e-Appendix 1: Glossary of frequently reported global health indicators

Measures of mortality

The best indicators of mortality among children are the probabilities of dying in certain periods of life. The probabilities (*P*) measure the chances of dying by a certain age (*x*) or age range (*x* + *n*). These probabilities are calculated as follows:

$$P_n = \frac{\text{no. of deaths from age } x \text{ to age } (x - n)}{\text{no. of people from age } x \text{ to age } (x + n) \text{ at risk of dying during the specified period}}$$

It is usually not possible or practical to calculate these probabilities, because in practice not every child in the denominator is followed forward in time for the outcome of interest. Furthermore, most developing countries do not have registration data on births and deaths, and thus the actual number of children at risk and the total number of deaths are unknown. This situation means that measures of mortality that approximate the probability of death are calculated, usually for a calendar year. These measures are a mix of proportions, rates and ratios, which inevitably leads to confusion about definitions and meaning. For example, the terms "probability" and "rate" are used interchangeably, and in some cases the measure is not actually a rate, but a proportion or a ratio. No wonder there is such confusion among researchers and readers.

The following are the most widely reported mortality indicators. They are based on the available data, in large part derived from national demographic and health surveys and verbal autopsies. Demographic and health surveys include the birth histories of mothers and household deaths. The age at death is typically recorded, and a verbal autopsy (an interview to elicit the signs and symptoms at the time of death) may follow. For each mortality indicator listed below, we have included the following descriptive information: what the indicator is intended to measure, what the estimate actually measures and comparative outcomes in developing and developed countries.

Perinatal mortality rate (PNMR)

The probability of dying between the date of gestational viability and 7 days postpartum. It is estimated by determining, for a specified period, the number of deaths among newborns that occur after 22 weeks gestational age, during childbirth and up to 7 completed days after birth, and dividing this by the number of live births over the same interval. The PNMR is usually reported as a "rate" per 1000 live births in a specified calendar year:

$$\text{PNMR} = \frac{\text{no. of deaths from 22 wk gestation to 7 d postpartum}}{\text{no. of live births}} \times 1000$$

Here, perinatal deaths are intended to represent the sum of stillbirths and early neonatal deaths. The cut-off of 22 weeks is meant to reflect the point at which a fetus is considered viable, but the interpretation of viability varies among countries, and therefore some will apply 24 or 28 weeks as the cut-off. The PNMR is considered an indicator of obstetric care. In developed countries, about 6 perinatal deaths per 1000 live births are reported (e.g., for Canada for the year 2000, the number was 6.7 per thousand[1]), whereas in developing countries PNMR ranges from 25 to 200 perinatal deaths per 1000 live births.[2,3] Countries that apply a later gestational age cut-off will report relatively lower PNMRs.

Neonatal mortality rate (NMR)

The probability of dying in the period from birth to 28 days of age, estimated as the number of deaths between 0 and 28 days of age over a specified period divided by the number of live births during the same period. This is usually expressed as the "rate" per 1000 live births in a specified calendar year:

$$\text{NMR} = \frac{\text{no. of deaths from age 0 to 28 d}}{\text{no. of live births}} \times 1000$$

The NMR in Canada and other developed countries ranges from about 4 to 6 deaths per 1000 live births,[4] but in most developing countries it is in excess of 40.[4] About half of all neonatal deaths occur in the first week of life.[5] The occurrence and causes of neonatal deaths in developing countries are not well documented because the vast majority of births occur at home; however, such deaths are believed to be largely attributable to low birth weight, birth injury, asphyxia or hypoxia, hypothermia and infection.[5,6]

Infant mortality rate (IMR)

The probability of dying in the period from birth to the first birthday. In reality, newborns are not prospectively observed for deaths occurring up to 1 year of age. Instead, the probability of dying is calculated on the basis of the number of reported infant deaths during a calendar year divided by the estimated number of live births occurring in the same year. Although it is actually a ratio, the IMR is presented as a "rate" per 1000 live births. For a specified calendar year,

$$\text{IMR} = \frac{\text{no. of deaths from age 0 to 365 days}}{\text{no. of live births}} \times 1000$$

