Chapter 4

Levels and Causes of Mortality under Age Five Years

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INTRODUCTION

This chapter reviews recent estimates of levels and distributions by cause of death of children under age five years, including stillbirths. We focus on 2000–15 and present results by World Bank region. We introduce an innovation by including information on stillbirths, defined as deaths from the 28th week of gestation. The standard convention has been to use live birth as the starting point of risk measurement, as in Millennium Development Goal 4 (MDG 4) to reduce mortality under age five years by two-thirds from 1990 to 2015 (UN 2000). However, substantial proportions of stillbirths are preventable given adequate obstetric care, and would, if prevented, increase the number of live births. We argue that including stillbirths in summary measures of child mortality provides a more inclusive assessment of health service provision than the standard convention.

Data on levels and trends of mortality before age five years are taken from the 2015 report by the United Nations Inter-Agency Group on Mortality Estimation (IGME) (You and others 2015). Data on levels and trends of causes of mortality under age five years are taken from the latest estimates produced by the World Health Organization (WHO) and UNICEF's (United Nations Children's Fund) Child Health Epidemiology Reference Group (Liu and others, forthcoming).

LEVELS AND TRENDS OF MORTALITY UNDER AGE FIVE YEARS, 2000–15

Mortality rates among young children are the best single indicator of child health in low- and middle-income countries (LMICs), and they are often also used as indicators of general social and economic development. The most widely used measure of child mortality in recent years has been the under-five mortality rate (U5MR), defined as the probability of dying between live birth and age five years; this measure was adopted as the primary target for MDG 4 (UN 2013). However, like all summary measures, the U5MR conceals age detail and patterns of mortality—and mortality change—in the first month and year of life that are of epidemiological and programmatic interest. In this chapter, we include stillbirths as part of the risk of dying under age five years, and the pregnancies at risk as all those that reach 28 weeks gestation (described as "viable fetuses"). We introduce a new measure, the total under-five mortality rate, or TU5MR, defined as the probability of dying between the 28th week of pregnancy and the fifth birthday.

We present estimates both as probabilities of dying and in the form of numbers of deaths and for age ranges 28 weeks to live birth, live birth to 27 days, 28 days to one year, and one year to five years. The probabilities of dying for these age ranges correspond to the conventional stillbirth, neonatal, postneonatal, and child

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mortality rates. We also present estimates of the broadest measure of child mortality risk, the TU5MR.

As a result of using this new conceptualization, we have to combine information from two sources, one for stillbirths and the other for mortality following a live birth, and make some approximations along the way. However, the approximations are relatively minor and do not affect the overall picture of recent levels and trends in TU5MR.

Sources

The estimates presented in this section are based on separate estimation exercises, one for the stillbirth rate and one for mortality of live-born children to age five years. For mortality of live-born children, we use the estimates by the IGME (You and others 2015); the methodology used by the IGME to arrive at estimates is described elsewhere (Alkema and others 2014). We present the probabilities of dying from live birth and the ratio of numbers of deaths to live births for World Bank regions for 2000 and 2015.

The derivation of stillbirth rates and numbers of stillbirths is less direct. The most recent systematic analysis of stillbirth rates provides estimates for MDG regions for 1995 and 2009 (Cousens and others 2011). We use the rate of change in the stillbirth rate between 1995 and 2009 for each MDG region to interpolate to 2000 and extrapolate to 2015. We then assume that these rates for MDG regions, suitably aggregated, closely approximate those for World Bank regions for those years. Specifically, to approximate the World Bank region of East Asia and Pacific, we combine the MDG regions of East Asia, South-East Asia, and Oceania; for the World Bank region of Middle East and North Africa, we combine the MDG regions of Western Asia and North Africa; and for the World Bank region of Europe and Central Asia, we combine the Commonwealth of Independent States (CIS) Europe and CIS Asia.

To estimate numbers of stillbirths, we use the relationship between rates and numbers of events. The neonatal mortality rate (NMR) is calculated as the number of neonatal deaths (ND) divided by the number of live births, so given the number of ND and the NMR, we can calculate the number of live births. The stillbirth mortality rate (SBR) is calculated as the number of stillbirths divided by the sum of the number of stillbirths and live births. We can estimate the number of stillbirths from the NMR, ND, and SBR as follows:

$$SB = ND \times SBR/[NMR \times (1 - SBR)].$$

These numbers are not affected by differences in numbers of live births between MDG and World Bank regions, only by possible differences in stillbirth rates, which are likely to be minor, given the close overlap of the regions.

Results

Table 4.1 shows probabilities of dying for the four age ranges and for the TU5MR. Globally, the TU5MR declined from 95.4 per 1,000 viable fetuses in 2000 to 59.1 in 2015, an annual average rate of reduction (ARR) of 3.2 percent (table 4.2). For LMICs, the TU5MR declined from 105.9 in 2000 to 65.2 in 2015, and the decline for high-income countries (HICs) was from 14.3 to 9.7. The ARR was somewhat faster in the LMICs (3.2 percent) than in the HICs (2.6 percent), so the risk ratio for LMICs to HICs declined from 7.4 to 6.7 over the period; the absolute difference narrowed much more sharply, from 92 to 56 per 1,000 viable fetuses. In both years, there is large variation across regions. HICs had the lowest risks, about one-third that of the next best region, Latin America and the Caribbean. Sub-Saharan Africa had the highest risk, with the TU5MR remaining substantially greater than 100 per 1,000 in both years, more than 10 times the risk in HICs. The region with the second-highest risk in both years was South Asia, although its TU5MR fell to less than 100 in 2015; its disadvantage relative to HICs declined only slightly, however, from 8.3 to 7.9. The remaining regions had rather similar TU5MRs, between 44 and 59 per 1,000 in 2000 and between 26 and 36 in 2015, slightly narrowing their disadvantage relative to HICs.

