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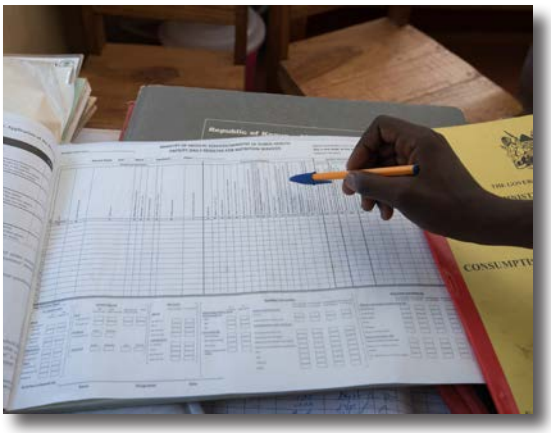
Using Health Management Information Systems Data to Contextualize Survey-Based Estimates of Fertility, Mortality, and Wasting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Using Health Management Information Systems Data to Contextualize Survey-based Estimates of Fertility, Mortality, and Wasting

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EXECUTIVE SUMMARY

Introduction: Population-based household surveys, such as those conducted through The Demographic and Health Surveys (DHS) Program, are generally considered one of the best sources for estimates of reproductive, maternal, newborn, and child health and nutrition (RMNCH+N) outcomes. However, questions sometimes surface about the validity of these estimates. The examination of data from various sources allows for a better understanding of estimates and trends. In this report, we examine the use of routine health facility data to contextualize estimates of fertility, maternal mortality, under-5 mortality, and wasting.

Data sources for health outcomes: Country health information system(s) (HIS) include both routine and non-routine data. Non-routine sources of HIS data include population-based household surveys, like DHS surveys, and facility surveys or assessments such as the Service Provision Assessment survey. Routine data are collected through health facilities and other sources, such as civil registration and vital statistics. Routine health facility data include service delivery data as reported by facilities or designated community health workers (in some countries) and included in a country's health management information system(s) (HMIS). Unlike DHS surveys, which are nationally representative, routine health facility data do not represent the entire population for many indicators but do provide more granular and more frequent data points.

Considerations for triangulation: Triangulating DHS data and HMIS data provides an opportunity to obtain a more robust picture of RMNCH+N estimates, although there are several overarching considerations when triangulating data from different sources. The first consideration is to triangulate using multiple indicators with the purpose of understanding trends rather than validating point estimates. This includes comparing overlapping estimates where applicable and exploring information. The second step is to assess data quality, limitations, and biases associated with the unique data sources, such as completeness, selection or non-response bias, and measurement-related differences or error. Timing can also play an important role, ranging from issues of when data are collected (e.g., seasonality) to a lag between interventions and outcomes. Finally, individual, household, community, and environmental factors that may influence outcomes should be considered.

Contextualizing fertility estimates: The major proximate determinants of fertility include marriage, contraceptive use, postpartum infecundity, and abortion. The only determinant that is consistently captured across countries in HMIS platforms relates to contraceptive use, including volume or count indicators of commodities distributed, service visits, and current uses. These can be used to calculate "Estimated Modern Use", a measure of contraceptive use that may mirror trends in, but not equate to, contraceptive prevalence as assessed in household surveys given biases in HMIS. Routine health facility data may also inform susceptibility to unintended pregnancy when other indicators such as postpartum family planning uptake, method mix, stock outs, and couple years of protection are examined. As contraceptive use is only one determinant of fertility (and one that doesn't always yield an inverse relationship with fertility), other determinants and influencing factors should be considered. These include age at marriage, use of traditional methods, abortion, and breastfeeding practices. However, routine health facility data do not contain this information, so other data sources are necessary to conduct a more robust triangulation to understand changes in total fertility rates.

Contextualizing maternal mortality estimates: Estimates of the maternal mortality ratio, and respective margins of error, can be produced using nationally representative survey data. HMIS data can be used to contextualize these estimates with information related to (a) institutional mortality and causes of death; (b) information about morbidity; (c) availability and readiness of facilities; and (d) delivery of preventive or curative interventions, reflecting quality of care. It is important to note that institutional and household-based maternal mortality estimates may not align, as these are calculated among different populations and reference periods and the data reported in HMIS may not be complete. Further, although some interventions may prevent many maternal deaths, maternal mortality has many causes and many treatments to prevent it, so coverage or provision of multiple indicators should be examined. These include (but are not limited to) coverage of antenatal care, facility delivery, cesearean sections, and postnatal care as well as availability and provision of key life-saving treatments such as magnesium sulfate and uterotonics. Although some of this information may be ascertained using HMIS data, systems in many countries are still under development.

Contextualizing under-5 mortality estimates: Under-5 mortality is captured in both household and HMIS data; household estimates of mortality rates are calculated among a nationally representative sample whereas HMIS mortality-related indicators are facility-based and not representative. However, HMIS, when well-functioning, can provide contextualizing information about the health system's role in preventing child mortality. Such information, including coverage or readiness to provide interventions such as immunization, and provision of life-saving interventions that prevent major causes of death (e.g., antibiotics for pneumonia or treatment for diarrhea), can be used for triangulation. As there are many causes of under-5 mortality, several indicators should be examined for a robust triangulation exercise, including indicators representing pertinent factors outside of the health system.

Contextualizing wasting estimates: Wasting is an acute event with multifactorial causes ranging from those at the individual (e.g., illness), household (e.g., poverty), and contextual (e.g., famine) levels. Weight-for-height z-score (WHZ) is used to estimate wasting in DHS surveys, and WHZ or mid-upper arm circumference (MUAC) can be used to screen for acute malnutrition and monitor growth in routine settings. Although trends in wasting estimates between DHS surveys and HMIS may provide some context, HMIS estimates differ from survey-based estimates in important ways. MUAC is not equivalent to WHZ, the denominators for routine data do not capture the total population, and the quality of assessments may be poorer in a routine context. The health service environment can also provide contextually important information on the management of acute malnutrition through semi-quantitative rapid assessments on coverage and barriers to services along with HMIS performance data. Factors from other data sources on seasonality, disease, political unrest, and famine (for example) are also relevant to contextualizing estimates. Given the robust set of data quality indicators that exist for wasting, internal assessment of survey data may provide the best information on the quality of wasting estimates at this time.

Conclusion: The outcomes described in this report are complex and are determined by myriad health systems and non-health systems factors. Thus, it is imperative to triangulate with multiple indicators from routine health facility data in tandem to comprehensively contextualize the outcomes while acknowledging the biases attributable to each data source.

ACRONYMS AND ABBREVIATIONS

AMTSL	active management of the third stage of labor
CRVS	civil registration and vital statistics
CYP	couple years of protection
DHIS-2	District Health Information System 2
DHS	Demographic and Health Survey(s)
DSS	demographic surveillance site(s)
EMU	Estimated Modern Use
FEWS NET	Famine Early Warning Systems Network
FPET	Family Planning Estimation Tool
HIS	health information system(s)
HMIS	health management information system(s)
HRIS	human resources information system(s)
IPTp	intermittent preventive treatment in pregnancy
ITN	insecticide-treated net
IYCF	infant and young child feeding
LiST	Lives Saved Tool
LMIC	low- and middle-income country
LMIS	logistics management information system(s)
MAM	moderate acute malnutrition
MCSP	Maternal and Child Survival Program
MDG	Millennium Development Goal
MICS	Multiple Indicator Cluster Surveys
MMR	maternal mortality ratio
MUAC	mid-upper arm circumference
PRMR	pregnancy-related mortality ratio
RAMOS	reproductive age mortality survey(s)
RMNCH+N	reproductive, maternal, newborn, and child health and nutrition
S3M	simple spatial survey method
SAM	severe acute malnutrition
SARA	Service Availability and Readiness Assessment
SDG	Sustainable Development Goal
SHSS	sentinel health surveillance site(s)
SLEAC	simplified lot quality assurance sampling evaluation of access and coverage

SMART	standardized monitoring and assessment of relief and transitions
SPA	Service Provision Assessment
SQUEAC	semi-quantitative evaluation of access and coverage
SS	service statistics
TFR	total fertility rate
UN DESA	United Nations Department of Economic and Social Affairs
UN IGME	United Nations Inter-Agency Group for Child Mortality Estimation
UN MMEIG	United Nations Maternal Mortality Estimation Inter-Agency Group
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHZ	weight-for-height z-score

1 INTRODUCTION

Information is necessary from multiple levels within the health system to monitor progress and better understand reproductive, maternal, newborn, and child health and nutrition (RMNCH+N) outcomes. The health system comprises nested levels that include individuals, health care workers, the organizations that employ them, and the general political and economic environment under which individuals, care teams, and organizations operate (Fanjiang et al. 2005). To monitor health systems, a number of data sources provide varying information. For example, periodic nationally representative household surveys provide information about key health outcomes, while routine health facility data provide complementary information on the availability and quality of care at health facilities. Although periodic national health facility surveys also provide high quality information on availability of services and care, they are conducted infrequently or not at all in some countries. Triangulating data from multiple sources—or examining indicators from different data sources side-by-side—from the various levels of the health system can provide a more robust understanding of the health system.

Examining data from different sources is especially important when data quality concerns arise. Although household surveys are often considered the best source for nationwide health outcome estimates in the absence of complete civil registration data, questions sometimes surface when estimates don't theoretically align with the programmatic efforts in place to reduce morbidity and mortality. Triangulating thus provides an opportunity to substantiate these data, so long as there is an awareness of and proper adjustments for biases and errors originating from each source (WHO 2009). Examining data from various sources also allows for a better understanding of estimates and the feasibility of trends in major health outcomes. Further, it provides program managers, analysts, and other stakeholders with additional information for improving the design and targeting of interventions. This information can help identify the key barriers and challenges to optimizing RMNCH+N outcomes as well as provide insight on areas to target for improving RMNCH+N.

As periodic household surveys have decades of experience, publicly available resources such as recode manuals and online tutorials are available to support data use. Resources for using routine health information system(s) (HIS) are less developed as these systems are newer, they are not standardized across countries, and their data are not typically publicly available. Although some guidance focuses on the use of routine health facility data in the context of tuberculosis, malaria, immunization, and HIV/AIDS, there is a paucity of guidance on how to use routine health facility data for RMNCH+N (MCSP 2018). Recently, the World Health Organization (WHO) produced documentation for program managers using health facility data for reproductive, maternal, newborn, child, and adolescent health (WHO 2019c). The WHO and the United Nations Children's Fund (UNICEF) are also developing guidance for nutrition indicators. However, there is minimal direction about triangulating information from both sources to inform health outcomes.

The objective of this report is to explore the extent to which routine health facility data can be used to contextualize estimates of fertility, maternal and child mortality, and wasting collected by the Demographic and Health Surveys (DHS) Program. Thus, this report provides an overview of data sources that capture specific RMNCH+N outcomes. It describes the health systems determinants related to fertility, such as contraceptive use and facility-related services. For maternal and child mortality, as well as child nutrition (wasting), we describe relevant health systems interventions, such as facility-based delivery services and prevention and treatment of childhood illness. The reports highlights considerations for the use of routine

data sources for contextualizing household estimates. Specifically, we focus on routine health facility data that stem from health management information system(s) (HMIS) to contextualize household data collected by The DHS Program. However, we explore other sources where relevant throughout the report.

Chapter 2 describes the data sources that are integral to assessing the performance of the health system, and Chapter 3 presents an overview of necessary considerations for triangulating data from these sources. Chapters 4 through 7 present unique considerations for each major outcome. In each of those chapters:

- We review and define the outcome and interventions or determinants. We do not review factors that are distal, such as wealth or education, and may influence access to interventions. The interventions or determinants are based on a review of the literature and the Lives Saved Tool (LiST) Visualizer (https://listvisualizer.org/) (Box 1.1).

> **Box 1.1 Lives Saved Tool Visualizer**
>
> The Lives Saved Tool (LiST) Visualizer demonstrates the causal pathways between interventions, intermediate risk factors, and outcomes of maternal mortality, stillbirth, neonatal mortality, child mortality, and nutritional status. The tool was built to demonstrate the conceptual framework for the LiST model, housed within SPECTRUM software, which is a linear deterministic model used to calculate the impact of coverage of interventions on maternal and child health outputs and outcomes.[1]

- We describe how different sources of data, including DHS data and routine health facility data, can be used to measure the outcome, determinants or causes, and interventions. We first describe how both DHS and HMIS data can be used to measure related outcome and proximate determinants or major causes, as applicable to the outcome. We then describe key interventions that may be captured by these data sources, as well as other major data sources, that will help broaden our understanding of the health system's role in addressing the outcome. For factors that may be assessed using routine health facility data, we present standard indicators based on existing and forthcoming global recommendations put forth by the WHO, UNICEF, and other health data partners.[2]

- We describe considerations necessary for triangulating DHS data and routine health facility data to contextualize the outcome.

- We provide outcome-specific recommendations.

Finally, Chapter 8 presents a brief conclusion of the report.

