standard practice to examine the mortality experiences of a population by age groups and sex. The Age Specific Death Rate (ASDR), for a particular age group, is calculated by dividing the number of deaths recorded for the age-group by the persons at risk of death in that age group. The mid-year population of the age group is used as the at-risk population, except for calculating infant mortality rates where the number of live births is used as the population at risk of dying.

A distinction is made between death rate and mortality rate although these two terms are often interchangeably used in the literature. Death rates are based on mid-year population, whereas the mortality rates are based on probability of dying

and are identical to q_x values in a life-table (i.e. based on the population exposed at the beginning of the age interval).

IMR

The infant mortality rate for a year is conventionally computed by dividing the number of deaths in infancy by the total number of live born children in that year, expressed as per 1,000 live births. This rate gives the probability of a live born child in a specified year dying before he/she reached his/her first birthday.

It should be noted that infant deaths occurring in a year normally include the number of deaths among children born in the same year as well as some deaths which occurred among babies born in the previous year. Some babies born in the previous year die in the current year. Similarly babies born in this calendar year are likely to die during infancy in the next year. If the proportion of the babies born in previous year dying in the current calendar year and those born in the current calendar year who might die in the following year does not change significantly, then the infant mortality rate computed according to the conventional method provides a good indicator of infant mortality of a population. When any of these components of infant deaths changes some adjustments to the computational method is needed. These methods are not discussed in this paper but are available in Logan, 1953 (pp 30-60) and Shryock and Seagel (1971).

Child Mortality Rate (CMR) (aged 1-4 years)

The child death rate, also known as the early childhood death rate, is calculated by dividing the number of deaths among children, aged 1-4 years by the mid-year population of children of the same age group. The rate is expressed as per 1,000 of the mid-year population.

Under-five Mortality Rate

Using the conventional method the under-five mortality rate can be computed using the mid-year population 0-4 years of age, and deaths under age 5 recorded in a year. The formula for calculating U5MR by the conventional method is as follows:

$$\frac{D_{(0-4)}}{P_{(0-4)}}$$

Where $D_{(0-4)}$ is the number of deaths among children 0-4 years and $P_{(0-4)}$ is the mid-year population of the children aged 0-4 years. This is approximately equals the life table death rate 0-4 years of age: $\cong \frac{(l_0 - l5)}{l0}$

However, in many developing countries the mid-year population estimates of children are often subject to inaccuracies (Hill *et al*, 1999). The basis of the mid-year estates of Sri Lanka are prepared using the age-sex distribution of the population adjusted for natural increases and net migration. The census counts for the child population are frequently found to be incomplete in many developing countries as the migration data on the child population are defective. A study carried out to assess the coverage of child population enumerated in the 1971 population census in Sri Lanka revealed that the number of children under the age of five years reported in the census was nearly 6 percent lower that the number expected based on the child population estimates derived by applying the balancing equation method. The assumed under-coverage of the children varied by age from 86 percent for children aged 1 year and 99.9 percent for those aged 4 years (UN-ESCAP, 1976: 384). However, in recent years in Sri Lanka there has been no assessment carried out to measure the relative coverage of the population censuses[23].

MDG Methodology for Computation of U5MR

The MDG indicator guidelines suggest that the under five mortality should be calculated by dividing the number of deaths of children under five years in a calendar year by the total

[23] After the 1981 census the next decennial population census which was due in 1991 was not conducted due to the prevailing political problems in some parts of the country. The 2001 census which covered the entire country found the population counts in the North and East were unreliable and therefore results in those areas were suppressed. The most recent population census was conducted in 2011.

number of live births in the *same year* and multiplying the ratio by 1,000.

The formula for computing this indicator is

$$U5MR\ (n) = \frac{D(0-4,n)}{B(n)} * 1000$$

Where,

U5MR (n) is the under-five mortality rate for the calendar year n; D (0-4, n) is the number of children aged 0-4 years who died during the year n n; and B (n) is the number of live births occurring during year n.

This is the formula suggested in the official list of MDG indicator: (Goal 4, reduce child mortality (Department of Economic and Social Affairs, 2012), clearly does not take into account the true population at risk of death, (except for children under 1 year); live births in a given calendar year do not represent the true population at risk of death of children in early childhood who were born 1-4 years ago. The rationale for using the live births in the current year possibly seems to stem from data-quality issues. It has also been observed that in countries where the vital registration systems are not functioning effectively, live births are captured more accurately than the number of deaths (Hill, *et al*, 1999). The other data issue is the potential inaccuracy in the population estimates for the under-five population.