At the global level, the neonatal period has the highest age-specific risk in both 2000 and 2015. This is also the case for LMICs as a group and for all regions individually, except Sub-Saharan Africa in 2000 and East Asia and Pacific in 2015. For all LMICs, and particularly for Sub-Saharan Africa, the age range of lowest risk shifts from stillbirths in 2000 to ages one to five years in 2015. South Asia's lowest risk is in the postneonatal group in 2000; for all other regions, the lowest risk in both years is from ages one to five years. The absolute difference between the highest and lowest risk among age ranges decreased by more than 90 percent from 2000 to 2015. The mortality rate estimate for Sub-Saharan Africa is 2.4 times that of the next highest region (South Asia), for both postneonatal and ages one to five years, despite similar neonatal and stillbirth rates.

Table 4.2 shows the ARR in probabilities of dying between 2000 and 2015 for the age ranges and regions shown in table 4.1. As noted, the ARR for TU5MR globally was 3.2 percent, somewhat less than the rate needed (4.4 percent) to achieve the MDG 4 target for the conventional U5MR. If we apply the MDG 4 target for U5MR to the TU5MR, the only region to

Table 4.1 Probabilities of Dying per 1,000 Pregnancy Completions from the 28th Week of Pregnancy to Age Five Years, 2000 and 2015

World Bank region	2000					2015				
	28 weeks gestation to birth	Birth to 27 days	28 days to 1 year	1–5 years	TU5MR	28 weeks gestation to birth	Birth to 27 days	28 days to 1 year	1–5 years	TU5MR
Low- and middle-income countries	22.8	33.0	25.0	25.1	105.9	19.1	20.7	13.7	11.7	65.2
East Asia and Pacific	15.2	21.0	12.2	9.1	57.5	9.2	8.9	5.9	3.0	27.0
Europe and Central Asia	10.0	19.7	14.9	7.6	52.2	8.1	10.6	7.1	2.6	28.4
Latin America and the Caribbean	10.8	15.1	12.8	5.7	44.4	7.6	9.6	6.2	2.9	26.2
Middle East and North Africa	14.8	22.2	13.4	9.1	59.4	11.4	13.8	6.7	3.6	35.7
South Asia	28.9	44.9	21.3	23.9	119.0	25.3	29.2	11.4	10.6	76.5
Sub-Saharan Africa	30.0	39.6	51.5	56.3	177.4	27.2	27.8	26.8	25.2	107.0
High-income countries	3.6	5.7	3.2	1.7	14.3	2.8	3.7	2.1	1.0	9.7
World	20.6	29.9	22.5	22.4	95.4	17.3	18.9	12.4	10.5	59.1

Sources: Based on Cousens and others 2011; and 2015 UN Inter-Agency Group for Child Mortality Estimation (IGME).
Note: TU5MR = total under-5 mortality rate.

Table 4.2 Annual Rates of Reduction in Probabilities of Dying per 1,000 Pregnancy Completions from the 28th Week of Pregnancy to Age Five Years, between 2000 and 2015

World Bank region	2000–15				
	28 weeks gestation to birth	Birth to 27 days	28 days to 1 year	1–5 years	TU5MR
Low- and middle-income countries	1.18	3.11	4.01	5.09	3.23
East Asia and Pacific	3.35	5.72	4.84	7.40	5.04
Europe and Central Asia	1.40	4.13	4.94	7.15	4.06
Latin America and the Caribbean	2.34	3.02	4.83	4.51	3.52
Middle East and North Africa	1.74	3.17	4.62	6.18	3.39
South Asia	0.89	2.87	4.17	5.42	2.95
Sub-Saharan Africa	0.65	2.36	4.35	5.36	3.37
High-income countries	1.68	2.88	2.81	3.54	2.59
World	1.16	3.06	3.97	5.05	3.19

Sources: Based on Cousens and others 2011; and 2015 UN Inter-Agency Group for Child Mortality Estimation (IGME).
Note: TU5MR = total under-5 mortality rate.

exceed the MDG 4 target ARR was East Asia and Pacific (5.0 percent), although LMIC countries of Europe and Central Asia (4.1 percent) came fairly close. All other regions, with ARRs ranging between 2.6 percent and 3.5 percent, performed well below the MDG target. Globally and in all regions, declines were slowest for stillbirths, averaging only about 1 percent per year in the aggregate, and highest for child mortality rates except for Latin America and the Caribbean; rates of decline for postneonatal mortality exceeded the TU5MR, on average, in most regions. It is interesting to note how similar the rates of decline are for postneonatal mortality risks and risks between ages one and five years on the one hand, and how different stillbirth rates of decline are from declines of risk after birth, on the other hand. The ARR of mortality risk after the neonatal period was very close to or greater than the rate of reduction required to achieve the primary MDG 4 target in all LMICs; failure

Table 4.3 Numbers of Deaths from the 28th Week of Pregnancy to Age Five Years, 2000 and 2015
(thousands)

	2000					2015				
World Bank region	28 weeks gestation to birth	Birth to 27 days	28 days to 1 year	1–5 years	TU5MR	28 weeks gestation to birth	Birth to 27 days	28 days to 1 year	1–5 years	TU5MR
Low- and middle- income countries	2,639	3,826	2,891	2,906	12,262	2,420	2,625	1,735	1,478	8,256
East Asia and Pacific	420	581	337	252	1,591	279	270	178	89	816
Europe and Central Asia	39	78	59	30	206	36	47	31	12	126
Latin America and the Caribbean	111	156	132	59	458	71	90	58	27	246
Middle East and North Africa	102	154	93	63	412	105	128	62	34	328
South Asia	1,130	1,755	834	932	4,651	925	1,065	416	389	2,795
Sub-Saharan Africa	836	1,103	1,437	1,569	4,945	1,003	1,025	990	928	3,946
High-income countries	54	86	49	25	213	44	58	33	16	152
World	2,693	3,912	2,940	2,931	12,476	2,464	2,682	1,768	1,494	8,408

Sources: Based on Cousens and others 2011; and 2015 UN Inter-Agency Group for Child Mortality Estimation (IGME).
Note: TU5MR = total under-5 mortality rate.