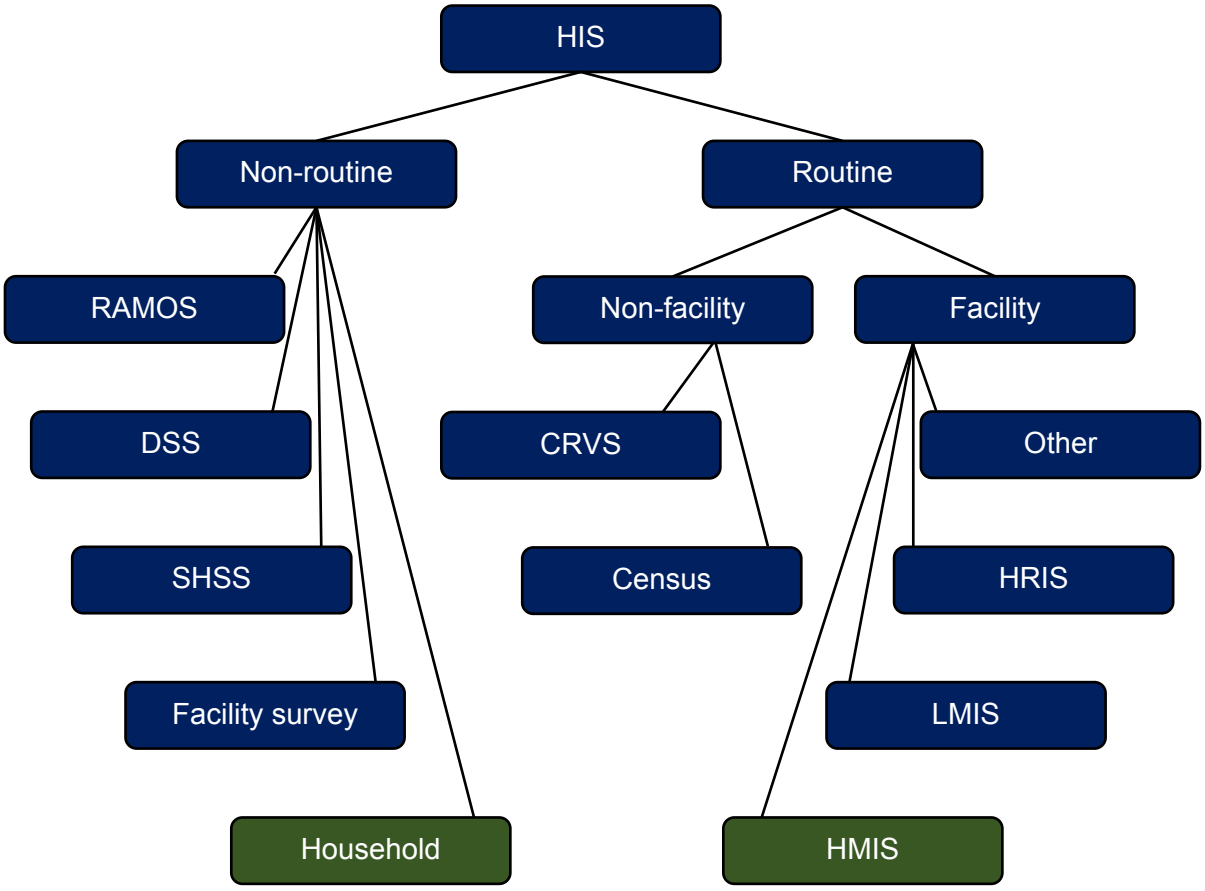
[1] The outputs include risk factors for mortality as well as intermediate characteristics or risk factors such as maternal anemia, prematurity or small size at birth, and child stunting or wasting; outcomes include all cause and cause-specific maternal, neonatal, and under-5 mortality as well as stillbirth (Walker, Tam, and Friberg 2013). The model multiplies the estimated number of cause-specific deaths (based on baseline mortality data) by the coverage of the intervention (as inputted by the user) by the effectiveness of the intervention (based on empirical evidence) (Walker, Tam, and Friberg 2013). The effects of additional interventions are calculated based on residual deaths not averted by other inputted interventions. The effects are calculated for preventive interventions first, before curative measures are considered.

[2] Accessible online here: https://www.who.int/healthinfo/tools_data_analysis_routine_facility/en/

2 DATA SOURCES

A country's HIS includes both routine and non-routine data (Figure 2.1) (Graham et al. 2008; WHO 2018a). Routine data are collected outside of health facilities, through civil registration and vital statistics (CRVS), and through health facilities. Routine health facility data that capture service delivery as reported by facilities or designated community health workers (in some countries) are known as HMIS data. However, routine health facility data can also include management and information systems for laboratories, hospitals, disease surveillance, supervisory systems, financial and administrative systems, logistics, human resources, infrastructure, and equipment. Non-routine sources of HIS data include population-based household surveys and facility surveys or assessments.

Figure 2.1 Data sources in the health information system



Note: CRVS = civil registration and vital statistics; DSS = demographic surveillance site(s); HIS = health information system(s); HMIS = health management information system(s); HRIS = human resources information system(s); LMIS = logistics management information system(s); RAMOS = reproductive age mortality survey(s); SHSS = sentinel health surveillance site(s). This figure is based on a WHO description of the HIS (WHO 2018a).

Although each of these sources provides valuable data to inform the health system, no data source alone can capture all aspects of the health system or the multitude of factors that influence health outcomes. Which data source is used depends on the research, programmatic, or policy needs. These needs can encompass routine monitoring, cross-country comparisons, identification of regional disparities within a country, identification of determinants, or estimation of overall levels of health. The choice of data source also depends in part on available resources such as time, money, and country technical capacity (Graham et al. 2008). Additionally, each data source may be able to provide information for different types of indicators, including coverage, availability or readiness, and service delivery, defined in Box 2.1.

Box 2.1 Types of indicators

Coverage: Coverage of an indicator related to an intervention or service is traditionally defined as the number of individuals in need of the service who received the intervention or service, divided by the number of individuals who need the service.

Availability or readiness: Availability of a service is whether the service is provided. Readiness refers to whether facilities can provide the service (i.e., if they have the personnel, infrastructure, medicine, equipment, supplies, and commodities to provide it adequately).

Service delivery: Service delivery reflects the provision of care by a service provider. It includes providing medicines or commodities; conducting critical, recommended practices for the specific service; and providing counseling for the client. Service delivery reflects aspects of quality of care, which is a multi-dimensional construct.

Each source has strengths and limitations related to frequency and timeliness, degree of disaggregation, coverage, consistency, and cost. In the following section, we review the strengths and limitations of the two data sources we focus on in this report: household surveys and HMIS.

2.1 Household Surveys

The main sources of data for estimating major health and demographic outcomes such as fertility and mortality are household surveys including the United States Agency for International Development (USAID) DHS surveys and, more recently, the UNICEF Multiple Indicator Cluster Survey(s) (MICS). Since 1984, The DHS Program has provided technical assistance to more than 400 surveys in over 90 countries advancing global understanding of health and population trends in developing countries. More than 300 MICS surveys have been conducted in over 100 countries in the past 2 decades. In 2015, a collaborative group was established to better harmonize these surveys.

Information that The Demographic and Health Surveys Program collects

- Fertility
- Pregnancy-related and maternal mortality
- Neonatal, infant, and under-5 mortality
- Family planning
- Maternal and child health
- Gender and violence
- HIV/AIDS-related behaviors
- Biomarkers (e.g., for anemia and malaria) and anthropometry
- Nutrition
- Sociodemographic characteristics

The reliance on population-based household surveys as a mechanism to collect data on priority maternal and child health and nutrition outcomes in low- and middle-income countries (LMICs) began in the 1970s with the World Fertility Surveys and Contraceptive Prevalence Surveys and was born from the poor quality of routine data at the time (Magnani et al. 2018). The Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) increased the

demand for national-level data in LMICs to support performance monitoring and resource allocation (Day et al. 2019; Maina et al. 2017). In this context, national household surveys became the key source for RMNCH+N indicators (Day et al. 2019; Maina et al. 2017).

2.1.1 Unique features of household data

In addition to providing information about health outcomes, service utilization (coverage), and self-reported receipt of selected components of services (interventions), the correlates and determinants of priority health outcomes can be very useful for informing the design and targeting of interventions aimed at reducing mortality and morbidity. Since data are collected within households, national-level indicators are calculated based on denominators of either households or individuals interviewed within households, such as women of reproductive age. Through complex sampling designs, the surveys are also representative at subnational levels by region and urban-rural residence. Data are typically freely and publicly available; summary reports are published with the release of data sets.

2.1.2 Limitations

Population-based household surveys are typically conducted approximately every 3 to 5 years. They provide self-reported, retrospective accounts, which are subject to biases including recall bias (McCarthy et al. 2016) and social desirability bias (Arnold and Khan 2018; McCarthy et al. 2016); further, the surveys are samples of the population and thus subject to sampling error in addition to non-sampling error, which can contribute to large uncertainty intervals for statistically rare events such as maternal mortality. For indicators that are not self-reported, such as biomarker information, the logistical and technical complexities associated with their measurement can impact quality. Population-based surveys are expensive, often necessitate support from bilateral or multilateral agencies, and can be cost-prohibitive for LMICs to fund independently. Cost is driven by sample size, and a larger sample size is needed for a representative survey that captures rare events.

2.2 Health Management Information Systems (HMIS)

HMIS collate routine information collected and reported by health facilities on services provided by the facilities and on patient status, including admission, discharge, morbidities, and fatalities (Mbondji et al. 2014; MEASURE Evaluation 2017; WHO 2018a). HMIS may also contain information recorded by community health workers attached to facilities (MCSP in press). Health workers record information during visits, and these "data elements" are entered into summary forms for facilities and associated community health workers (MCSP in press). Facility-level data are then aggregated through the administrative units of the country—from the lowest-level facilities within communities, to district and regional levels, and finally to the national level; individual, patient-level data are often not included in HMIS (MCSP 2018; WHO 2019c)

Health management information systems collect and aggregate data about services provided at health facilities, including data on:

- Service access and availability
- Service quality and safety
- Coverage of interventions
- Risk factors and behaviors
- Health status
- Institutional mortality

Improvements in software and infrastructure have supported the shift from paper-based facility records to electronic recording via HMIS. However, electronic systems are more commonly available at district- and higher-level facilities, while many health centers or facilities operating at lower administrative levels still rely on paper-based systems in which information is aggregated and entered into electronic systems at the district level (MCSP 2018). In the past 2 decades, international development donors such as the Global Fund and USAID have made substantial investments to bolster the availability and quality of routine health statistics, for example through projects such as MEASURE Evaluation[3] and the Maternal and Child Survival Program (MCSP).[4] Advancement in HMIS platforms has led to more accurate routine data (Day et al. 2019). The District Health Information System 2 (DHIS-2) is an example of a digital HMIS platform. DHIS-2 is now being used in more than 60 countries, although access to the data is often restricted to health staff and managers within the countries at the district or higher levels of the health system.

2.2.1 Unique features of HMIS

One key benefit of HMIS is that they provide timely and frequent health facility data that can be used to monitor the health system more often than periodic household or facility surveys. Additionally, HMIS capture data at a more granular geographic information level than household surveys. That is, they provide data about lower-level administrative units whereas household survey data are typically representative only at the first administrative unit (typically regions). Further, these aggregated routine facility data, also called service statistics or health service statistics, when collected, managed, and used appropriately, can identify geographic areas or facilities in need of additional support for patients, resources, commodities, and health workers (MEASURE Evaluation 2019). These systems are especially valuable for providing service delivery information in areas where health services are typically provided through government-run programs and public facilities (MCSP in press). Although not all systems are designed or prepared to collect patient information that would allow for disaggregation on the basis of certain characteristics such as age or gender, the WHO recommends that systems work toward this capacity (WHO 2019c). Additionally, routine data, when combined with population-based denominators, can be used to estimate the levels of coverage for indicators such as institutional delivery or childhood immunization (Burton et al. 2009; Maina et al. 2017).

2.2.2 Limitations

The known limitations of HMIS data are that only public facilities are typically required to report, so data are not representative of populations even after combining with population-based denominators to calculate levels of coverage. Because data are aggregated and patient-level data are not maintained for HMIS reporting, information that would allow for disaggregation according to individual characteristics is lost, and HMIS do not capture sociobehavioral or socioeconomic characteristics.

As these systems are country-owned and standard indicators are only now being developed, the information collected across systems varies across countries, and information obtained from these systems are not always comparable or harmonized (MCSP 2018). Each country collects and reports on indicators that are of priority to that specific country, based on national strategic frameworks (MCSP 2018). Further, as HMIS are still developing, quality can vary across and within countries, and the interoperability of multiple

[3] https://www.measureevaluation.org/our-work/routine-health-information-systems
[4] https://www.mcsprogram.org/resource/hmis-review/

systems and platforms remains a challenge to optimal data utilization. While DHIS-2 or another countrywide HMIS platform is rolled out and scaled up, other parallel systems may exist in tandem. For example, some countries have parallel systems that collect and report on service delivery for malaria or family planning programs. Finally, the data are not typically available for public use and the process for gaining access varies widely from country to country.

To summarize, Table 2.1 highlights the strengths and limitations of the two key data sources covered in this report: routine health facility data and population-based household data.

Table 2.1 Strengths and limitations of data from health management information systems and households

	Strengths	Limitations
Routine health management information systems data	• Provide frequent and continuous information • Geographically more granular down to the district and facility levels • Provide information on availability, content, and provision of care	• Do not represent the entire population, or all facilities (e.g., typically include only public facilities and do not consistently capture community-based services) • Aggregation of data results in the loss of detailed information on individual characteristics • Quality (i.e., timeliness, consistency, completeness) can vary by country capacity • Do not include information on knowledge, attitudes, behaviors, and socioeconomic status variables
Periodic population-based household data (e.g., DHS data)	• Representative at the national level and often at the subnational level • Comparability over time and between countries • Include information on knowledge, attitudes, behaviors, and socioeconomic status variables • Free and publicly available	• Conducted infrequently • Subject to sampling error and large uncertainty for rare outcomes • Subject to non-sampling error, such as interviewer bias, recall bias, or social desirability • Costly

2.3 Other Data Sources

Additional sources of health data are worth noting, although the use of these data is not the central focus of this report.