Table 1
Infant, early childhood and under-five mortality rates per 1,000 live births for Sri Lanka 2003-2007

Age /period of deaths in years	2003	2004	2005	2006	2007
0	4,200	3,580	4,150	3,752	3,298
1	260	320	687	266	254
2	207	233	764	218	174
3	163	205	722	134	149
4	161	242	722	116	131

Age /period of deaths in years	2003	2004	2005	2006	2007
Early childhood deaths (1-4)	791	1,000	2,895	734	708
Under-five deaths (0-4)	4,991	4,580	7,045	4,486	4,006
Live births	370,643	364,711	370,731	373,538	386,573
Infant mortality rate per 1,000 live births	11.3	9.8	11.2	10.0	8.5
1-4 mortality rate per 1,000 live births	2.1	2.7	7.8	2.0	1.8
U5MR (per 1,000 live births)	13.4	12.5	19.0	12.0	10.3

Source: Registrar General's Department, 2011

This method allows monitoring progress of the under-five mortality target on an annual basis. The method proposed by the MDG guidelines could yield reasonable results, but only if the numbers of live births does not change substantially from year to year. This is not normally the case, as recent data for Sri Lanka reveal in Table1. During the period 2003 to 2008 the number of live births in each calendar year in Sri Lanka fluctuated and ranged between 364,711 in 2004 and 386,573 in 2007. Consequently, the U5MRs varied by the changes in the number of live births or under-five deaths or both. For example, between 2003 and 2004, the number of live births decreased by 1.6 percent from 370,643 (2003) to 364,711 (2004). Although the number of under-five deaths declined by 8.2 percent (from 4,991 to 4,580) in the same period, the estimated U5MR decreased by 6.7 percent. The decrease in live births over the period has resulted in a lowering of the rate of decline U5MRs.

On the other hand, between 2006 and 2007 the number of live births rose by 3.5 percent while the numbers of under-five deaths declined by 36 percent. During the corresponding period, the number of infant deaths decreased by 10 percent and the early childhood deaths declined by over 75 percent[24], with under-five deaths declining by 11 percent. The decline in the U5MR was however, 14 percent higher than the rate of decline in under-five deaths. The increase in the number of live births from 2006 to 2007 has acted to enhance the rate of decline in U5MR between the two years.

The impact of changing live births on U5MRs in successive years is an issue if the strategies implemented to achieve different MDG targets produce changes in both live births and number of infant and early childhood deaths over time, when countries are achieving progress in achieving several MDG goals. Accordingly, the future infant and U5MRs could show changes as a result of either the changes in the live births (denominator for calculating U5MR) or under-five deaths (numerator for calculating U5MR) or both. These could cause problems in determining the actual progress of the MDG target of reducing the under-five mortality rates using the U5MRs.

An alternative Method of Computing U5MRs

The MDG indicator of U5MR is a period measure that estimates the mortality rate by dividing the numbers of under-five deaths in a calendar year in a population by the numbers of live births in the same calendar year. This method is used in Sri Lanka in computing U5MR. The method proposed in this paper is a cohort method, where the mortality experience of a cohort of babies born in a given calendar year is assessed as this cohort of babies pass though infancy and early childhood, subject to age-specific mortality rates applicable to those ages. Mortality rates are expressed as per 1,000 live births.

[24] The number of deaths in 2006 was unusually higher because a large number of under-five deaths occurred during the tsunami which struck the island on Boxing Day in 2005. Many of these deaths were registered in 2006.

For example, this method shows the probability of dying of babies born in a specific year who die in the subsequent year as they aged. The U5MR is computed by summing all deaths that are reported each year following the birth of a child up to the age of 5 years. This rate is the true probability of a child, born in a given calendar year, dying before reaching his/her fifth birthday, and is consistent with the definitions of U5MR.

The formula for computingU5MR can be written as follows:

$$\text{U5MR (n)} = \frac{\text{D}(0-5)}{\text{B(n)}} * 1{,}000$$

B (n) is the cohort of live-born babies in a calendar year, n and D (0-5) is the number of deaths that occurred to the cohort of live born babies during the five-years following birth.

An Illustration

Table 2 presents the under-five deaths by age reported in each year following birth reproduced from Table 1 for live born babies in 2003. In 2003, 370,643 live births were recorded. In the same year 4,200 infants had died.[25] The estimated probability of a live born child in 2003 dying in infancy ($_1q_0$) is 11.3 per 1,000 live births (4,200/370,643)*1,000). The probability of a child born baby in 2003 dying before reaching his/her fifth birth day ($_5q_0$) is estimated at 15.0 per 1,000 live births (5,549/370,643)*1000). In 2004, 320 children had died before reaching their second birthday. These children were born in 2003. So the probability of dying at age 1 is 0. 86 per 1000 live births (320 deaths divided by the number of live births in the original cohort). Similarly the probabilities dying in the 2, 3, and 4 years are 2.1, 0.4 and 0.4 respectively (see last column in Table 2).