Table 4.4 Annual Rates of Reduction in Numbers of Deaths from the 28th Week of Pregnancy to Age Five Years, 2000 and 2015

	2000–15				
World Bank region	28 weeks gestation to birth	Birth to 27 days	28 days to 1 year	1–5 years	TU5MR
Low- and middle-income countries	0.58	2.51	3.41	4.51	2.64
East Asia and Pacific	2.73	5.12	4.26	6.94	4.45
Europe and Central Asia	0.63	3.37	4.19	6.30	3.28
Latin America and the Caribbean	2.99	3.66	5.47	5.29	4.15
Middle East and North Africa	–0.19	1.24	2.72	4.18	1.51
South Asia	1.33	3.33	4.64	5.83	3.40
Sub-Saharan Africa	–1.21	0.49	2.49	3.50	1.50
High-income countries	1.31	2.64	2.51	2.85	2.27
World	0.59	2.52	3.39	4.49	2.63

Sources: Based on Cousens and others 2011; and 2015 UN Inter-Agency Group for Child Mortality Estimation (IGME).
Note: TU5MR = total under-5 mortality rate.

to achieve the target rate of decline overall was the result of relatively slower declines for stillbirths (especially) and neonatal mortality.

The numbers of deaths by age range are a product of risk (probability of dying) and numbers at risk (whether population, births, or viable fetuses). Table 4.3 shows estimated numbers of deaths by age range, region, and year. The number of deaths between 28 weeks of gestation and age five declined from 12.5 million in 2000 to 8.4 million in 2015, a decline of 2.6 percent per year (table 4.4). Globally, the numbers of deaths are highest in the neonatal period in both years, followed by the postneonatal period in 2000 but by stillbirths in 2015. The numbers of deaths declined for all regions and for all age ranges, except for stillbirths in Sub-Saharan Africa and the Middle East and North Africa, which increased at 1.21 percent and 0.19 percent per year, respectively, reflecting slowly increasing risks, especially in Sub-Saharan Africa. The numbers of deaths under age five years declined fastest in Latin America and the Caribbean and in East Asia and Pacific; the slowest rate of decline, by a substantial margin, was in Sub-Saharan Africa and the Middle East and North Africa (1.5 percent in both regions); the third-slowest were HICs (2.2 percent).

During this period, there was a marked concentration of global deaths before the fifth birthday in Sub-Saharan Africa, with the proportion increasing from 40 percent to 47 percent; the proportion of child deaths between the ages of one and five years increased from 54 percent to 62 percent. Approximately 98 percent of deaths occurred in LMICs in all age groups in both 2000 and 2015. In East Asia and Pacific and South Asia, which are the two regions with shares of global deaths under age five years of more than 10 percent, the proportion declined, from 13 percent to 10 percent and from 37 percent to 33 percent, respectively.

Estimates of stillbirth rates have not been developed by gender of the fetus, but estimates are available of the conventional U5MR by gender. For LMICs overall in 2013, the ratio of boys to girls U5MR was about 1.08, but this average conceals substantial regional variation. For Europe and Central Asia, Latin America and the Caribbean, East Asia and Pacific, and HICs, the ratio ranged from 1.19 to 1.26; for Sub-Saharan Africa and the Middle East and North Africa, the ratio was about 1.15, but was less than 1.0 in South Asia, indicating a disadvantage for girls (results not shown). The numbers of deaths by gender of child reflect both differences in risk by gender and differences in gender ratios at birth, such that the overall ratio for LMICs of deaths of boys to deaths of girls under age five years is 1.17; this rate varies from 1.08 in South Asia to about 1.30 in East Asia and Pacific (elevated by the very high sex ratio at birth in China), Europe and Central Asia, Latin America and the Caribbean, and HICs. As a general rule (Hill and Upchurch 1995), the ratio of boys to girls U5MR tends to rise as overall U5MR declines until it reaches values of less than about 25 per 1,000 live births, so the ratio for LMICs is likely to increase in coming decades.

Discussion and Policy Implications

A major advance in the discussion of child mortality change in this chapter is the inclusion of stillbirths in overall mortality before age five years; this change adds 2.5 million deaths before age five, many of them preventable given existing interventions, to the global total in 2015. We see this as important because some overlap exists between the infrastructure and interventions to prevent stillbirths and those to reduce neonatal deaths.

Our analysis shows that both mortality risks and numbers of deaths under age five years declined substantially from 2000 to 2015, and that all four age ranges benefited in all regions. However, the global pace of decline was still slower than that required to achieve the MDG 4 target. This disappointing rate of decline was due to slow progress in reducing stillbirth and neonatal mortality rates (annual rates of decline of 1.2 percent[1] and 3.1 percent, respectively, at the global level) and a shift in at-risk populations away from lower mortality to higher mortality regions, particularly in Sub-Saharan Africa. Population estimates (UN 2015) indicate that the proportion of global births in Sub-Saharan Africa increased from 20.1 percent in 2000 to 25.3 percent in 2015, and this trend is expected to continue. Another characteristic of under-five mortality in Sub-Saharan Africa is the high child mortality rate (ages one to five years) relative to other age ranges.