The following sources are managed from within the health sector:

- **Logistic management information system(s) (LMIS) and human resources information system(s) (HRIS)**, which collect information on the availability of supplies, commodities, and human resources. These systems are often managed separately, but ongoing efforts seek to improve the interoperability between systems (MEASURE Evaluation 2017). As systems become integrated, these data could be used together under one platform within interoperable routine health facility data systems.

- **Periodic health facility surveys** including the Service Provision Assessment (SPA) conducted by The DHS Program and the Service Availability and Readiness Assessment (SARA) conducted by the WHO collect information on the availability of services and the readiness to provide such services. As these surveys are also nationally representative, they too can be costly and lengthy. Similar to household surveys, the costs of facility surveys are driven by sample size. Although some surveys observe visits related to selected services, they cannot be used to assess population-level health outcomes. However, key technical aspects of quality of care cannot be accurately reported by clients in a household survey (especially inpatient care, such as delivery care), so facility surveys that include observation of client-

provider interactions (e.g., the SPA) provide unique information that contributes to understanding health outcomes and informing programmatic strategies.

- **Reproductive age mortality surveys** (RAMOS) can provide the most accurate information by collecting data from different sources (e.g., from reviews of health facilities and records, or from verbal autopsy), but they are conducted on smaller scales and are expensive.

- **Demographic surveillance sites** can be used to register births and deaths; however, they are not common and don't provide national information.

- **Sentinel health surveillance sites**, either through specified community or facility sites, can be used to collect data on a specific disease or condition (Last 1995). This system is especially useful for capturing data on vulnerable populations or collecting ongoing health data to identify outbreaks or trends (Tuffrey and Hall 2016). For instance, sentinel sites have been used to collect data on acute malnutrition, which often occurs in small pockets of at-risk individuals, such as in insecure settings (Chinjekure et al. 2018).

Many systems managed outside of the health sector provide the information necessary for monitoring key health indicators (Mbondji et al. 2014). The following sources are examples of such systems:

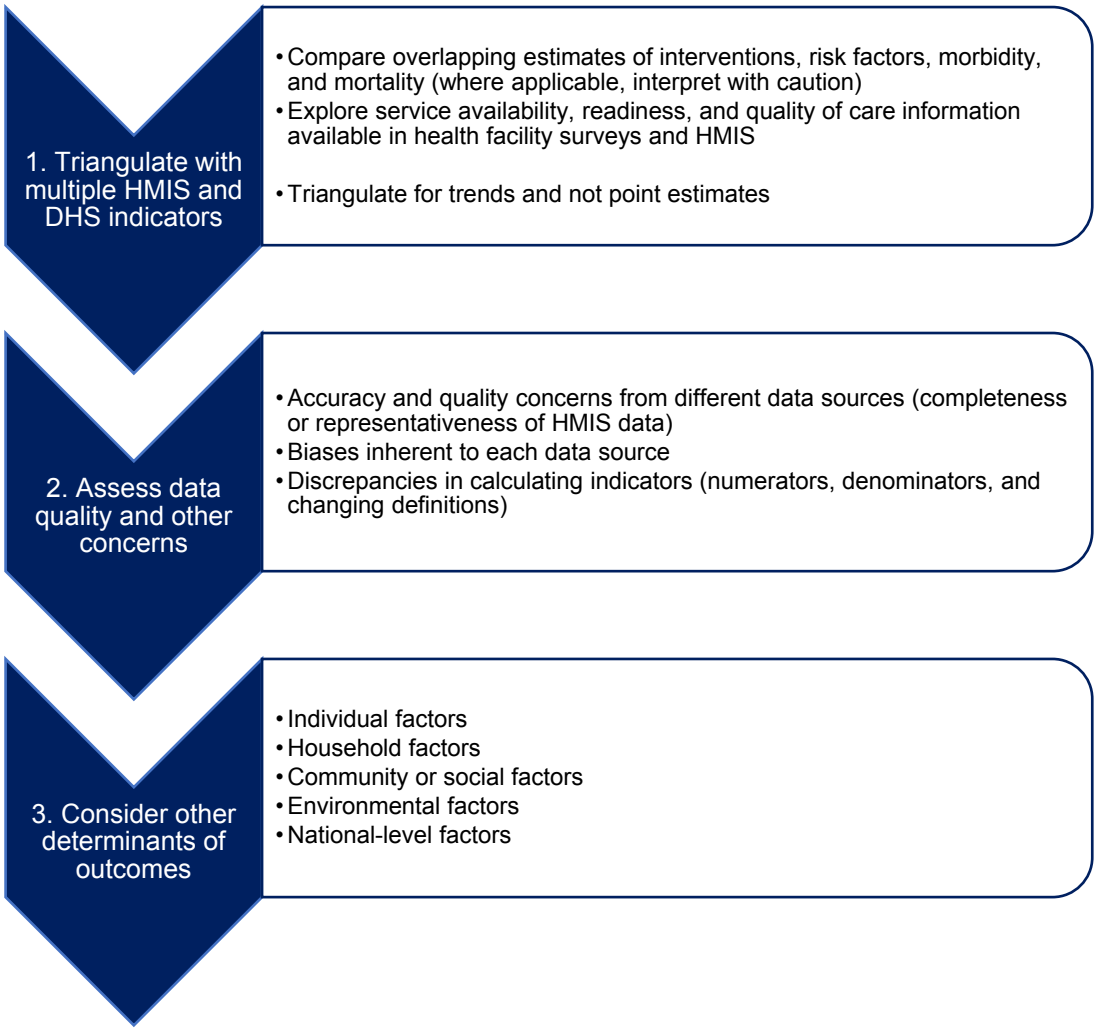
- **Civil registration and vital statistics systems** (CRVS) maintain birth and death records and can be used to calculate indictors related to fertility and mortality. If medical certification of death is obtained, cause of death can be ascertained and used to monitor cause-specific mortality at a population level (WHO et al. 2019). However, in most LMICs, CRVS systems are weak and incomplete; the World Bank identified 110 LMICs that lack an adequate CRVS system (World Bank 2018). Although these systems are improving, albeit slowly, only approximately two-thirds of births are recorded and just over one-third of deaths are registered globally (Mikkelsen et al. 2015).

- **Census surveys** collect counts of the population every 10 years, which can be used to determine population growth or decline. Census surveys also ask mothers about births and the survival statuses of their children, which can be used to estimate fertility and mortality.

3 CONSIDERATIONS FOR TRIANGULATION

Triangulation is defined as the use of data from multiple sources to compare, examine, and interpret evidence to strengthen conclusions about observations (WHO 2009). This chapter provides an overview of considerations needed to triangulate data from different sources to contextualize estimates of mortality (i.e., maternal mortality and under-5 mortality), fertility, and wasting (a critical indicator of acute malnutrition). Three critical steps to triangulation, summarized in Figure 3.1 and described in detail afterward, are used to contextualize outcomes.

Figure 3.1 Steps to triangulation



3.1 Triangulate with Multiple Indicators

Several indicators from HMIS can be used to provide additional context around household-based fertility, mortality, and wasting estimates. For example, for maternal mortality, HMIS elements of insitutional mortality, morbidity, intervention coverage, readiness, and service delivery can be used. Examining many components together can help to comprehensively contextualize trends in mortality. For household

estimates of mortality to decrease, institutional mortality should decrease while coverage, readiness, and quality measures improve. The indicators relevent and critical for each outcome are detailed in the following chapters.

When triangulating from different sources, reflecting on the trends from each source is recommended over comparing point estimates at one point in time. Battle et al. (2019) compared coverage estimates of malaria-related interventions in Malawi, finding similar trends between household survey data and routine health facility data among comparable indicators. As discussed below, quality issues, differences in methods of calculation, differences in indicator definitions, differences or changes in denominators, and other biases would suggest that the estimates themselves are not comparable; thus, we recommend comparing long-term trends.

Because of these issues, the comparability of trends may also be impacted, and trends should be interpreted with caution. For example, if nearly all facilities are reporting inconsistently, increases in the coverage of interventions could be misinterpreted as increases in service provision; true changes are more reliably estimated in systems with more complete and consistent reporting. Emerging efforts are underway to correct biases in routine health facility data and combine data from multiple sources to calculate more precise national or subnational estimates. Maina et al. (2017) propose a method to correct for incompleteness wherein assumptions are made about facilities that do not report and an adjustment factor is applied based on household survey data. Jeffery et al. (2018), as well as the Family Planning Estimation Tool (FPET) described in Chapter 4 of this report, apply methods for creating hybrid estimations of intervention coverage using data from both sources.

Another factor related to interpreting trends is the timing of data collection for indicators examined. When examining indicators that may be influenced by seasonal spikes in disease burden, we recommend examining long-term trends over short-term trends for triangulation purposes. As household surveys provide a cross-sectional picture of child illness (e.g., fever and diarrhea) and associated care seeking, survey data may reflect seasonal spikes if the data were collected during peak times. Data from HMIS can provide more frequent snapshots of care seeking and can help to contextualize indicators from household surveys conducted during a specific time period. Thus, it is critical to identify the period during which household survey data are collected and compare that with monthly HMIS data over several years. Environmental factors such as natural disasters should also be considered when examining long-term trends. Given the frequency of their data collection, HMIS may be better suited to demonstrate the impact of these natural disasters on health needs over time.

3.2 Assess Data Quality and Other Concerns

Considerations related to the quality of HMIS data, completeness in reporting, biases, timing of data collection, and definitions of the indicators themselves are important to keep in mind when triangulating between different sources and indicators.

3.2.1 Quality and accuracy of data

All data sources have limitations in data quality. The extent to which these limitations impact the ability to use the data to draw reliable conclusions should be assessed before beginning any triangulation exercise. Although assessing the quality of HMIS data is not the focus of this report, the quality of HMIS data is a

substantial concern in many LMICs as these systems are still under development and under-resourced (Countdown to 2015 & Health Metrics Network 2011). In over-burdened resource settings, challenges to obtaining and maintaining high-quality data have been noted (Mbondji et al. 2014). For example, where the cost of electronic systems is prohibitive, paper records must be maintained, and data from these registers must be transcribed into summary forms and electronic systems, which can introduce errors (WHO 2018a). The WHO and collaborating organizations have developed a comprehensive toolkit to assess the quality of HMIS data (WHO 2017). Briefly, the WHO documents several areas that can be used to evaluate data quality:

Completeness and timeliness

The information gleaned from HMIS data represents only the facilities or service delivery among the facilities that report to the system. In many countries, only public facilities are required to report; however, private facilities may play an important role in delivering care. Master facility lists, if maintained and inclusive of all health facilities, can be used to identify the distribution of facilities by managing authority and type of facility. Additionally, household survey data can be used to better understand reliance on facilities outside the public sector, including private-sector facilities or informal markets such as pharmacies, or traditional medicine.

Among the facilities that are required to report to HMIS, the completeness of reporting is another consideration. Experts from Track20 and research conducted by Maina et al. (2017) concur that to assess trends, at least 80% of facilities must have reported consistently for at least 3 years. Additional measures of completeness are discussed in the Data Quality Review Toolkit (WHO 2019c). Timeliness refers to whether reports are submitted in proper accordance with established deadlines.

Internal consistency

Internal consistency can be assessed by examining trends over time and identifying, exploring, and correcting outliers as needed (Maina et al. 2017). The WHO suggests comparing related indicators that should produce similar coverage estimates, for example first antenatal visit and one dose of intermittent preventive treatment in pregnancy (IPTp) or tetanus toxoid.

External consistency with other data sources

We touch on comparisons between HMIS and household sources in each chapter in more detail, although the purpose is to compare trends in overlapping coverage estimates to better contextualize DHS outcomes. Triangulation exercises can compare coverage estimates for comparable indicators as calculated from different sources in order to inform data quality (WHO 2017).

External comparison with population data

Determining external consistency with population data involves calculating indicators based on denominators originating from different data sources (WHO 2017).

In addition, calculating indicators of quality of mortality or morbidity data may include assessing the proportion of cases that are assigned “garbage” or “junk” codes, in which the cause of death or illness is not well-defined or is recorded as undetermined or unknown (WHO 2019b). High proportions of junk

codes, unavailability of medical diagnoses, or inadequate death certification by physicians are indicators of poor quality.

3.2.2 Biases

Biases inherent to each data source may influence estimates. In DHS data, report of care during the prenatal, intrapartum, and postnatal period is subject to recall bias (Liu et al. 2013; McCarthy et al. 2016; Stanton et al. 2013). HMIS are biased toward the population who seek care in public facilities. That is, not all women in need seek antenatal, delivery, or postpartum care at facilities. Therefore, not all illnesses, morbidities, or deaths are captured; the cases that are included are not necessarily representative of all who suffer the illness or death. For example, in some contexts, women are encouraged to attend a facility for delivery only if they have a known complication (Magoma et al. 2010), potentially inflating estimates of morbidity and mortality based on HMIS data alone. On the other hand, geographic and financial barriers to care impede care seeking; accordingly, HMIS include only those who attend facilities. Thus, HMIS contain a biased sample of those who have greater access to care or an established need for care. Further, there may be important differences among populations who access public facilities (typically captured by HMIS) and those who use private facilities or community health workers, discussed more in the next section.