The IMR in Canada is about 6 infant deaths per 1000 live births.[1] IMRs in developing countries vary widely, the highest being over 100 infant deaths per 1000 live births in several sub-Saharan African countries.[7] Apart from neonatal causes (outlined above), the major causes of infant death

are pneumonia, diarrhea, malaria and malnutrition.[8] For countries with an IMR below a threshold of 50–60, neonatal deaths will account for the majority of infant deaths.[7]

Child mortality rate (CMR)

(also referred to as "***child death rate***")

The probability of dying between the first and the fifth birthdays (the sum of the probabilities of dying in the second, third, fourth and fifth years of life). Calculation of the probability of dying for each year of life usually relies on data from a survey or registry of all birth and death histories. When such data are not available child mortality, or the rate of death, is estimated for any given calendar year by summing all reported deaths of children 1–4 years of age that occurred in a given year and dividing that number by the number of live births in the same year or the estimated number of children aged 1–4 years. If available, the latter denominator is preferred. For a given calendar year,

$$\text{CMR} = \frac{\text{no. of deaths age 1-4 yr}}{\text{no. of children age 1-4 yr}} \times 1000$$

Readers may also come across the term "child mortality ratio," which is calculated by substituting in the denominator the number of live births per 1000. The latter, it should be noted, theoretically allows for a ratio greater than 1.

The causes of death after the first year of life vary considerably from country to country. Injuries and malnutrition become more dominant contributors to mortality in this age group. For example, in rural Bangladesh the most important cause of death in this age group is drowning.[9]

Under-5 mortality rate (U5MR)

Probability that a newborn child will die before reaching his or her fifth birthday (the sum of probabilities of dying in the first, second, third, fourth and fifth years of life). This cumulative probability is expressed per 1000 live births. It is meant to estimate the likelihood at the time of birth that a child will not survive to his or her fifth birthday. The U5MR is frequently reported by sex and is referred to as male and female child mortality. For a calendar year,

$$\text{U5MR} = \frac{\text{no. of deaths from birth to 4 yr}}{\text{no. of live births}} \times 1000$$

The U5MR in Canada is about 7 deaths per 1000 live births.[10] In times of war or famine, a least developed country will have a U5MR as high as 250 per 1000 live births (i.e., each child has a 25% chance of dying before reaching the age of 5 years). In most of sub-Saharan Africa the U5MR exceeds 125 per 1000 live births.[11]

Despite the different causes of death, there is a need for caution when considering child mortality at ages 1–4 years as distinct from infant mortality. When asked, mothers tend to round their children's ages, which makes it difficult to distinguish infants from children over 1 year of age and therefore results in less accurate estimates of infant and child (1–4 years) mortality. For this reason, a mortality measure encompassing ages 0–4 years, such as the U5MR, may be preferable for many developing countries.

Maternal mortality ratio (MMR)

Maternal death is defined as the death of a woman as a result of pregnancy or childbirth, during pregnancy or within 42 days after delivery. Classification of a death as a maternal death is highly dependent on a recorded diagnosis or the conduct of a verbal autopsy to ascertain the cause of death. In practice, the MMR is often an estimate based solely upon the time of death, i.e., death while pregnant or within 42 days after delivery. The MMR is expressed as the number of maternal deaths per 100 000 live births over a specified period. For a specified calendar year,

$$\text{MMR} = \frac{\text{no. of maternal deaths}}{\text{no. of live births}} \times 100\,000$$

Because deaths other than those due to pregnancy or childbirth are often included in this indicator, it may represent an overestimate. However, this may tend to balance out the underreporting of deaths that are truly due to maternal causes in some countries. The MMR is expensive to measure because of the large sample sizes needed to obtain precise estimates. Therefore, proxy measures of maternal mortality, such as the presence of a qualified, skilled birth attendant at the delivery or the occurrence of at least 3 antenatal care visits, are commonly substituted. These measures correlate closely with the MMR.[12,13] The greatest disparities in deaths among developed and developing countries occur for the MMR. In Canada a maternal death is rare, and the MMR is less than 5 per 100 000 live births.[14] MMRs reported for Asia and Africa usually exceed 400 and 900, respectively.[15] In regions of East and West Africa, the MMR exceeds 1000.[15] Of the estimated half a million maternal deaths each year, 95% occur in Africa and Asia.[16]

As with the CMR, the MMR can also be calculated as a rate by replacing the denominator with the number of women 15–49 years of age.