Further reductions in child mortality accordingly face several challenges:

- First, faster reductions in stillbirth rates and neonatal mortality rates are needed. In both cases, progress will require greater contact with effective health systems around childbirth, with higher proportions of deliveries taking place in well-equipped facilities with high quality of care; the development of such facilities will be expensive.
- Second, faster declines must be achieved at all ages under five years in Sub-Saharan Africa; given a continuing trend toward higher proportions of births in the region, declines in risk must reach at least the LMIC average so as not to be a brake on global progress; some preliminary evidence (You and others 2015) suggests that rates of decline are accelerating in some countries in the region.
- Finally, the high mortality risk of children between their first and fifth birthdays is a concern, particularly in Sub-Saharan Africa. Progress has been substantial in this age range, but risks remain high; in some regions, injury risks are actually increasing (Liu and others, forthcoming).

Child mortality reduction benefits from some tailwinds however. An increasing proportion of births will occur in urban areas, with lower mortality risks (Fink and Hill 2013). The numbers of births are likely to stop increasing in regions other than Sub-Saharan Africa; in some regions, the numbers are already falling, which will affect the numbers of child deaths, although not the rates. Falling fertility will also somewhat reduce the risk profile of births, with smaller proportions of high parity births and births to older mothers; falling fertility does, however, increase the proportion of one high risk group, first births, and it appears to have limited impact on birth intervals (Hill and Liu 2013). One of the most widely recognized factors associated with child mortality decline is maternal education (Hill and Liu 2013), and the educational profile of women in LMICs is improving rapidly; cohorts with high proportions of women with

secondary or higher education, the levels with the strongest associations with reduced child mortality, are now approaching the peak years of reproduction.

A final positive factor is likely to be continued economic growth, which, according to some forecasts, may differentially favor Sub-Saharan Africa; much may depend, however, on how the gains in income growth are distributed among populations.

LEVELS AND TRENDS OF CAUSES OF MORTALITY UNDER AGE FIVE YEARS, 2000–15

Both probabilities of dying and numbers of deaths under age five years declined substantially from 2000 to 2015. At the global level, however, the declines failed to reach the MDG 4 targets, and acceleration is needed at the global, regional, and national levels beyond 2015. Progress can be accelerated by using reliable information about the distribution of deaths by cause and by scaling up cause-specific interventions (Bhutta and others 2008; Darmstadt and others 2005; Jones and others 2003; Lawn and others 2011). To guide global and national programs and research efforts, information about the distribution of causes of child deaths should be routinely updated. To assess the lasting effects of child health interventions and assist the development of long-term child survival strategies, time trends of child deaths by cause that are derived using consistent methods are needed.

This chapter focuses on major child deaths from the 28th week of pregnancy to age five years, so we discuss causes of both stillbirths and deaths from live birth to age five years. Because there is only moderate overlap between the causes of death in late pregnancy and in the neonatal period, we will first discuss cause structures of stillbirths, and then the causes of death after a live birth.

National data on causes of stillbirth are not available for either HICs or LMICs. As of 2011, more than 35 stillbirth classification systems had been published in the literature, the majority of them developed to describe the 2 percent of stillbirths occurring in HICs. These classification systems generally require fetal surveillance, advanced diagnostics, and post mortem examination, making their use in resource-constrained settings impractical (Lawn and others 2011). Even if data exist, unexplained stillbirths have been shown to account for 15 percent to 71 percent of stillbirths, limiting the usefulness of the data, especially for comparative purposes. Flenady and others (2009, 10) state that restricting reporting to the underlying cause of stillbirth is "challenging, (and often inappropriate), due to the complexity of the clinical situation in which the fetus dies." For this reason, data are also needed on contributing causes and factors associated with stillbirth, two aspects of the International Classification of Diseases that are particularly weak.

With respect to deaths in childhood, the Child Health Epidemiology Reference Group has published a series of estimates of the distribution of causes of child death since 2005, during which time estimation methods and the quality and quantity of input data have improved (Black and others 2010; Bryce and others 2005; Johnson and others 2010; Lawn, Wilczynska-Ketnede, and Cousens 2006; Liu and others 2012; Liu and others 2015; Liu and others, forthcoming; Morris, Black, and Tomaskovic 2003). We report here estimates of the distribution of child deaths by cause among live births in 2015 and time trends of child deaths by cause since 2000 (Liu and others 2015).

Data and Methods

In LMICs, data on stillbirths by cause are sparse and generally based on classification systems that rely on maternal history and health and intrapartum events, and less frequently, on placental histopathology and other tests. Such classification systems have been judged to be suboptimal and are not recommended (Flenady and others 2009). Given that approximately 40 percent of births in LMICs are managed at home and that limited stillbirth data are recorded even at health facilities, the WHO and collaborators have developed a stillbirth verbal autopsy, validated in Ghana (Edmond and others 2008), India (Aggarwal, Jain, and Kumar 2011), and Pakistan (Nausheen and others 2013), with the goal of establishing population-based cause-of-stillbirth data. Other endeavors to expand the available data on the causes of stillbirth include a probabilistic model to predict likely causes of stillbirth based on verbal autopsy questions (Vergnano and others 2011) and the use of birth attendants as respondents for stillbirth verbal autopsy (Engmann and others 2012).