3.2.3 Discrepancies in calculating indicators

For many indicators, HMIS data are well-served as numerators, but not denominators, in equations to calculate population coverage of interventions. The numerator can be defined as the number of individuals in need of a service who received the intervention or service. However, for some indicators, such as those capturing interventions delivered in both facility and community-based settings (e.g., vaccinations), the numerator may over-count those who received a service (Munos et al. 2017). More problematic—and a perennial challenge to using routine health data—is the identification of the target population, or the number of individuals who need the service, which is the denominator in the equation. HMIS typically track information such as the number of individuals receiving a specific treatment. Yet, because the information is based only on those who attend facilities, there is no way to know exactly how many individuals were in need of that service. Thus, it is difficult to precisely capture disease incidence or coverage of an intervention. Notwithstanding this issue, facility-based denominators can be used to provide perspective about the quality of care received among those who attend facilities (MCSP 2018).

Population estimates—often based on census data and adjusted for annual population growth rates—may be used to estimate a denominator (WHO 2018a). However, the more time that has passed since the last census, the less accurate the estimate. In weak systems, population counts may also face methodological challenges that can contribute to inaccurate estimates. Urbanization and migration continue to impact population size estimates but may not be accurately accounted for in the estimates. Another approach to estimating denominators for HMIS indicator calculation is to use the numerator, or the number of clients attending a facility for a specific service, from an indicator for which near universal coverage is expected. For example, if nearly all women (95%) attend at least one antenatal care visit for a given pregnancy, the number of women attending a first visit can be used as a denominator for pregnancy-related indicators (WHO 2018a, 2019b). This calculation also requires confidence in estimates of nearly universal coverage, which may be inferred from the most recent household survey estimates.

When calculating indicators from either source, it is also important to consider issues that may affect the numerator or denominator, including the reference periods for the indicator, and the ways in which they have changed or differ between the two sources. For indicators that combine HMIS data for the numerators and population estimates for the denominators, it is important to consider whether the population estimates have been updated according to recent census or estimate projections. For instance, the United Nations Department of Economic and Social Affairs (UN DESA), Population Division (UN DESA 2019), also produces modeled estimates of population size annually. For household data, it is equally important to examine whether any filters that may impact the denominator have been modified according to DHS estimates. Considerations should be made for whether or not the indicators are truly capturing the same phenomenon and whether or not indicators from different sources are comparable. It is also important to consider the time period in which an indicator is measured. For example, mortality estimates based on household survey data may be calculated using a reference period of several years, and institutional mortality estimates may be cacluated annually. Likewise, intervention-related indicators using HMIS data may reflect interventions provided on a monthly basis.

Although HMIS data reflect more frequent data captures at lower administrative units than household survey data, there are additional challenges to obtaining subnational denominator estimates (Maina et al. 2017). Within-country care seeking is not always confined by government-imposed regional or subregional boundaries, and estimating the precise population in need becomes more difficult at lower levels. Thus, coverage estimates may be impossibly high (more than 100%)—statistically speaking—or unrealistically low (Maina et al. 2017). Although proportionate coverage cannot mathematically exceed 100%, people may cross administrative boundaries to use services in neighboring areas, which would inflate the coverage; on the other hand, the use of inaccurate or changing population estimates may result in estimates that are too low (WHO 2019b).

3.3 Consider Other Determinants

Finally, outcomes such as fertility, mortality, and wasting are influenced by several factors, not all of which can be assessed by health sector data from both DHS and HMIS sources. Interventions may be delivered through channels within the health sector, but within the community rather than at the facility level, making them less likely to be captured by HMIS platforms. Further, Bishai et al. (2016) document that the health sector accounts for only 50% of the reduction in maternal and child mortality over time, with the remaining 50% stemming from changes in gross domestic product, education, gender equity, or other non-health sector factors. Thus, incorporating contextual information, such as environmental factors including natural disasters or conflict, can also inform estimates.

4 FERTILITY

This chapter reviews the outcome of fertility and the proximate determinants of fertility. We include a discussion about the data sources used to calculate both the outcome and the determinants and how triangulating from multiple data sources, specifically from HMIS, can inform our understanding of fertility. The information drawn from HMIS data may help to further contextualize our understanding of fertility, by examining different types of indicators related to contraceptive use and other factors detailed below.

4.1 Fertility Definition and Data Sources

Total fertility rate (TFR), defined in Box 4.1, is expressed as the number of children per woman. TFR is directly calculated as the sum of age-specific fertility rates (usually referring to women age 15-49), or five times the sum if data are given in 5-year age groups. An age- or age-group–specific fertility rate is calculated as the ratio of annual births to women at a given age or age group to the population of women at the same age or age group, in the same year, for a given country, territory, or geographic area. Population data from the United Nations correspond to mid-year estimated values, obtained by linear interpolation from the corresponding United Nations fertility medium-variant quinquennial population projections.

Box 4.1 Definition of total fertility rate

Total fertility rate: The average number of births a woman would have at the end of her reproductive period if she survived throughout the reproductive years and were to bear children at certain age-specific fertility rates (Bongaarts 1978).

Data for calculating fertility rates usually come from three sources: CRVS, population censuses, and sample surveys. Although civil registration systems, via birth registration data, are considered the best source for fertility data, these systems are strongest in higher and middle income countries and less complete, timely, and of good quality in lower income countries, according to a metric developed by (Phillips, Adair, and Lopez 2018). Many countries rely on censuses and household surveys for fertility estimation. Although civil registration systems allow annual estimation, fertility data based on census data and household survey data are only available when a census or household survey is conducted. Household surveys usually include retrospective birth histories, so TFR can be calculated using the histories for the 3 years before the survey. Census surveys usually use a 10-year interval.

4.2 Proximate Determinants of Fertility

According to Bongaarts' model of proximate determinants of fertility, the observed TFR in a population is a result of the effects of several proximate determinates on humans' potential fecundity rate (Bongaarts 1982). These proximate determinants include sexual exposure, contraception, abortion, and postpartum infecundity. An index can be calculated for each determinant to measure its effect on fertility, ranging from 0 (no inhibiting effect) to 1 (the maximum inhibiting effect). The total effects of the determinants on fertility can be expressed in an equation as follows:

$$TFR = C_m C_c C_i C_a \, TF$$

where
TFR = Observed total fertility rate
C_m = Marriage index
C_c = Contraception index
C_i = Postpartum infecundability index
C_a = Abortion index
TF = Total fecundity rate.

- **The marriage index** used to refer to the proportion of women in union with an assumption that only women in union are at risk of childbearing (Bongaarts 1978). However, this assumption has become less justifiable as sexual activity has become more common outside of formal marriages or consensual unions. Therefore, is also necessary to consider unmarried women who are exposed to sexual activity. In a revised fertility model, Bongaarts suggests that the estimation of the marriage index should include both married women (or women in union) and unmarried women who are sexually active, pregnant, using contraception, or postpartum infecund (Bongaarts 2015).

- **The contraception index** has increasingly become an important determinant of fertility because of the global prevalence of family planning programs. The effect of contraceptive use on fertility varies by contraceptive methods due to differences in their effectiveness. The effectiveness of a method also varies by age; therefore, an age-specific proximate model is recommended to examine the effects of contraception on fertility (Bongaarts 2015).

- **The postpartum infecundity index** refers to the period following a birth during which a woman cannot conceive due to postpartum abstinence or postpartum amenorrhea. This period is affected by the duration and frequency of breastfeeding. It can vary from 1.5 months in the absence of breastfeeding to 2 years if the mother breastfeeds (Bongaarts 1978).

- **The abortion index** refers to deliberate interruptions of normal gestation (Bongaarts 1978). The number of births averted by induced abortion is largely determined by contraceptive use after abortion; a refined approach for estimating the abortion index was suggested by Bongaarts and Westoff (2000).

4.3 Sources and Availability of Data for Proximate Determinants of Fertility

Examining changes in proximate determinants help to understand changes in fertility. Multiple sources of data, including DHS surveys, SPA surveys, and routine health facility data (from HMIS or LMIS) provide information on these proximate determinants (Table 4.1).

Table 4.1 Summary of data sources for capturing proximate determinants of fertility

Risk factor/Intervention	DHS	SPA	Routine health facility data
Sexual exposure	Yes	No	No
Contraceptive prevalence	Yes	No	Yes
Abortion	Country-specific	Country-specific	Country-specific
Postpartum fecundity	Yes	No	No

4.3.1 How do household and periodic health facility surveys capture data on proximate determinants of fertility?

Table 4.1 lists the proximate determinants of fertility that can be assessed using household and periodic health facility data. Household surveys such as DHS surveys (including their predecessors—World Fertility Surveys and Contraceptive Prevalence Surveys), MICS, and Performance Monitoring for Action surveys (household surveys focused on family planning),[5] as well as some national household surveys, ask women about their marriage or union statuses, their recent exposure to sexual activities (timing of the last sex), and their current use of contraceptive methods. These data provide information about sexual exposure and contraceptive prevalence. In household surveys, data on abortion are not as commonly collected as data on sexual exposure and contraception, especially where abortion is considered illegal. Where abortion data are collected, data quality can be a concern if women are reluctant to report abortions because of social stigma (Singh et al. 2019). Postpartum fecundity could also be determined in household surveys based on women's self-reported duration. Health facility sample surveys or censuses may collect information on provision and quality of family planning services or abortion services, as well as counseling on breastfeeding. However, they do not collect data that can be directly used to assess changes in the proximate determinants of fertility.

4.3.2 How do HMIS capture data on proximate determinants of fertility and other relevant data?

Although DHS surveys or other household surveys provide data for almost all proximate determinants of fertility, their high cost and infrequency limit a country's ability to assess these determinants and interventions more frequently or in real time. Service statistics collected in HMIS, especially those on family planning, can help to fill this gap. These data could be used to complement survey data in assessing changes in the contraception determinant, therefore helping to explain changes in fertility.

Routine health facility data can be used to approximate contraceptive prevalence (Table 4.1); however, contraceptive prevalence calculated from this source alone is subject to several biases, which can be addressed by the tools described in section 4.4. In settings where abortion is legal and reliable routine health facility data on post-abortion care are available, it is possible to estimate abortion rates from post-abortion care data with adjustments. Methods have also been developed to estimate abortion rates with health facility survey data (Singh et al. 2019).

The WHO recommends two indicators for measuring and monitoring reproductive health programs: contraceptive first-time users and postpartum family planning acceptors (WHO 2019c). Tracking the number of contraceptive first-time users over time can provide information about contraceptive needs or issues in contraceptive supply or access. The WHO recommends also examining this indicator by age group and sex. However, gender information about family planning clients is not commonly collected in HMIS. Further, it is important to note that global family planning indicators are only calculated among women. The second recommended indicator measures the percentage of postpartum women delivering in facilities who initiate a contraceptive method before discharge. It could be used to assess the performance of postpartum counseling in increasing contraceptive use. Comparisons could be made by method type and

[5] More information on Performance Monitoring for Action can be found here: https://www.pmadata.org/.

geographical location. Despite the usefulness of both indicators, neither can be used to assess any of the four proximate determinants of fertility.

4.4 Contextualizing Survey-based Estimates of Fertility with HMIS Data for Contraceptive Use

Because service statistics should not be used alone to calculate indicators reflecting contraceptive use, methods have been developed to combine routine health data with other data to create projections of contraceptive use that correct for biases. The Track20 Project assessed how well three components (volume indicators) commonly reported in family planning service statistics in Family Planning 2020 could approximate levels and trends in modern contraceptive prevalence (rate).[6] These three components were commodities distributed to clients, service visits, and current users (Magnani et al. 2018; Skiles et al. 2015; Tin, Williamson, and Sonneveldt 2019), defined in Box 4.2. Although service visits and new users can be tracked through HMIS, commodities distributed can be tracked through either HMIS or LMIS, depending on each country's unique systems.

Box 4.2 Common service statistics indicators on contraceptive use

1. **Family planning commodities or services distributed to clients:** This measures the number of commodities or services delivered to clients (e.g., the number of pill cycles, injections, intrauterine devices, or female and male sterilizations).
2. **Service visits:** The number of times clients visited a provider for contraceptive services. Method refills may account for multiple visits by one client. This needs to be considered when converting service visits to number of contraceptive users.
3. **Current users:** The number of people who currently use a contraceptive method, including those who use a method received previously. The calculation of this indicator is not straightforward and can be challenging for reasons such as double counting of clients and inaccurate tracking of method discontinuation.

The service statistics (SS) to estimated modern use (EMU) tool can be used to triangulate routine health facility data and to complement a country's understanding of contraceptive use. The SS to EMU tool was developed by Track20—a project charged with monitoring progress toward the goals of the Family Planning 2020 initiative, in order to convert family planning volume indicators into EMU and make necessary adjustments (Magnani et al. 2018). For example, use of private sectors for family planning services is not always represented in service statistics. Estimates need to be adjusted to consider the private-sector share of the family planning market. The adjustment factor could be calculated using data from household surveys that collect information on the source of contraception methods.