Indicators of nutritional status

Malnourished children

For public health and epidemiologic monitoring of child nutrition in a population, age-specific heights and weights are obtained. These values are then compared with standard distribution references and what would be expected, on average. Either a z score (a child's deviation from the expected value, divided by 1 standard deviation of the mean) or the percentage of children with the expected value is determined. The cut-off thresholds vary, and there

is considerable debate about the validity of arbitrary, mathematically determined classifications. The cut-off values shown in the accompanying Table 1 are applicable for all 3 subgroups described below.

Table 1: Typical cut-off thresholds for determining malnutrition* (applicable to height and weight for a particular age category)

Category	*z* score†	% of expected value
Mild	–1.0 to –1.9	< 90
Moderate	–2.0 to –2.9	< 80
Severe	≤ –3.0	< 70

*Applicable for determining all 3 malnutrition subgroups: underweight, stunted and wasted (see text for further explanation).
†Deviation of child's measured value from the expected value, divided by 1 standard deviation of the mean.

The 3 malnutrition subgroups that are routinely monitored and reported are proportions of children who are underweight, stunted or wasted (see below for definitions). Each of these subgroups is then categorized as the proportion whose deviance from expected is mild, moderate or severe.

Child malnutrition is usually measured among those 6–59 months of age. For the stunted and wasted measures in children 6–23 months of age, the body length (with the child lying prostrate) is usually measured; thereafter the standing height is measured.

Underweight

Determined by dividing a child's weight (in kilograms) by his or her age (in years) and comparing the result with gender-specific standards. If the data are taken from a single, cross-sectional survey, the underweight value is an indicator of either acute or chronic deficiencies in energy intake. If the measurements are repeated, changes will reflect trends in acute malnutrition.

Stunted

Determined by dividing a child's height (in metres) by his or her age (in years) and comparing the result with gender-specific standards. This value is an indicator of chronic or persistent deficiency in energy intake and reflects social or economic conditions.

Wasted

Determined by dividing a child's weight (in kilograms) by height (in metres) and comparing the result with gender-specific standards. This value is an indicator of acute or persistent insufficient protein energy intake and is useful as an early warning of impending shortages of food in a population.

Low birth weight (LBW)

Defined as a birth weight less than 2500 g, this indicator reflects both intrauterine growth retardation and prematurity. The LBW "rate" is actually a proportion, calculated as the number of LBW births per 1000 live births (for babies who have been weighed). In many developing countries the vast majority of deliveries occur in the home, where no scale is available. However, hospital-based birth weights overrepresent high-risk pregnancies and mothers with higher income and education level (i.e., lower-risk pregnancies). The prevalence of LBW births is an indirect measure of the nutritional status of women of childbearing age and varies widely by region. It is highest in Southeast Asia, where in some countries over 30% of all newborns have LBW, largely because of intrauterine growth retardation.[7] In Canada approximately 6% of births are associated with LBW, primarily because of prematurity.[1]

Prevalence of anemia in women of childbearing age

The proportion of women 15–49 years of age with a hemoglobin level less than 110 g/L (if pregnant) or less than 120 g/L (if not pregnant). This is an indicator of expected maternal health and also correlates well with the risk for maternal death. Portable, accurate and technologically feasible field kits are now available at low cost. However, the utility of this information is questionable, given the limited success of programs to effectively prevent or treat the problem.