Accordingly, given the current state of cause-of-stillbirth data, for the purposes of this chapter, global estimates of the percent of stillbirths occurring after the onset of labor are presented. Where cause data are weak, categorizing stillbirths by time of death (antepartum versus intrapartum) is helpful in that many intrapartum deaths are term fetuses who should survive if born alive; these deaths are often associated with poor quality care (Lawn and others 2011). In addition, selected data are presented to illustrate common causes of stillbirth from HICs and LMICs.

A detailed description of the input data and estimation methods for the cause-of-death distribution among live-born children has been published elsewhere

(Liu and others 2012; Liu and others 2015; Liu and others, forthcoming).

Results

Table 4.5 shows the percentage of stillbirths occurring during the intrapartum period by world region based on the results of a systematic review of the literature (Lawn and others 2011). Globally, 45 percent of stillbirths occur during labor, ranging from 14 percent in HICs, to 16 percent in the Middle East and North Africa, and 23–56 percent in LMICs (Lawn and others 2011).

Table 4.6 summarizes the distribution of single causes of stillbirth and contributing conditions from areas within six HICs using the Cause of Death and Associated Conditions classification system that was judged favorably for retention of stillbirth information in an evaluation of stillbirth classification systems (Flenady and others 2009). The six countries include Australia, Canada, the Netherlands, Norway, the United Kingdom, and the United States. Stillbirth is defined in table 4.6 as a fetal death at a gestational age of 22 weeks or more, or 500 or more grams birth weight. The leading causes of death are "unknown" (30 percent), followed by placental pathology (29 percent) and infection (12 percent). Fewer than 10 percent of stillbirths were attributed to any one of the remaining five causes. However, although only 7 percent of stillbirths were attributed to maternal conditions as the single cause, maternal causes contributed to 24 percent of stillbirths, and placental pathologies contributed to more than 50 percent of all stillbirths. Using this data-intensive classification system, intrapartum conditions, defined narrowly as extreme prematurity

Table 4.5 Estimates of the Percentage of Stillbirths during the Intrapartum Period, by Region, 2008

World region	Estimated intrapartum stillbirths (%)
Low- and middle-income countries	44.3
East Asia and Pacific	24.0
Europe and Central Asia	20.0
Latin America and the Caribbean	23.1
Middle East and North Africa	16.4
South Asia	56.6
Sub-Saharan Africa	46.5
High-income countries	13.7
World	43.7

Source: Adapted from Lawn and others (2011) to reflect regions consistent with those used elsewhere in this chapter.

Table 4.6 Distribution of Single Causes of Stillbirth and Percentage of Contributing Causes in Six High-Income Countries Using the Cause of Death and Associated Conditions Classification System

Percent

Single cause of stillbirth		Contributing causes of death	
Unknown	30	Lacking or despite documentation and autopsy results	30
Placental pathologies	29	Infection or inflammation, abruption or retroplacental hematoma, infarction and thrombi, circulatory disorders, transfusion or feto-maternal hemorrhage, small-for-gestation placenta, villous or vascular maldevelopment	59
Infection	12	Unspecified, Group B streptococci	14
Cord	9	Knots, loops, abnormal insertion, focal anomaly, generalized anomaly, infection or inflammation	17
Maternal	7	Unspecified, hypertensive disorder, cervix insufficiency, hematology, diabetes, autoimmune disease	24
Congenital abnormalities	6	Unspecified, cardiovascular or lymphatic, triploidies	11
Fetal	4	Unspecified	7
Intrapartum	3	Extreme prematurity, asphyxia of unknown cause	5
Associated perinatal	n.a.	Small for gestational age, oligohydramnios, preterm premature rupture of the membranes, multiples, antepartum hemorrhage, suboptimal care	26
Associated maternal	n.a.	Smoking, maternal body mass index ≥ 30 kg/m^2, obstetric history	10
Total	*100*		

Source: Flenady and others 2009.

Note: kg/m^2 = kilograms per square meter; n.a. = not applicable. High-income countries for this table comprise Australia, Canada, the Netherlands, Norway, the United Kingdom, and the United States.

Table 4.7 Distribution of Causes of Stillbirth during the Antepartum and Intrapartum Periods in Kintampo, Ghana, 2003–04

Percent

	Antepartum period	Intrapartum period
Congenital abnormalities	1.7	0.8
Maternal disease	14.0	0.0
Obstetric complications	0.0	59.3
Maternal hemorrhage	4.1	4.8
Other	22.8	3.6
Unexplained	57.4	31.5
Total (N)	100 (413)	100 (248)

Source: Edmond and others 2008.

Table 4.8 Distribution of Causes of Stillbirth in a Hospital in Chandigarh, India, 2006–08

Causes of stillbirth determined via clinical assessment	Percent
Congenital malformations	12.0
Underlying maternal illness	12.9
Pregnancy-induced hypertension	30.7
Antepartum hemorrhage	15.6
Obstetric complications	8.4
Multiple pregnancy	2.2
Asphyxia not explained by any maternal condition	1.8
Other specific fetal problem	4.0
Unexplained stillbirth	10.2
Unexplained small size for gestational date	0.0
Unexplained preterm birth (< 37 weeks)	2.2
Total (N)	100 (225)

Source: Aggarwal, Jain, and Kumar 2011.

and asphyxia from unknown cause, were responsible for only 3 percent of stillbirths in these HICs. Nine percent of stillbirths occurred during the intrapartum period (data not shown), although the cause of most of them stemmed from the antepartum period.