Converting service statistics to EMU has heretofore required the use of the SS to EMU tool in Microsoft Excel; however, Track20 is developing and launching an application for DHIS-2 called the Family Planning Module.7 It is an application that can be added to and embedded within the DHIS-2 platform. Thus, it is directly linked to routine service statistics data. The tool converts the service statistics data to track the

[6] Although modern contraceptive prevalence is commonly referred to as a rate, it is defined as the percentage of women of reproductive age who are using modern contraception; as this indicator does not include a unit of time, it is a ratio and not a rate.
[7] More information on the Family Planning Module for Track20's DHIS-2 can be found at the following URL: http://www.track20.org/pages/about_us/hmis.php.

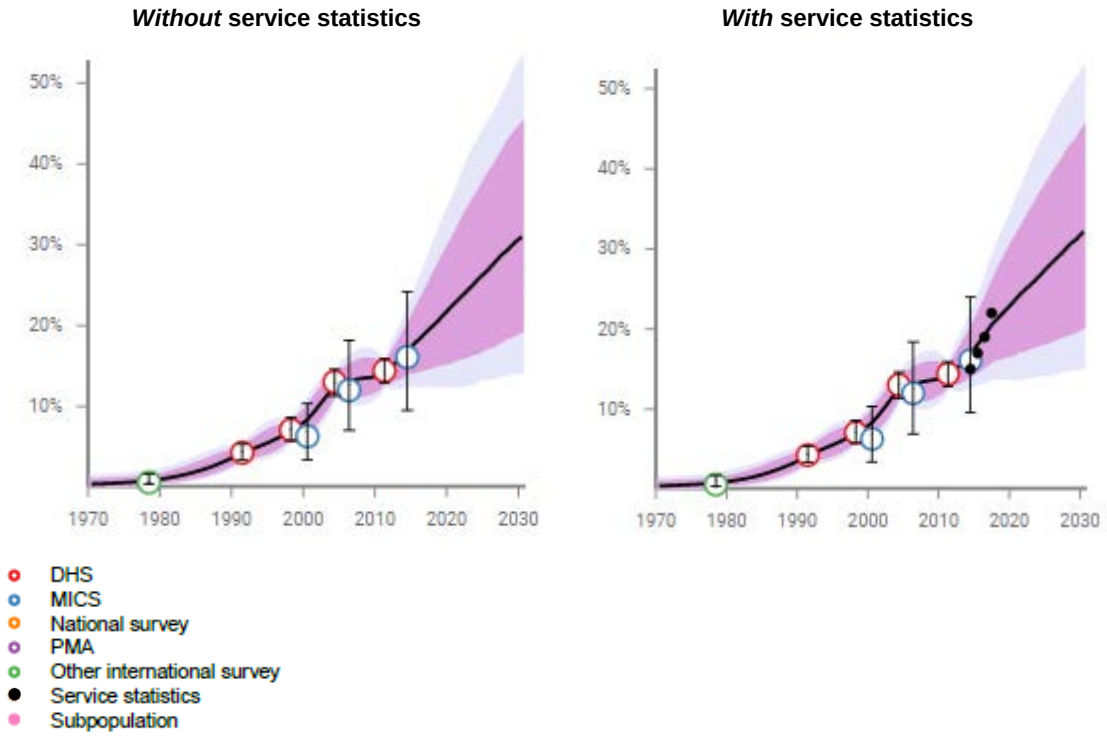
progress of family planning services within HMIS in several ways. First, the tool digitizes "SS to EMU" estimates within the platform and incorporates monthly EMU estimates; thus, it reflects more frequent estimates that may be used to contextualize DHS estimates. Additionally, the tool can analyze data, benchmark against external data, and examine quality. It has the capacity to analyze data at aggregate levels and at the facility level. Converting service statistics to EMU provides another vantage point for examining contraceptive use within a given country, which may provide additional context about fertility in that country.

Another option to explore for a better understanding of contraceptive use in a country is the FPET—a tool that integrates multiple sources of data. Magnani et al. (2018) compared the EMU estimates with the survey-based world population estimates of contraceptive prevalence. They found that the three measures of EMU poorly approximated levels of contraceptive prevalence but were useful for tracking trends in modern contraceptive prevalence. Based on these findings, the authors recommended to not use service statistics data alone to estimate modern contraceptive prevalence, but rather incorporate them to estimate past trends and future levels of family planning indicators following a national survey. This approach has been applied in all Family Planning 2020 countries to produce annual estimates of contraceptive prevalence, and the tool is updated as new survey data are released.

An important benefit of including service statistics data in the FPET is that it improves the precision of the estimates when survey data are not available to catch recent dramatic changes in use of services. Figure 4.1 shows contraceptive prevalence estimates (black lines), both without and with service statistics data included. In the version with the service statistics included (on the right), narrower uncertainty ranges (95% confidence interval in grey and 80% confidence interval in purple) are seen than in the version without service statistics data (left), especially in the years immediately following the most recent household survey. The open circles along the lines are data points from surveys (DHS surveys in red, MICS in blue, and others in green).

When using EMU based on service statistics data in FPET to predict future family planning indicators, several considerations should be taken into account in addition to those discussed in Chapter 3 (i.e., at least 80% completeness for 3 years and data that are of consistent high quality and comparable over time). These include the type of national family planning statistics available (e.g., on commodities, visits, and users), which may impact contraceptive prevalence estimates. Additionally, considerations should be made as to whether the data generally appear to align with the country's family planning efforts. For example, as new methods are introduced, service statistics data will reflect whether recent program efforts have expanded use of these new methods.

Figure 4.1 Estimates of modern contraceptive prevalence using the Family Planning Estimation Tool



Source: http://track20.org/download/pdf/FPET_Overview_2019_Eng.pdf

4.5 Considerations for Contextualizing Survey-based Estimates of Fertility

This section describes additional considerations when triangulating with HMIS or LMIS and survey-based estimates of fertility.

4.5.1 Contraceptive use may not inversely align with fertility

As discussed in Chapter 3, when contextualizing outcomes such as fertility, it is important to triangulate with multiple indicators. That is, an inverse relationship between contraceptive use and fertility is not always seen. As discussed, HMIS do not provide data for most proximate determinants of fertility. Although approximate measures of contraceptive prevalence based on service statistics can be used to monitor and evaluate family planning programs, they are limited in understanding fertility changes, as the relationships between contraceptive use and fertility differ by country and geographic region. Although an inverse relationship between contraceptive use and fertility has been documented in some instances (Mauldin and Segal 1988; Tsui 2001), the relationship is not universal (Bongaarts 2017; Choi, Fabic, and Adetunji 2018; Westoff and Bankole 2001). Moreover, service statistics data do not capture the use of traditional methods, but their role in shaping fertility is not negligible in regions where the prevalence of traditional contraceptive use is high (Rossier and Corker 2017).

The mathematical impact of contraceptive use during the postpartum period is not necessarily well-accounted for in Bongaarts' proximate determinants model. As contraceptive use increases in the

postpartum period, there is "double counting" of women in Bongaarts' original model. Many of these women are not susceptible to pregnancy (given lactational amenorrhea and postpartum abstinence), so contraceptive prevalence may rise but fertility may remain unchanged (Bongaarts 2017). Additionally, lactational amenorrhea, which requires adherence to specific guidelines around breastfeeding, is considered modern contraception, further complicating and contributing to overlap in the model. Bongaarts has acknowledged this limitation and developed a revised model that accounts for this (Bongaarts 2015).

Thus, an understanding of what contraceptive uptake is during this time period, and how that is changing over time, can improve understanding of fertility and fertility intentions. Future research could examine in more depth how postpartum family planning use impacts fertility and intentions (i.e., whether contraceptive use during this time is meeting women's needs for birth spacing, limiting their total number of births, or both). Currently, data on postpartum use are not widely collected; however, the Rwanda HMIS has debuted new data elements to address this area. As systems evolve, examining postpartum family planning use according to HMIS data could help elucidate these issues.

Finally, the lack of a consistent relationship between contraceptive prevalence and TFR could be attributed to differences in the way the indicators are measured (Choi, Fabic, and Adetunji 2018). Contraceptive prevalence is a point-in-time, cross-sectional measure of current use of contraception among interviewed women of reproductive age. On the other hand, TFR is calculated using a synthetic cohort approach and combines birth histories of cohorts of women for the 3 years preceding the survey. As such, changes in contraceptive use will not be immediately reflected in TFR (Bongaarts 2017). Further, TFR is an age-adjusted measure while contraceptive prevalence is not. Differences in the age distribution of contraceptive users could yield different impacts on fertility; that is, TFR would be higher than expected given contraceptive prevalence in a country if contraceptive use is skewed toward older women with less fecundity (Choi, Fabic, and Adetunji 2018).

4.5.2 Other relevant information about contraception may also inform fertility

Examining the combination of methods used or distributed, couple years of protection (CYP), and stock outs could provide insight about susceptibility to pregnancy—intended or unintended—and expected trends.

Method mix and stock outs

Information about the method mix, gathered through commodities distributed and ascertained through either HMIS or LMIS databases depending on the country, can be used for triangulation to understand trends in fertility. For example, examining trends in method mix has shown an increase in reliance on less effective methods (Bertrand et al. 2014). The availability of methods, which can be understood in more depth by examining data around contraceptive stock outs, influences decisions about methods. Contraceptive stock-out data collected in LMIS inform about family planning commodities and services that are available to users. The Reproductive Health Supplies Coalition suggested four categories of indicators that can be measured with the LMIS stock-out data: methods offered, point-in-time stock outs, range of methods available, and frequency and duration of stock outs over time (Reproductive Health Supplies Coalition 2015). Taken together with method mix (if method mix is skewed toward short-acting methods and stock outs of these methods are common or widespread), unintended pregnancy may contribute to TFR.

Couple years of protection

Another indicator that is commonly calculated based on routine health facility data is CYP. This is defined as the estimated protection provided by family planning services based upon the volume of all contraceptive methods delivered to women of reproductive age, including male condoms and male sterilization. It is calculated by summing up the duration of protection provided by each method, which is the product of the quantity of each method distributed and a method-specific conversion factor. The conversion factor takes into account method failure, discontinuation, and wastage. CYP provides information on the coverage, but not actual use, of contraceptive services. It is relatively simple to calculate based on commodity data routinely collected in the LMIS or HMIS. CYP allows programs to compare coverage by contraceptive methods.[8]

4.5.3 Other determinants may provide additional context

Proximate determinants in addition to contraception also contribute to changes in fertility, and sometimes the effects of these determinants can be counterbalanced. Determinants including exposure to pregnancy, postpartum insusceptibility, contraceptive effectiveness, frequency of intercourse, and biological infecundity differ across countries (Bongaarts 2017). In the late 1990s, a contradictory relationship was observed in Bangladesh between contraceptive prevalence and fertility: contraceptive prevalence increased but fertility remained stable. Analyzing DHS data and data from the Matlab Demographic Surveillance System revealed that reduced breastfeeding and increased use of ineffective contraceptive methods might explain the inconsistent relationship between contraceptive use and fertility (Rani, Bonu, and Harvey 2007).

In contrast, Nepal observed a stagnant contraceptive prevalence but a great reduction in fertility rate between 2001 and 2016. One important contributor was women's reduced exposure to sexual activities, therefore reduced risk to pregnancy, due to spousal separation associated with the enormous international migration in Nepal (Fabic and Becker 2017). In 2016, more than one-third of women reported that their husbands were living away from home. As illustrated in the fertility proximate determinants model, women achieve their fertility desires in various ways. Kenya and Ghana have similar fertility, but contraceptive prevalence is much lower in Ghana than in Kenya (Askew, Maggwa, and Obare 2017). Studies found that Ghanaian women, especially highly educated ones, opt for a combination of traditional methods, reduced coital frequency, and abortion to regulate their childbearing because of health concerns associated with hormonal methods (Machiyama and Cleland 2014).

In addition to these proximate determinants, cultural, psychological, economic, social, health, and environmental factors also affect fertility, often through the four proximate determinants. For example, a study based on DHS data in 21 sub-Saharan African countries found that a higher socioeconomic status is associated with a more rapid decline of fertility because of delayed marriage and greater use of modern contraception (Finlay, Mejía-Guevara, and Akachi 2018). The authors found that fertility declined slowly among the poorest and that postpartum infecundability was an important factor behind their fertility change. Social norms can also play an important role in shaping fertility. Although the demographic transition experienced by East Asian countries is a result of economic development, it is also substantially influenced by the social norms associated with Confucianism—the unequal gender division of childcare and the stigma

[8] The Track20 project provides a tool that furnishes conversion rates and calculates CYP. It can be accessed online here: http://www.track20.org/pages/resources/track20_tools.php

attached to out-of-wedlock births. Researchers found that these norms drive the unique marriage and fertility patterns in these countries—low fertility rates accompanied by high marriage rates (Myong, Park, and Yi 2018).

4.6 Recommendations for Contextualizing Survey-based Estimates of Fertility

In summary, we recommend the following steps to better contextualize fertility estimates when estimates are higher or lower than expected, including triangulating with data from routine health facility information systems to inform the context of contraceptive use. However, factors not captured by routine health systems, including other proximate determinants, should also be examined to gain a more robust understanding of fertility estimates.

4.6.1 Examine contraceptive prevalence from other vantage points

Measures of contraceptive use can be derived from both household survey data and routine health facility data. The EMU based on service statistics can be used to assess the quality of service statistics by comparing the trends of EMU alongside contraceptive prevalence from survey data. Although EMU estimates based on service statistics are not expected to be the same as contraceptive prevalence estimated from household surveys, their trends should align during the same time period. Such comparisons could provide insights about the quality of service statistics, which is important to consider before incorporating service statistics into the FPET.