Demographic indicators

Crude birth rate (CBR)

Number of births per 1000 population over a specified period. The CBR is typically reported for a calendar year; the numerator is the total number of live births in the year and the denominator the average population during the year, estimated by the population at midyear.

In high-fertility situations, CBRs will be in excess of 30 births per 1000 population. Most developed countries have CBRs under 15 per 1000; Canada's is about 12 per 1000.[1] CBRs have very limited value for comparison between populations because of differences in the proportions of women of reproductive age. The total fertility rate (see below) is a preferred indicator because it takes into account the age structure of the population.

Crude death rate (CDR)

Number of deaths per 1000 population over a specified period. As with the CBR, the CDR is usually reported on a yearly basis; the numerator is the estimated number of deaths over the year and the denominator the estimated total population at midyear. The CDR is of limited value for comparison of mortality between populations because of differences in age structure. However, it has some value for assessing short-term changes in mortality within the same population, as the proportion of those most at risk will not vary a great deal over a few years.

CDRs over 15 per 1000 population should be considered high. Canada's CDR is about 7 per 1000.[17] Because this indicator is not age-standardized, low CDRs can be misleading and do not necessarily indicate that a country's

population is doing well. In the absence of birth or death registries, numerators are derived from periodic surveys or selected demographic surveillance sites. Reports may be stratified by urban and rural populations.

Crude growth rate (CGR)

Also referred to as the "natural population growth." Determined by subtracting the CDR from the CBR for any given year and converting the result to a percentage. In countries with high out-migration or in-migration rates, these rates may also be included in the determination of the actual growth rate, but this is unusual for developing countries. The CGR in developing countries generally exceeds 1%, and in some cases is nearer 3%.

Life expectancy (LE_0 or e_0)

The number of years that a person born today (or at any other designated point in time) is expected to live, given the age-specific death rates for the country in which he or she lives at the time of birth. Given the large number of deaths in the first year of life in developing countries, a second estimate of life expectancy, at 1 year of age, is also a useful indicator (LE_1 or e_1). Life expectancy is a useful summary indicator for the mortality experience of an entire population, one that takes into account the population's age structure. It is usually reported separately for males and females.

In Canada, the LE at birth is 75.4 years for males and 81.2 years for females.[1] Over the past 2 decades, life expectancy in developing countries has increased by about 10 years, rising from 55 to 65 years. This trend has reached a plateau, and there are now over 30 countries experiencing declines in life expectancy due to civil disorder, economic transitions or the HIV/AIDS pandemic.[13]

Healthy life expectancy (HALE)

A relatively new indicator, defined as the number of years a newborn child can be expected to live, adjusted for the time spent in ill health. Uniform definitions of ill health are difficult to implement and are based, in part, on subjective assessments. Nevertheless, estimates of HALE represent an important population health indicator of the World Health Organization (WHO) and serve to highlight disparities in the overall health of nations. In 2001, country-specific estimates of HALE ranged from 28.6 years (in Sierra Leone) to 75.0 years (in Japan).[18] HALE reaches 72.0 years in Canada and 69.3 years in the United States.[18] Twenty countries worldwide have HALE values below 40 years, 19 of these located in sub-Saharan Africa.[18]

Total fertility rate (TFR)

Number of births that a woman can expect to have during her childbearing years (15–49 years), given current age-specific fertility rates in her population or country. The TFR is therefore the sum of all age-specific fertility rates at one point in time. A TFR of 2.1 is cited for Western countries as the replacement rate that will lead to zero population growth.[19] However, depending on the age structure of the population, growth could continue for many years after this rate is reached, a phenomenon referred to as "population momentum."