[25] Some of these deaths occurred for babies born in 2002. It is expected that some children of this birth cohort will die in 2004. This computation assumes the share of infant deaths occurring in the two years is similar.

Table 2
Under-five mortality rates for Sri Lanka based on cohort method, 2003-2007 (birth cohort of 2003 numbered 370,643)

Died at age (in years)	Year of deaths						Probability of dying*
	2003	2004	2005	2006	2007	2003-07	
0	4,200						11.3
1		320					0.86
2			764				2.06
3				134			0.36
4					131		0.35
0-4						5,549	15.0

Note: *Probability of a live born baby in 2003 dying before reaching a specified age following birth per 1,000 live births

The number of children who had died in 2005 before reaching their third birthday numbered 764, yielding a mortality rate of 2.1 per 1,000 live births. This is relatively high compared to the age-specific mortality rates at other early childhood ages, and reflects the period effects of the impact of the tsunami on mortality experienced by the 2003 cohort of children recorded in the vital registration system in 2005.

The advantage of using the cohort method to estimate under-five mortality is that it assesses the probability of a child born alive in a particular year dying at different ages following birth when he or she passes through infancy and early childhood subject to the age-specific mortality pattern prevailing at those ages. The mortality rates estimated represent the true probabilities of dying at different ages. Another advantage of using the cohort approach is that it does not rely on the mid-year population estimates, which may be not as accurate as the mid-year estimates for adult age groups. The cohort method uses a denominator which represents a population at risk of dying when the cohort of children passes through infancy and early childhood. It is consistent with the definition of under-five mortality and provides an indicator which can be used to assess the progress towards MDG goals in a country and sub-populations within a country. A limitation of this method is that

it gives the under-five mortality for a five year period and mortality rates cannot be calculated for the birth cohorts until they reach five year of age. It should also be noted that the under-five mortality rate, irrespective of the method used for computation, can be affected by the migration of families with under-five children. However, this impact is assumed to be negligible at the national level, but could be significant when mortality estimates are computed for subnational areas.

Conclusion

The U5MRs estimated in different countries from different sources generally to produce varied results. UNICEF in co-ordination with the WHO, the World Bank, and the UN Population Division have developed methodologies to reconcile these differences, to minimize any errors embodied on each estimate and harmonize trends along time to allow comparisons between countries (Hill *et al.*, 2007). The best source of data for computing infant and under-five mortality rates remains an effective vital registration system covering the entire country. Many countries are not on track to achieve the MDG goal of halving the 1990 U5MR with one more year to go (Lawn, *et al.*, 2005). It is likely that MDG targets will be revised after an evaluation of the progress achieved by individual countries. Sri Lanka already had low infant and under-five mortality at the national level when the MDG targets were set. However, opportunities exist to improve the U5MR by focussing specifically on infant mortality.

As the vast majority of under-five deaths in Sri Lanka occurs in the neonatal period If 1-4 mortality rate declines with no change in infant mortality rate, the proportion of infant deaths in total childhood deaths (mainly neonatal), would increase. Neonatal mortality being less responsive to intervention, substantial improvements in care before, during and after delivery is required to reduce the neonatal mortality rate. The knowledge on the effectiveness of the interventions to reduce infant and early childhood mortality can be enhanced if the causes of infant and early childhood deaths are disaggregated by neonatal, post-neonatal and early childhood ages.

As stated earlier the cohort method is one of the accurate ways of summarizing mortality of under-five children in a population and recommended for use in Sri Lanka in computing U5MRs. However, the major limitation of the cohort method is that cohort rates are not cross-sectional measures, except for infant mortality. If the progress of U5MRs is required to measure on an annual basis the cohort method may not be useful for that purpose. Under the circumstances some data users may use cross-sectional measures such as the one suggested for MDG monitoring, despite its limitations discussed above. Interested data users can compute U5MRs relating infant and early childhood deaths to live births as the infant and early childhood deaths are available on an annual basis.

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8

PERSISTENCE OF SUBSTANTIAL DIFFERENTIAL EDUCATIONAL ATTAINMENT AMONG ETHNO-RELIGIOUS COMMUNITIES IN SRI LANKA AFTER HALF-CENTURY OF FREE-EDUCATION: A *QUASI*-COHORT ANALYSIS

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Research Problem

Sri Lanka enjoys a relatively unique position among the 193-strong member countries of the United Nations in that its population has benefited from being consistently afforded free-education at public expense from the kindergarten to the university since 1945. Due primarily to this public investment made over the last six decades, the country has achieved

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