Standard or modeled estimates of contraceptive prevalence, however, do not take into account the age structure of women of reproductive age; thus, it is possible to calculate measures of contraceptive prevalence weighted by age (Bongaarts 2017; Choi, Fabic, and Adetunji 2018). Research has also shown that age-adjusted measures of contraceptive use may inform fertility better than unadjusted measures of contraceptive use (Choi, Fabic, and Adetunji 2018). As older women represent an increasing share of contraceptive users, age-adjusted measures of contraceptive use account for different fertility risks among different age groups of women using modern contraception (Choi, Fabic, and Adetunji 2018).

4.6.2 Examine modeled projections of contraceptive prevalence using multiple data sources

Based on the differences between calculating EMU and calculating contraceptive prevalence, it has been recommended that service statistics should not be used alone to directly estimate contraceptive prevalence. Rather, EMU can be used in FPET along with data from household surveys to estimate family planning indicators. Inclusion of high-quality service statistics in the FPET improves the precision of estimates when survey data are not yet available. FPET can also be used to estimate unmet need and demand satisfied, which can provide additional context.

4.6.3 Explore additional contextualizing information available in HMIS or LMIS

HMIS provide other information that may improve understanding of fertility, such as the potential for unintended pregnancy if there is a reliance on short-term methods combined with frequent stock outs and, thus, susceptibility to pregnancy. Data on method mix, CYP, and stock outs can help shed light on these

factors. Our recommendation for future research is to go a step beyond considering the role of contraceptive use in estimates of TFR by examining other related factors.

4.6.4 Consider other proximate determinants of fertility

Although HMIS data can be helpful when approximating contraceptive use, contraceptive use is only one determinant of fertility. Other determinants should be taken into account to understand fertility. Changes in exposure to sex, switches to ineffective methods or traditional methods, abortion, and breastfeeding practices can all contribute to changes in fertility. This information can also be used to triangulate with DHS calendar data related to pregnancy terminations. The role of postpartum family planning use as it relates to postpartum infecundity and contraceptive use within a framework of proximate determinants should be further examined.

5 MATERNAL MORTALITY, MORBIDITY, AND RELATED INTERVENTIONS

Routine health facility data can help broaden our understanding of the context of maternal mortality in a given country when examined alongside DHS data. Specifically, HMIS data can provide insight into (a) mortality and causes of death, (b) information about morbidity, (c) availability and readiness of facilities, and (d) delivery of preventive or curative interventions. This chapter describes what can be ascertained and what limitations exist in the capacity to inform both household survey trends in maternal mortality and the broader health system. Our summary of availability of information in HMIS draws largely from efforts by MCSP. Recently, MCSP documented the data elements that are available in 24 LMICs for maternal and newborn health (MCSP 2018).

5.1 Maternal Mortality Definition and Data Sources

5.1.1 Maternal mortality definition

Maternal mortality is a leading cause of death among women of reproductive age in developing countries, although the majority of these deaths are preventable. Box 5.1 defines common terms used to describe maternal mortality.

Box 5.1 Population-based maternal mortality terms and definitions

Maternal death: Death of a woman who is pregnant or is within 42 days of giving birth or terminating the pregnancy, including causes related to the pregnancy or its management but not to accident, injury, or other unrelated causes.

Pregnancy-related death: Death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death.

Maternal mortality ratio: The number of pregnancy-related or maternal deaths in a given time period per 100,000 live births in the same time period.

Pregnancy-related mortality ratio: The number of pregnancy-related deaths per 100,000 live births.

Source: WHO (2010)

5.1.2 Data sources

Various data sources used to calculate population-based maternal mortality ratios (MMRs) include CRVS, population-based household surveys, RAMOS, confidential enquires into maternal deaths, censuses, and other national maternal mortality or verbal autopsy studies (WHO et al. 2019). Although data from complete and functional CRVS systems are ideal (WHO et al. 2019), household surveys are often a key source of maternal mortality estimates. HMIS data can be used to calculate institutional maternal mortality and inform the cause of death structure.

Household surveys such as DHS surveys and MICS historically defined maternal mortality as death during pregnancy or within 42 days thereafter; however, these surveys have recently adapted a more precise definition of maternal mortality to exclude causes not related to the pregnancy itself, such as accidents or violence. The previous indicator is now appropriately called the *pregnancy-related* mortality ratio (PRMR).

Therefore, only trends in PRMR can be calculated until more surveys are conducted, and comparisons between the two indicators should be made with the understanding of the differing definitions. A common period used to calculate both MMR and PRMR is the 7 years preceding the survey.

5.1.3 How do household surveys capture maternal mortality?

The DHS Program and MICS use the sisterhood method, which asks respondents to list their siblings and survival statuses. If a female sibling died at age 12 or older, the respondent is asked a series of questions to determine if it was a maternal death. In DHS surveys prior to DHS-7 (finalized in 2015), respondents were asked only if the sister died during pregnancy, childbirth, or within the 2 months after delivery. Following the 2015 update, respondents were prompted further to determine whether the death was within 42 days and if the death was accidental or due to violence.

5.1.4 How do HMIS capture maternal mortality?

HMIS data may be used as a subsitute where deaths are adequately reported and certified by physicians (WHO 2019c). Institutional maternal mortality (Box 5.2) may include women delivering in a facility as well as women who delivered outside of the facility but who were admitted after delivery. Institutional maternal mortality after birth and prior to discharge can help inform the quality of care provided by the health system.

Several core mortality indicators can be examined (WHO 2019c, 2019a). For maternal mortality, these are number of deaths, MMR, and cause of death. Each provides information that could lead to additional understanding of maternal mortality in a country when examined alongside survey estimates.

Box 5.2 Health facility-based maternal mortality terms and definitions

Maternal death in a health facility: Death of a woman in the health facility, either while pregnant or within the first 42 days after the end of pregnancy. This can include a woman who gave birth outside the health facility but died inside the facility.

Institutional maternal mortality ratio: The number of maternal deaths in a health facility per 1,000 admissions during the same time period (WHO 2019a).

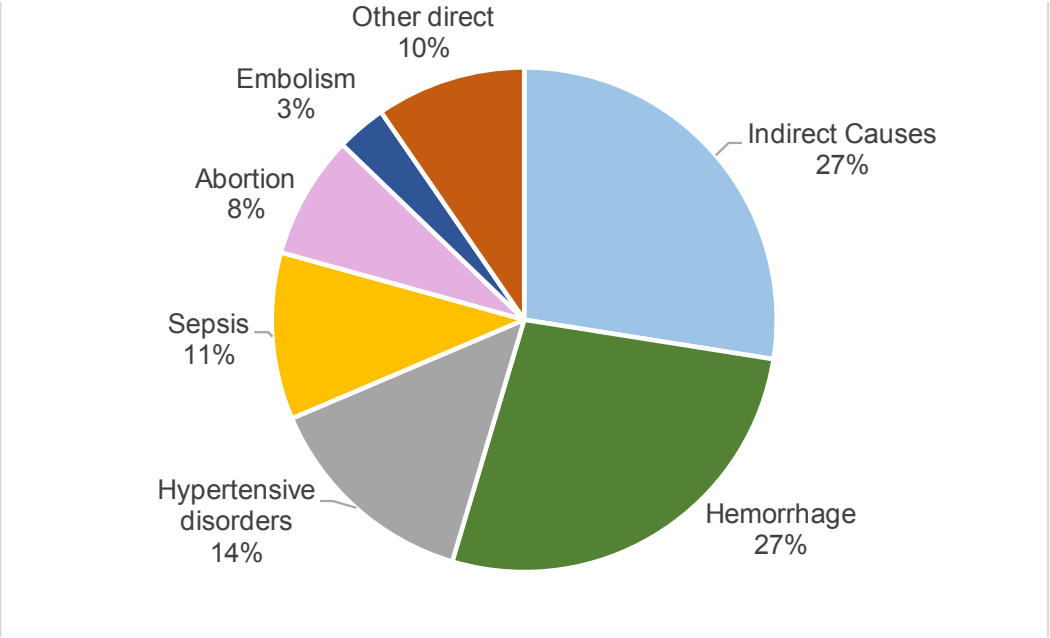
Estimates and trends in institutional deaths can be examined as a stand-alone indicator. As maternal mortality is rare, the WHO recommends that HMIS present the number of deaths rather than the ratio (WHO 2019c, 2019a). The Quality of Care Network suggests that an indicator for number of maternal deaths be limited to pre-discharge deaths only, as a means of understanding the process or quality of care in facilities, especially when disaggregated by cause of death (WHO 2019e).

5.2 Causes of Maternal Mortality

Nearly half of all maternal deaths occur during labor, during delivery, or in the first day after giving birth, and the majority occur within the first week (Li et al. 1996; Ronsmans, Graham, and Lancet Maternal Survival Series Steering Group 2006). Figure 5.1 shows the causes of maternal deaths. The direct causes of maternal mortality include abortive causes, pre-eclampsia and eclampsia, hemorrhage, sepsis, and other complications from delivery (Say et al. 2014), which account for the majority of maternal deaths. Approximately one-quarter of maternal deaths have indirect causes, such as HIV/AIDS or non-

communicable diseases that are exacerbated by pregnancy (Say et al. 2014). Say et al. (2014) summarized causes of death globally; however, the authors noted variation across regions.

Figure 5.1 Causes of maternal mortality



Source: Say et al. (2014)

5.2.1 How do household surveys capture the cause of maternal death?

DHS Program provide an option for countries to add optional modules. In phases prior to DHS-7, optional modules included a verbal autopsy, which can be used to better understand causes of death (Croft, Marshall, and Allen 2018). Additionally, several countries have conducted maternal health and mortality-specific surveys. However, special surveys or surveys with these modules are infrequent. Recent examples include the Ghana Maternal Health Survey and the Pakistan Maternal Mortality Survey.

5.2.2 How do HMIS capture the cause of maternal death?

There are opportunities for HMIS to include information about causes of death. If data are accurately reported, overall distribution of the causes, as well as case fatality rates for leading causes, can be ascertained. However, according to an assessment of antenatal care, labor and delivery, and postnatal care registers in HMIS, many countries generally count deaths but do not record diagnoses or causes of death (Creanga et al. 2014; MCSP 2018; Say, Souza, and Pattinson 2009).[9] Furthermore, MCSP (2018) describes that is often difficult to determine timing and cause of death.

[9] This information could have been recorded in separate maternal death registers that were not reviewed.

5.3 Maternal Morbidity

Maternal morbidities include adverse conditions resulting from or aggravated by pregnancy; they can also include "near miss" cases of women who suffered but survived a complication related to pregnancy, childbirth, or the 6 weeks after childbirth (Creanga 2014; Say 2009).

5.3.1 How do household surveys capture maternal morbidity?

In a standard DHS survey, little information is collected related to maternal morbidities. Women who suffer and survive complications during pregnancy, delivery, or the postpartum period are not asked to report on any problems that may have arisen as a result of their pregnancy. However, special surveys such as the Maternal Health Survey do ask about problems arising during labor, during delivery, or after. DHS suveys include measurements of hemogobin concentrations in the blood, which are used to estimate the population-based prevalence of anemia (Pullum et al. 2017).

5.3.2 How do HMIS capture maternal morbidity?

HMIS data can fill a gap in knowledge around maternal morbidity and inform indirect and direct causes of maternal deaths. Under ideal reporting systems, morbidity data from HMIS stem from diagnoses recorded and reported through inpatient discharge records and outpatient records (WHO 2019b). The WHO has proposed indicators that will help countries assess their institutional disease burden, including discharge diagnoses (as rates per population and distribution among cases) and incidence. Of the 24 countries assessed by MCSP, 17 collect information about anemia screening and diagnosis during antenatal care, although treatment is not typically noted according to a review of HMIS systems (MCSP 2018). Typically, for anemia, information on treatment is not collected, but this may change as nutrition-related HMIS systems develop further.

5.4 Interventions and Sources and Availability of Data for Interventions

This section describes key interventions to prevent or treat maternal morbidity and mortality as captured in household surveys, periodic health facility surveys, and routine health facility information systems. The section is organized according to the type of information about the interventions—whether the information represents coverage of an intervention, availability and readiness, or service delivery.

5.4.1 Interventions

Several interventions prevent and reduce maternal mortality. Each of these interventions targets one or more causes—either direct or indirect—and some interventions work to prevent or treat mediating risk factors. Figure 5.2 shows critical, highly effective interventions to prevent or treat the main causes of mortality (Marchant et al. 2016; Pollard, Mathai, and Walker 2013). In addition, contraceptive use and reduced fertility play an important role in reducing maternal mortality (Ahmed et al. 2012; Bishai et al. 2016), although these are not covered in this section.