TFRs have dropped dramatically over the past 20 years in most developing countries, from between 6 and 7 to under 4. The TFR in Canada is 1.5 (below the replacement rate of 2.1, but compensated by in-migration), whereas in the least developed countries it is in excess of 4. In Ethiopia, Bolivia and Bangladesh it is 6.1, 3.8 and 3.5, respectively.[12]

Contraception prevalence rate (CPR)

Proportion of women of childbearing age (15–49 years) using some form of modern contraception (although sometimes reported with traditional methods included). Methods can be permanent (e.g., tubectomy) or temporary (e.g., intrauterine device or oral contraceptive pill). The CPR in Canada is above 75%.[20] Clearly, there is a close correlation between the CPR and the TFR, the former being a more immediate barometer of the success of family planning programs. Zero population growth is unlikely to be reached until CPRs exceed 70%.

Indicators of resources and service performance

Percent attended deliveries

An attended delivery is defined as a delivery for which a trained birth attendant or midwife was present. A trained birth attendant is someone trained in hygienic birthing practices, including proper care of the umbilical cord and the newborn, as well as early recognition and referral of high-risk deliveries. An alternative indicator, skilled attended delivery, refers to the proportion of deliveries attended by a midwife, nurse or physician. Given the difficulties in measuring maternal mortality, the latter is considered a useful proxy indicator of the likelihood of maternal death.

Percent exclusive breastfeeding (EBF)

The WHO and UNICEF define EBF as ingestion by an infant of no food other than breast milk from the mother, breast milk from a wet nurse or expressed milk. No other liquids or solids are ingested, except for drops or syrups containing vitamins, mineral supplements or medicines. The optimal duration of EBF is variably interpreted as between 4 and 6 months, after which complementary foods are added.

Percent of population with access to safe (protected) water

This indicator refers to water intended for drinking and cooking. Determination of safety is usually based on coliform counts of samples from specified water collection sites. To qualify as safe or "protected," a site must conform

to standards of acceptable safe-water construction. Piped water in urban settings is usually considered safe. Thus, there are huge differences between urban and rural populations in the proportions of the population reported to have access to safe water. "Safe" is probably not the most appropriate descriptor, since water from even properly constructed sites may vary considerably in coliform count, as does piped water. Coliform counts will also be affected by the containers used to collect, store and retrieve the water. Access to a safe water site has been defined in terms of distance to the site (e.g., less than 1 km) or time needed to fetch the water (e.g., less than 15–30 minutes).

Safe water is influenced by factors other than exposure to microbes. For example, it was recently discovered that most "safe water" shallow-tube well sites in Bangladesh are contaminated by naturally occurring arsenic, which probably affects more than 20 million people.[21]

Percent of population with access to health services

Access will be determined by distance, time, cost and sociocultural factors. An example of the latter is culturally imposed restricted mobility of women. A frequently applied criterion is a travel distance of less than 10 km to reach a health care facility, but this is clearly not sufficient in all instances. Rivers and gorges represent important barriers, as do some changes in weather (e.g., access declines sharply in the rainy season).

Percent latrine construction

Latrine construction has been demonstrated to be the most important public health intervention for the prevention of diarrheal disease in the populations of developing countries. Latrine construction is determined on a household basis, with the percent coverage being extrapolated to the population covered. Crude construction designs, such as a pit or a structure hanging over water, do not qualify.

Percent of children fully immunized (EPI coverage)

The performance of expanded programs for immunization (EPI) must be constantly monitored. This indicator is highly correlated with the functional status of health care systems and is vulnerable during periods of civil instability. Full coverage is defined as children having received BCG (bacille Calmette-Guérin), 3 doses of DPT+P (diphtheria, pertussis, tetanus and polio) vaccines and measles vaccine by 12 months of age. In some instances, coverage may be reported for children 12–23 months of age, which allows more time to reach full coverage. Values determined with denominators limited to children with access to health services or to targeted populations represent secondary indicators of EPI coverage and should not be compared with primary, community-based estimates of coverage.

Literacy rate

Literacy is defined as the ability to both read and write simple sentences of direct relevance to one's daily activities. It is not feasible to test populations for levels of literacy; therefore, estimates of literacy rates are based on years of schooling. Generally, the cut-off applied is 4–5 years of successfully completed schooling, but this may vary and should be confirmed before values are compared between countries. Literacy is one of the most reliable predictors of health status within the populations of developing countries.

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