Table 4.7 presents the percentage distribution of causes of stillbirth occurring during the antepartum and intrapartum periods in rural Ghana (Edmond and others 2008). Data were collected via verbal autopsy among women who delivered at home and at health facilities, with stillbirth defined as fetal death at 28 or more weeks of gestation. More than 37.5 percent of stillbirths occurred during the intrapartum period. More than half of antepartum stillbirths were unexplained (57.4 percent), making interpretation of the remaining categories difficult. Among intrapartum stillbirths, 31.5 percent were unexplained and 59.3 percent were attributed to obstetric complications.

Table 4.8 presents hospital-based cause-of-stillbirth data from Chandigarh, India, based on clinical and laboratory information and following standard obstetric guidelines. Stillbirth is defined here as a birth for which no fetal heart sounds were heard during labor and the neonatologist perceived no signs of life upon physical examination after birth. Findings indicate that 30.6 percent of stillbirths occurred during the intrapartum period; 80.0 percent were attributed to the five major causes of stillbirth, with pregnancy-induced hypertension the leading cause (30.7 percent). Only 10.2 percent were classified as "unexplained" (Aggarwal, Jain, and Kumar 2011).

Among the 5.9 million deaths of live-born children who died in the first five years of life in 2015, 45.1 percent (2.7 million) occurred in the neonatal period (table 4.3). The three leading causes of deaths are preterm birth complications (1.056 million, 17.8 percent), pneumonia (0.922 million, 15.5 percent), and intrapartum-related events or birth asphyxia (0.689 million, 11.6 percent) (table 4.9). Other important causes include diarrhea (0.526 million, 8.9 percent), congenital malformation (0.505 million, 8.5 percent), sepsis or meningitis (0.525 million, 8.8 percent), and injury (0.331 million, 5.6 percent).

The burden of mortality by cause in live-born children younger than age five years varied widely across the regions in 2015 (figure 4.1). Nearly half (49.5 percent, 2.943 million) of deaths in children younger than age five years were in Sub-Saharan Africa, which included 96.4 percent (0.294 million) of global child deaths due to malaria and 90.6 percent (0.077 million) of global child deaths due to HIV/AIDS. South Asia had the highest number of any region of neonatal deaths in live-born children (1.065 million deaths, 57.0 percent). Preterm birth complications were the leading cause in this region, responsible for 24.8 percent, or 0.465 million deaths under age five years.

The Democratic Republic of Congo, Ethiopia, India, Nigeria, and Pakistan collectively accounted for about half the total number of global under age five years deaths (48.3 percent, 2.871 million) and neonatal deaths (50.8 percent, 1.362 million) in 2015. In India, 1.2 million children younger than age five years died in 2015; more than half of them (57.9 percent, 0.696 million) died in the first 28 days of life. Major causes of death included preterm birth complications (0.321 million, 26.7 percent), pneumonia (0.180 million, 15.0 percent), and intrapartum-related

complications (0.142 million, 11.9 percent). Angola, the Democratic Republic of Congo, India, Nigeria, and Pakistan were the top five countries with the most pneumonia deaths and the most diarrhea deaths. For intrapartum-related complications, Ethiopia replaced Angola on the list. For preterm birth complications, China replaced Angola. Burkina Faso, the Democratic Republic of Congo, Côte d'Ivoire, Mali, and Nigeria had the most malaria deaths.

Compared with 2000, approximately 4 million fewer deaths under age five years occurred in 2015. Deaths from pneumonia, diarrhea, and malaria decreased the most in absolute terms, by 680,000, 663,000 million, and 419,000 million, respectively. Collectively, the three causes were responsible for 43.9 percent of the absolute reduction in under age five years deaths in 2000–15.

In 2000–15, child mortality rates of all the causes decreased, albeit at differing rates. In neonates, the burden of preterm birth complications decreased from 1.242 million in 2000 to 0.946 million in 2015, with the associated mortality rate falling by 2.4 percent per year. Intrapartum-related deaths decreased from 1.040 to 0.635 million, with the mortality rate declining at an average ARR of 3.9 percent. Neonatal sepsis or meningitis decreased from 0.529 million in 2000 to 0.410 million in 2015, a rate of 2.3 percent per year. Neonatal tetanus decreased from 0.164 million to 0.034 million at 10.9 percent per year. For children who died between the ages of 1 and 59 months, trends in numbers and rates of death by cause were highly variable from 2000 to 2015. Pneumonia deaths in this age group decreased from 1.44 million to 0.76 million, with the pneumonia-specific mortality rate dropping an average of 4.8 percent per year. Diarrhea deaths decreased from 1.172 million to 0.509 million, a 6.1 percent decrease in the mortality rate per year during this period. Malaria deaths declined from 0.725 million in 2000 to 0.306 million in 2015, with the malaria-specific mortality rate dropping 6.3 percent per year. Measles mortality fluctuated, in part due to outbreaks, but overall it decreased from 0.481 million to 0.074 million, a rate of 13.1 percent per year.