Figure 5.2 Critical interventions to prevent maternal death

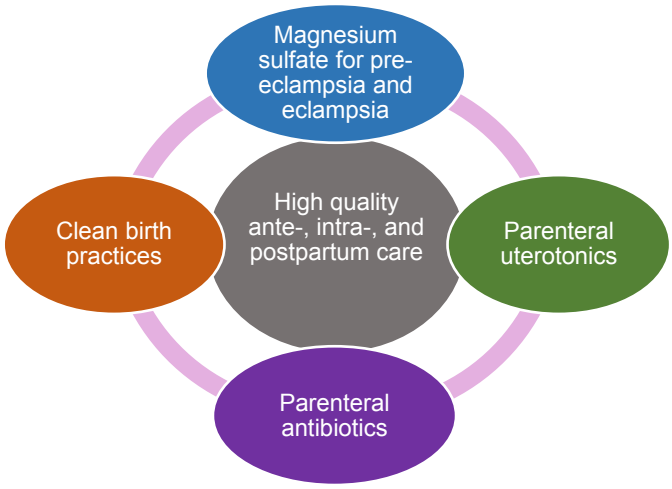


Table 5.1 shows the critical interventions that prevent or relate to maternal mortality. The content is organized by data sources that may capture the indicator, the type of indicator (i.e., coverage, availability/readiness, or service delivery, defined in Box 2.1), and the denominators that can be used to calculate each indicator. Estimates of these interventions can be obtained through household surveys, surveillance sites, program evaluation data or special surveys, and in an ideal setting, routine health facility data. However, the information gleaned from each source varies. For example, for antenatal iron supplementation (an intervention to prevent hemorrhage due to anemia), household surveys collect data about consumption (coverage). SPA data (and data from other health facility surveys) provide information on the availability of commodities in facilities (availability/readiness) as well as on whether providers gave a supplement or prescription during observed antenatal care visits and whether the providers counseled women about aspects of consumption (service delivery).

The interventions in Table 5.1 were chosen for their proven effectiveness at preventing maternal mortality and are also included in the LiST framework. Appendix Figure A.1 demonstrates the pathways between these interventions, intermediate characteristics or risk factors, and cause-specific maternal mortality. Several indicators are excluded from this table, for a few reasons. One important intervention to prevent maternal mortality—birth spacing to avoid high-risk births, which is attained through family planning and contraceptive use—is not included, as it is discussed in Chapter 4. Likewise, the availability of information related to post-abortion care is included in Chapter 4. Blanket iron supplementation/fortification, multiple micronutrient supplementation, and case management of maternal sepsis are also excluded, as no information about these was captured in any source listed. In LiST, indoor residual spraying is also included as an intervention to prevent malaria and related complications; however, due to lack of information this, too, was not included.

Table 5.1 is based on recommended indicators and may not necessarily reflect what is being captured across countries in routine health systems, specifically HMIS and LMIS in this table. Each country is bound to collect and report the indicators that are of high priority to that specific country based on national strategic frameworks. In their assessment of HMIS data elements, MCSP found that, at the time of their report, the availability of these indicators varied across countries (MCSP 2018). For example, only 3 of the 24

countries recorded four doses of IPTp as a unique data point, while four other countries (Ghana, Mozambique, Malawi, and Tanzania) recorded doses 1-4 of IPTp as four separate data points. Kenya, Nigeria, and Uganda each recorded only the first two doses, while Liberia recorded only the first dose. It is important to note that we report on information available at the time it was collected by MCSP. These systems continue to evolve and include more indicators over time.

Table 5.1 Interventions to prevent maternal mortality, potential data sources for indicators, and denominators for indicators

Intervention	DHS	SPA	Recommended for routine health facility data[1]
Antepartum			
Antenatal care	(A)		(G), (H)
Parenteral anticonvulsants		(D)	(I)
Calcium supplementation			(I)
Iron supplementation in pregnancy	(A)	(D)	
		(E)	
Intermittent preventive treatment in pregnancy	(A)	(D)	(G), (H)
		(E)	
Insecticide-treated nets	(B)	(D)	(G), (H)
		(E)	
Tetanus toxoid vaccine	(A)	(D)	(G), (H)
Intra and postpartum			
Facility delivery	(C)		(J)
Cesarean section	(C)	(D)	(J), (K)
Postnatal care for the mother	(A)	(D)	(J), (K)
Hypertensive disorder case management; parenteral anticonvulsants		(D)	(I)
AMTSL (including but not limited to parenteral uterotonics)		(D)	(I)
			(K)
Labor and delivery management (skilled birth attendance)	(C)	(D)	
Parenteral antibiotics		(D)	(I)
Clean birth practices		(D)	
Denominators			
(A) Number of women with a birth in the last 3-5 years,[2] most recent birth			
(B) Number of de facto households and household members, including pregnant women; can calculate both use and possession of nets			
(C) All births in the past 3-5 years[2]			
(D) Number of facilities with relative service			
(E) Number of women observed for antenatal care			
(F) Estimated number of women of reproductive age (census-based)			
(G) Estimated number of pregnancies = total number of births + early pregnancy loss of 10% (censused-based)			
(H) Number of first-visit antenatal clients			
(I) Number of facilities using HMIS/LMIS			
(J) Estimated number of deliveries = number of births – number of twins			
(K) Number of facility deliveries			
(L) Under development			
Coverage; Availability or readiness; Service delivery; Under development; No information			

Note: AMTSL = active management of the third stage of labor; ITN = insecticide-treated nets.

[1] Includes health management information systems and logistics management information systems only.

[2] DHS-7 and prior phases collected maternal health care seeking for most recent pregnancies resulting in a live birth in the past 5 years, with the exception of Bangladesh, where it was the past 3 years. DHS-8 will collect information for maternal health care seeking in the preceding 3 years only and among both live births and stillbirths.

5.4.2 Coverage

As shown in Table 5.1, DHS surveys primarily collect information about coverage of interventions (the percentage of the population in need of a service who receives that service) or services among relative populations. Similar coverage indicators, such as facility delivery, may also be calculated using HMIS data. In this case, the numerator of number of births that were delivered in facilities (as recorded by HMIS) can be divided by the denominator of the total estimated number of births in that same time period. The following four indicators have overlapping coverage in DHS surveys and HMIS:

- Antenatal care
    - In DHS surveys, the number of visits is ascertained to help calculate coverage of any number of antenatal care visits (e.g., one, four, or eight visits)
    - In HMIS, the first antenatal care visit can be calculated, with additional visits possible if patient-level data are included in the HMIS.
- Facility delivery
- Cesarean section
- Postpartum care

The denominators used to create coverage indicators from HMIS can be ascertained through population estimates based on the most recent censuses. Alternatively, if coverage of at least one antenatal care visit is nearly universal, the number of first antenatal care visits can serve as the denominator for number of women in need of antenatal care-related indicators. Adjustment factors can be applied based on estimated pregnancy loss, stillbirths, and twins to calculate intrapartum- and postpartum-related coverage indicators. This process is described in more detail elsewhere (WHO 2018a).

5.4.3 Availability and readiness

Both SPA surveys (and other health facility surveys such as the SARA) and LMIS data can provide information about availability of uterotonics to prevent postpartum hemorrhage, anticonvulsants to treat severe pre-eclampsia or eclampsia, and antibiotics to treat infections—three of the most critical interventions to prevent maternal mortality. LMIS data, through continuous reporting systems, have the additional potential of demonstrating the occurrence and duration of stock outs of these critical medications. However, LMIS data on availability and readiness are not typically tracked in the same digital system or platform as HMIS.

5.4.4 Service delivery

In SPA surveys, a sample of client visits for antenatal care are observed. Data recorded about these visits can inform the provision of care during pregnancy, including provision or prescription of iron supplementation or IPTp, or distribution of insecticide-treated nets (ITNs). Like readiness, these indicators of service provision can be summarized to create an index of quality of care within facilities and aggregated to sample strata or nationally. As opposed to periodic facility surveys, HMIS provide more frequent and

more granular information about provision of critical interventions that can be summarized and triangulated against mortality. For example, increased provision of uterotonics immediately after birth should theoretically yield decreases in mortality related to hemorrhage. The service delivery information available in facility registers that may be included in HMIS provides additional—and sometimes the only—information about provision of care in some settings (MCSP 2018). However, although registers may include information about service delivery (e.g., on specific services or content of care provided during antenatal care), this information isn't necessarily reported in summary forms and aggregated into the HMIS (MCSP 2018).

As this information is vital to understanding the level of care provided at facilities, the WHO recommends that HMIS also report on the provision of certain interventions through HMIS. The prophylactic provision of uterotonics after delivery is one of these indicators, calculated by dividing the number of women who gave birth in a facility who received a prophylactic uterotonic immediately after birth divided by the number of all deliveries in the facility. This is an example of an indicator that measures service delivery among the entire population of women delivering in a facility, as it is a preventive intervention that should be provided universally. As such, the numerator and denominator are contained within the HMIS, and calculation of the indicator is straightforward.

5.5 Considerations for Contextualizing Survey-based Estimates of Maternal Mortality

Survey-based maternal mortality estimates may be higher than expected, especially if considerable programs and policies have been enacted to reduce the burden. As described earlier, HMIS provide additional insight about institutional maternal mortality, coverage, and facility readiness and quality of care that can be examined to better understand maternal mortality in a country. Below are pertinent considerations for triangulating data from DHS and HMIS sources.

5.5.1 Varying definitions and limitations of capturing maternal mortality

Both sources of data are prone to limitations in capturing maternal mortality. Although household surveys are designed to be nationally representative, maternal mortality as captured through the sisterhood method is prone to non-sampling error. An assessment of DHS mortality estimates conducted in 2013 found that examining household populations through the sisterhood method results in underestimation of maternal mortality due to challenges in reporting timing of events and not knowing the pregnancy statuses of deceased siblings (Ahmed et al. 2014). The statistical rarity of the event also produces estimates with large margins of uncertainty. Additionally, household estimates are typically calculated using a 7-year reference period, which may complicate comparisons with other indicators.

The ability of HMIS data to accurately capture institutional maternal mortality is also limited. The estimates may be inflated compared with typically underestimated household data. That is, until universal coverage for health care is attained, estimates of institutional deaths may be biased by women who only attend a facility because of known complications or women whose previous complications put them at risk. Further, challenges in seeking antenatal care or delays in reaching a facility during labor would result in deaths that may have otherwise been averted with appropriate and early care, and so may not reflect quality of care at the facility level. Finally, the time period used to calculate institutional maternal mortality likely differs from the time period used in household-based estimates.

5.5.2 Cause of death and morbidity data

As HMIS data improve, cause of death and morbidity diagnoses can be used to better understand the drivers of maternal mortality. Examining trends in the cause of death structure in a country has implications for the performance of the health system and for disease outbreaks that indirectly contribute to mortality. Further, examining these trends can inform which interventions should be examined to understand trends in mortality estimates. These data would be vital for health management teams in lower-level administrative units and nationally, to both comprehend the unique burdens of different causes of death and to allocate resources for and monitor interventions that alleviate these cause-specific burdens (MCSP 2018). For example, as the ability to address maternal complications and treat infectious diseases improves, the share of indirect maternal mortality resulting from non-communicable diseases will decrease (Storm et al. 2014). However, as described, these data are not widely reported.

Additionally, like mortality, morbidity according to inpatient and outpatient data does not reflect disease incidence or trends within an entire population; it reflects them only among those who access facilities for care (WHO 2019b). As alluded to in Chapter 3, the proportion of diagnoses given vague codes can inform the overall accuracy of diagnostic reporting within a country and should be assessed prior to using this information. The accuracy can again be compared across subnational levels and by facility type; the availability of adequate diagnostic commodities may influence the ability to accurately diagnose and report morbidities.

5.5.3 Examine and triangulate indicators related to multiple interventions

Understanding not only the coverage of the intervention but also the availability or readiness of facilities and the service delivery of the interventions, is vital to understanding the health system. HMIS can provide another vantage point for observing trends in coverage, availablity, readiness, and provision of specific interventions along the continuum of care for maternal health, including antenatal care, facility delivery, cesearean section, and postpartum care. Triangulation across multiple indicators is critical for understanding complex outcomes such as maternal mortality. However, this process faces several limitations. Biases from each source of information, differences in definitions of indicators (including the populations captured),and differences in the reference periods of indicators may complicate this process. Additionally, when triangulating MMR estimates from household survey data against other indicators, it is important to consider that the reference period for MMR is 7 years, whereas the interventions being examined may be estimated with shorter periods or point-in-time estimates. Contextualizing maternal mortality therefore warrants a multistep process with considerations for these limitations.

Coverage

When overlapping indicators exist across sources, a triangulation analysis of trends can inform a more robust understanding of use. For example, as use of facilities for care during, before, and after birth increases to universal coverage, household mortality estimates and HMIS mortality estimates would theoretically follow the same trend. Additionally, the HMIS data could provide additional insight into any fluctuations that may have occurred during the time between household surveys.