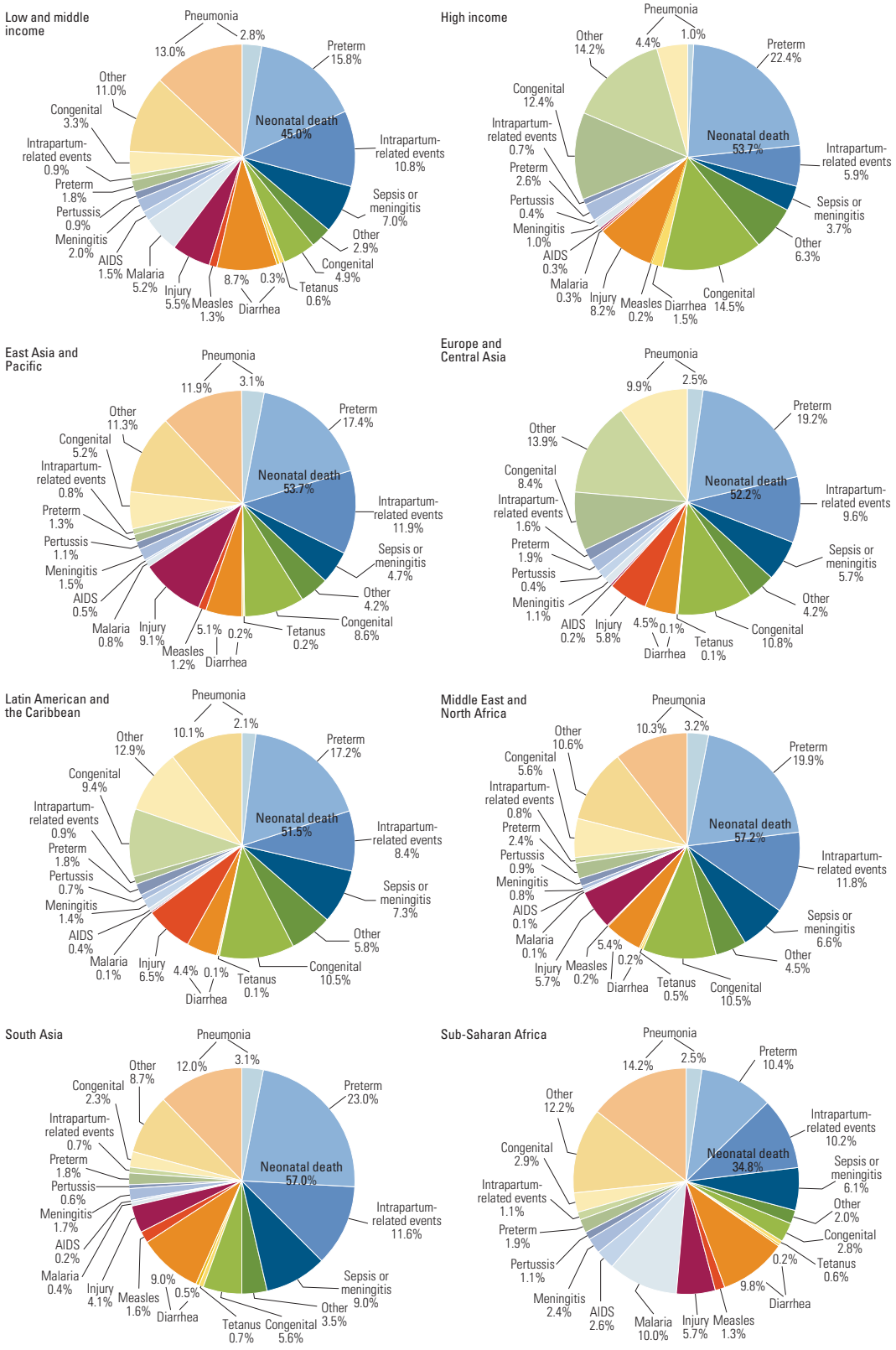
In 2000–15, the U5MR decreased at varying rates across regions. HICs and South Asia had the slowest reductions, at an average ARR of 3.0 percent and 3.8 percent, respectively. In Sub-Saharan Africa, the pneumonia-specific mortality rate among children ages 1–59 months decreased at an annual rate of 4.2 percent. The ARR for preterm birth complications was only 1.3 percent among children ages 1–59 months (0.3 percent among children under age five). The malaria-specific mortality rate decreased 7.6 percent annually. Measles had the highest ARR at an average of 16.5 percent. In South Asia, the mortality rates for pneumonia and diarrhea among children ages 1–59 months decreased on average by 5.6 percent and 6.1 percent per year, respectively. However, the mortality rate attributable to neonatal

Table 4.9 Estimated Numbers of Deaths by Cause among Live-Born Children Younger than Age Five Years, 2015

Causes	Estimated number (millions)	Cause-specific mortality rate (per 1,000 live births)
Neonates ages 0–27 days		
Preterm birth complications[a]	0.946	6.770
Intrapartum-related events[b]	0.635	4.547
Sepsis or meningitis[c]	0.410	2.937
Congenital abnormalities[d]	0.299	2.139
Other conditions[e]	0.177	1.268
Pneumonia[f]	0.162	1.159
Tetanus	0.035	0.247
Diarrhea[g]	0.017	0.125
Children ages 1–59 months		
Pneumonia[f]	0.760	5.443
Other conditions[e]	0.655	4.691
Diarrhea[g]	0.509	3.643
Injury	0.331	2.367
Malaria	0.306	2.193
Congenital abnormalities[d]	0.206	1.471
Meningitis[c]	0.115	0.826
Preterm birth complications[a]	0.110	0.790
AIDS	0.086	0.614
Measles	0.074	0.531
Intrapartum-related events[b]	0.054	0.388
Pertussis	0.054	0.387

Source: Liu and others, forthcoming.
Note: Other conditions among children ages 1–59 months include congenital malformation, causes originating during the perinatal period, cancer, pertussis, severe malnutrition, and other specified causes. Intrapartum-related events were formerly referred to as "birth asphyxia." AIDS = acquired immunodeficiency syndrome.
a. Estimated number of preterm deaths in children younger than age five years overall including the neonatal period is 1.056 million.
b. Estimated number of intrapartum-related events deaths in children younger than age five years overall including the neonatal period is 0.689 million.
c. Estimated number of sepsis or meningitis deaths in children younger than age five years overall including the neonatal period is 0.526 million.
d. Estimated number of congenital abnormalities deaths in children younger than age five years overall including the neonatal period is 0.504 million.
e. Estimated number of other conditions deaths in children younger than age five years overall including the neonatal period is 0.832 million.
f. Estimated number of pneumonia deaths in children younger than age five years overall including the neonatal period is 0.922 million.
g. Estimated number of diarrhea deaths in children younger than age five years overall including the neonatal period is 0.526 million.

Figure 4.1 Causes of Childhood Deaths among Live-Born Children Younger than Age Five Years, by World Bank Region, 2015



Source: Liu and others, forthcoming.
Note: AIDS = acquired immunodeficiency syndrome.

preterm births fell little, on average only 1.3 percent. At the country level, varying trends in cause-specific death rates were seen in 2000–15 (data are not shown).

Discussion and Policy Implications

Our estimate of 2.5 million stillbirths based on an extrapolation of previous estimates is very similar to a new estimate for 2015 of 2.6 million (Blencowe and others, forthcoming). The numbers have been declining by 0.6 percent annually since 2000 and showing the lowest rate of decline of the four age groups constituting TU5MR. Although cause-of-stillbirth data are sparse and lack comparability, it is clear that the percentage of intrapartum stillbirths is two to four times higher in LMICs than HICs and that continued improvements in the implementation of evidence-based obstetric care require policy prioritization to prevent the majority of these deaths. Equally important is the need for consensus on a cause-of-stillbirth classification system that can be used in high- and low-resource settings to monitor trends and assess program effectiveness. Although probabilities of stillbirth are eight or more times higher in South Asia and Sub-Saharan Africa than in HICs, many stillbirths in HICs are considered potentially preventable, particularly among disadvantaged women, requiring greater outreach for antenatal care and improved living standards. Research to address antepartum stillbirths and stillbirths associated with extreme prematurity and infection are priorities in high-income settings (Flenady and others 2009).

Among the 5.9 million live-born children who died before reaching their fifth birthday in 2015, 45.1 percent died in the neonatal period. Preterm birth complications and pneumonia remained the top killers in this age group. Intrapartum-related events became the third leading cause of child deaths globally. Other important leading causes of child deaths include diarrhea, congenital malformation, neonatal sepsis or meningitis, injury, and malaria.

From 2000 to 2015, substantial reductions in deaths under age five years were seen at the global level. However, the pace of reduction varied by cause. Pneumonia, diarrhea, and malaria collectively contributed nearly half of the total reduction. Other major causes, such as preterm birth complications, declined at a much slower rate globally and nearly stalled in South Asia.

Scale-up of proven interventions to prevent and treat childhood infectious diseases and leading neonatal conditions is urgently needed to maintain and accelerate the pace of improving child survival worldwide (Liu and others 2015). Improving quality care at birth, such as better implementation of neonatal resuscitation, antenatal corticosteroids, and kangaroo mother care, is a key strategy in reducing neonatal deaths due to intrapartum-related complications and preterm birth complications (Bhutta and others 2014). Scaling up new vaccines, such as *Haemophilus influenza* type B, pneumococcus, and rotavirus vaccines has the potential to further reduce pneumonia and diarrhea (Bhutta and others 2013; Walker and others 2013). Additional implementation research is urgently needed to understand how to better scale up coverage and quality of these interventions (Requejo and others 2015). Social interventions to improve child survival are as important as cause-specific interventions. Examples include improving family planning programs to help couples achieve their desired family size by minimizing unintended pregnancies and increasing women's education (Cleland and others 2012; Gakidou and others 2010).

Causes of 3.5 percent of deaths under age five years among live-born children were directly derived based on vital registration data and 6.4 percent from a model using vital registration data; causes for 90.1 percent were derived using verbal autopsy data (Liu and others, forthcoming). Verbal autopsy as a distinct scientific area has been improving substantially yet remains subject to inherent limitations (Anker 1997; Fottrell and Byass 2010; Murray and others 2011). Estimates produced by sophisticated modeling cannot and should not replace any existing and future data collection efforts to generate context-specific information, given that the strengths and limitations of the local data collection process are fully accessible and well understood. Furthermore, national civil registration and vital statistics systems need to be further strengthened and invested in more heavily to deliver on the promise of improved and reliable health statistics. Ultimately, evidence-based policy making and program planning can only be optimized if full openness and transparency can be achieved in the evidence-generating process (Sutherland 2013).

CONCLUSION

We present in this chapter a new concept of TU5MR, which is a composite measure of mortality occurring between 28 weeks gestation and age five years. Within this age group, child survival efforts should focus on stillbirth and neonatal mortality, as well as preterm birth complications, pneumonia, and intrapartum-related complications. More information is needed to better understand levels and causes of stillbirth. To end preventable child deaths in a generation and attain the ambitious Sustainable Development Goals, child survival needs to remain front and center on the global development agenda.

NOTES

World Bank Income Classifications as of July 2014 are as unnumbered note 1 as follows, based on estimates of gross national income (GNI) per capita for 2013:

- Low-income countries (LICs) = US$1,045 or less
- Middle-income countries (MICs) are subdivided:
  a) lower-middle-income = US$1,046 to US$4,125
  b) upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more.

1. A constant annual rate of decline was assumed when interpolating and extrapolating to derive stillbirth rates for 2000 and 2015 from 1995 and 2009 estimates, respectively. However, if the reduction of stillbirth rates has been accelerating in this period, we could have underestimated the annual rate of decline of stillbirth rates.

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