However, given the different methods for collecting data and calculating indicators, coverage indicators from two sources may not align in either point estimates or trends. Research has shown that point estimates

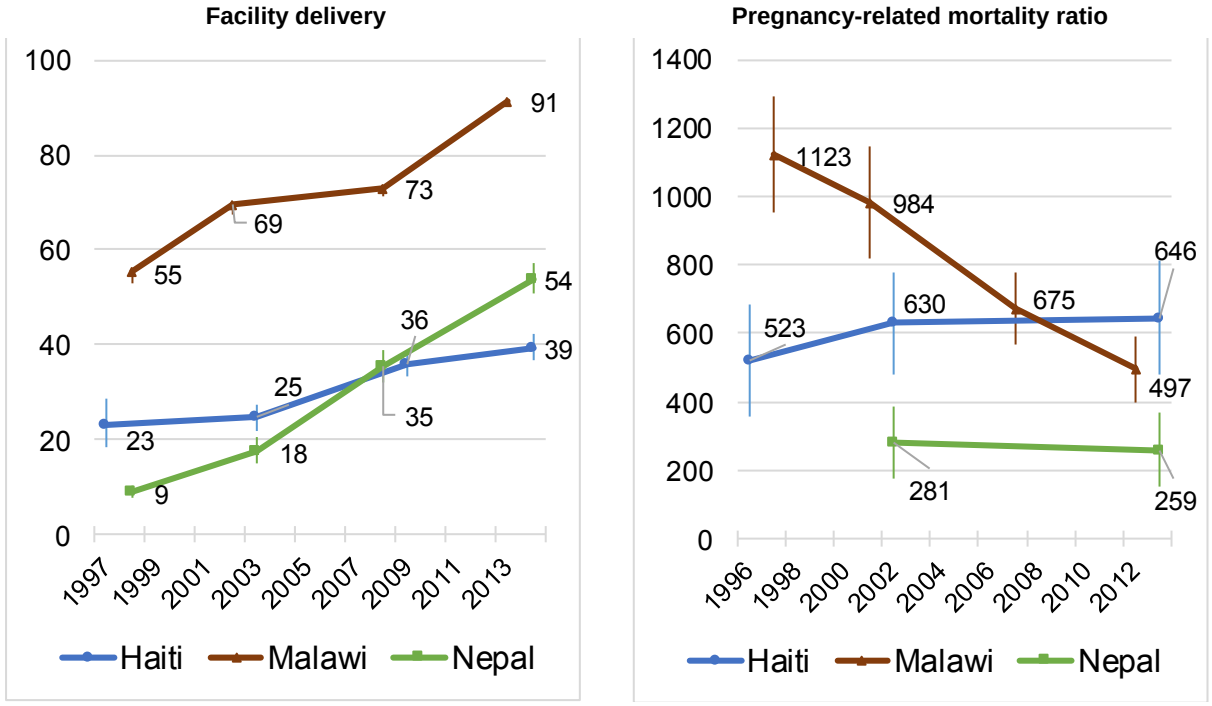
vary according to the source of data for producing indicators but that the overall trends should be similar. For example, Battle et al. (2019) compared ITN distribution and IPTp uptake between household surveys and DHIS-2 and identified similar trends, despite differences in denominators and populations assessed.[10] When trends do not align, further analysis and exploration is warrented. Although biases vary across countries, routine facility-based data are often biased by incomplete reporting, lack of representation of facilities in a country, and lack of formal health sector utilization (see Chapter 3).

Ideally, increased coverage would indicate a decrease in mortality. For example, an increase in coverage of facility delivery—an indicator that reflects contact with the health system, which enables care during childbirth, when most maternal deaths occur—should correspond with a decrease in maternal mortality. Facility delivery can be caluclated using both household and HMIS data, as described earlier. Other intervention indicators can also be included. If institutional MMR can be calculated using HMIS data, it can be compared with MMR calculated using household data as long as considerations for the differences are noted and quality is assessed. HMIS data can add more frequent data points to bolster the understanding of both the health system and health outcomes.

In Figure 5.3, DHS data are used to demonstrate trends in facility delivery alongside trends in PRMR, although HMIS data can be added to such a chart after calculating coverage of facility delivery with the appropriate denominators. Figure 5.3 shifts the estimates from the year(s) of the survey to the midpoint of the respective reference period for each indicator. Facility delivery is calculated among births delivered in the 5 years preceding each survey; the reference period for PRMR is 7 years. Thus, for each indicator of facility delivery and PRMR, the date of the estimate is recentered to 2.5 and 3.5 years preceding each survey, respectively. Additionally, as surveys can be conducted over several months to up to 2 years, we used the median date of the interview[11] as the start of the reference period.

[10] In this report, we define IPTp uptake and ITN distribution as captured by HMIS as service delivery. This is to emphasize the difference between population-based estimates that use a nationally representative sample as the denominator and provision of care as captured by routine facility-based data among care seekers.
[11] http://api.dhsprogram.com/rest/dhs/data/SV_INTV_H_YRI?f=html

Figure 5.3 Coverage of facility delivery and pregnancy-related mortality ratio



Note: The estimates are situated at the midpoint of the reference period for each indicator, using the median date of interview for each survey. The survey years are as follows: Haiti 2000, 2005-06, 2012, and 2016-17; Malawi 2000, 2004, 2010, and 2015-16; and Nepal 2001, 2006, 2011, and 2016.

An increase in coverage may not, in reality, correspond with a decrease in mortality, as demonstrated by Figure 5.3, and interpretations should be made with caution. For example, in both Haiti and Nepal, facility delivery increased over the past 2 decades, from 23% in 1997 (2000 survey) to 39% in 2014 (2016-17 survey) in Haiti and from only 9% in 1998 (2001) to 54% in 2014 (2016) in Nepal. Yet in both countries, PRMR did not significantly change. In Haiti, there was a non-significant increase in PRMR from 523 deaths per 100,000 live births in 1997 (2000 survey) to 646 in 2014 (2016-17 survey); in Nepal, there was a non-significant decrease from 281 to 259 from 2006 to 2016. In Malawi, facility delivery increased from 55% to 91% between the earliest and most recent surveys, and PRMR had significantly decreased from 1,123 deaths per 100,000 live births to just under 500. However, despite drastic increases in coverage to nearly universal facility delivery, the point estimates for PRMR in Malawi are nearly 2 times higher than the point estimates in Nepal, where just over half of all deliveries occur in a facility.

Availability, Readiness, and Service Delivery

As coverage of critical interventions alone is not sufficient for understanding trends or estimates in maternal mortality, another critical component of the health system to examine is the availability, readiness, and quality of care provided for pregnancy, childbirth, and the postnatal period. A recent study summarized the availability of many components necessary for high quality delivery according to SPA data (Wang et al. 2019). The authors found that facilities in Haiti, Malawi, and Nepal had only 53%, 67%, and 58%, respectively, of the maximum capacity to deliver services (Wang et al. 2019). The low coverage of facility delivery in combination with a relatively low readiness of facilities may in part explain the high maternal mortality in Haiti. However, although Malawi has significantly more effective coverage (the product of

coverage and readiness), the difference in MMR between Haiti and Malawi is not statistically significant according to their most recent surveys (Figure 5.3).

Defining the denominator is a challenge in the calculation of some indicators, which may inhibit interpretation. Uterotonics is an intervention that can be provided to all women prophylactically, as a means of preventing complications before they arise. Thus, the indicator is easy to calculate and triangulate against mortality. Conversely, other indicators of service delivery reflect treatment of a specific condition, only apply to a limited population in need, and pose additional challenges for triangulation. For example, magnesium sulfate, which can halt the progression of and treat seizures associated with severe pre-eclampsia and eclampsia, respectively, is only administered when the conditions occur and is not needed for the general population. Although all facilities providing basic or comprehensive emergency obstetric and newborn care are prepared to administer anticonvulsants, capturing the true population in need is difficult and not currently recommended for HMIS. That is, the HMIS may capture only the numerator and not the denominator. If the incidence of pre-eclampsia or eclampsia can be estimated, perhaps through morbidity or cause of death information recorded in HMIS, then the incidence could theoretically be multiplied by a census-based estimate of the total number of pregnancies or births to calculate a denominator. Alternatively, the numerator could be divided by the census-based estimate of all women or births, similar to the way in which cesarean section coverage is calculated (as there is no clear denominator for the number of women in need of a cesarean section). Triangulation between indicators without a clear denominator may or may not help explain trends in mortality. Best practices for estimating a denominator to calculate this type of indicator are under development (WHO 2019c).

5.6 Recommendations for Contextualizing Survey-based Estimates of Maternal Mortality

In summary, when household-based maternal mortality estimates are not trending in the expected direction, (i.e., if maternal mortality has stagnated or even increased), we recommend the following steps and considerations to contextualize estimates.

5.6.1 Compare trends in mortality data in both sources

Triangulation of household survey estimates of MMR (or PRMR) with the institutional MMR can provide insight for decisionmakers. However, household and institutional mortality estimates are not directly comparable, and comparison may limit the ability to draw conclusions about the estimates themselves. Although institutional mortality is not representative of mortality in a country, it can provide insight about quality of care at health facilities. Additionally, household survey-based estimates are limited by the statistical rarity of the event, which results in large margins of error. The true estimate is likely to fall within the lower and upper bounds, which can be substantially large.

One limitation of estimating institutional maternal mortality not previously noted is that an increase in deaths recorded at a facility may not necessarily parallel population-level trends in maternal mortality. Rather, the increase could reflect an increase in use of facilities for delivery, and consequently more institutional deaths. It could also simply reflect an increase in facility reporting of deaths. Considerations should also be made for changes in definitions over time. Further, it is important to understand that household MMR and PRMR are typically calculated using a 7-year period, whereas HMIS may use shorter times. Additionally, maternal mortality estimates can be triangulated against mortality as calculated from

other sources, such as other household surveys, CRVS, and modeled estimates such as those produced by the United Nations Maternal Mortality Estimation Inter-Agency Group (UN MMEIG) (WHO et al. 2019).

5.6.2 As HMIS data become more commonly reported, examine cause of death and morbidity

Information about the key drivers of mortality in a given country can be used to identify the types of interventions that require in-depth analyses to better contextualize maternal mortality estimates. Examining maternal deaths by cause, especially among pre-discharge deaths, can also provide information about the quality of care and potential shortcomings within facilities. Although cause of death is not commonly reported, future efforts to draw from this information can inform not only the context of mortality but also the factors to consider in relation to the health system's ability to prevent mortality.

5.6.3 Examine different types of indicators from both DHS surveys and HMIS alongside maternal mortality

As no one indicator of the health system can fully reflect mortality, multiple indicators should be reviewed. Coverage of multiple interventions should be examined comprehensively to better understand changes in mortality. Yet, despite the scale up of maternal health interventions, reductions in maternal mortality do not necessarily follow (Souza et al. 2013). This points to the need to examine availability, readiness, and quality of services or interventions delivered. Health facility data—routine or periodic—can be used to inform availability and readiness and can help to contextualize whether facilities are prepared to deliver services and address complications during pregnancy and delivery. Considerations should be made for differences in the reference time periods of the indicators.

5.6.4 Consider non-health systems factors not captured by HMIS

Maternal mortality is impacted by individual and environmental factors outside of the health system. Examples of individual factors include fertility risks, including high parity or maternal age at birth (Blanc, Winfrey, and Ross 2013; Muldoon et al. 2011). Environmental factors include government expenditures, economic factors, infrastructure, education, and gender equity (Bishai et al. 2016; Muldoon et al. 2011). These factors should be considered when contextualizing maternal mortality.

6 CHILD MORTALITY, MORBIDITY, AND RELATED INTERVENTIONS

Similar to its usefulness in clarifying the context of maternal mortality, HMIS data can shed light on institutional child mortality in a given country by providing information on mortality and its associated causes, morbidity, the readiness of health facilities, and their capacity to deliver critical prevention and treatment services. This section describes the information that can be gleaned from—and the limitations of—HMIS data and household surveys as they relate to child mortality. MCSP has also conducted an investigation of available data elements in HMIS related to child health, which informed much of the discussion presented in this section. This MCSP document is currently in press.

6.1 Child Mortality Definition and Data Sources

6.1.1 Child mortality definition

Mortality rates, particularly the under-5 mortality rate, are among the best indicators of child health in LMICs. The reduction of under-5 mortality is the primary target for the United Nations SDG 3.2 (and previously, MDG 4A). This follows several pledges by the international health community throughout the 1990s and early 2000s to systematically reduce the under-5 mortality rate, reflecting the continued prioritization of under-5 mortality as a major development target (Moultrie et al. 2013). Tremendous progress has been made, as more than 80 countries have reduced their under-5 mortality by over two-thirds. However, significant work remains: 5.3 million under-5 deaths still occurred in 2018 (Hug, Sharrow, et al. 2019). Mortality among children is usually divided into three age groups: neonatal mortality, infant mortality, and under-5 mortality, as definied in Box 6.1.

Box 6.1 Child mortality terms and definitions

Neonatal mortality rate: The number of deaths during the first 28 completed days of life per 1,000 live births in a given year or period.

Infant mortality rate: The probability that a child born in a specific year or period will die before reaching the age of 1 year, if subject to age-specific mortality rates of that period, expressed per 1,000 live births.

Under-5 (child) mortality rate: The probability of a child born in a specific year or period dying before reaching the age of 5 years, if subject to age-specific mortality rates of that period, expressed per 1,000 live births.

Source: UN IGME (2019)

6.1.2 Data sources

Although CRVS systems with high coverage are the preferred data source for measuring under-5 mortality rates, census and household surveys are possible data sources (WHO 2015). The data collected outside CRVS are obtained from mothers, which raises possibilities of selection bias in the under-5 mortality data collected (Moultrie et al. 2013).

6.1.3 How do household surveys capture child mortality?

The DHS Program calculates its child mortality indicators from the DHS birth history—a complete, chronological list of all the children a woman has ever given birth to, including each child's date of birth, sex, survival status, age (if alive), and age at death (if dead) (Croft, Marshall, and Allen 2018). This is the full birth history and is found in most DHS surveys.[12] Malaria Indicator Surveys employ a truncated birth history, collecting data for the 5 years immediately preceding the survey in reverse chronological order.

Two approaches are used to estimate neonatal, infant, and under-5 mortality rates: the direct method and the indirect method. The direct estimation method uses the date of birth of the child, the child's survival status, and either the date of death or the age at death for deceased children as reported in full birth histories. The indirect estimation method uses summary birth histories and relies on the survival statuses of children *to specific cohorts* of mothers—usually based on the time since first birth or specific age cohorts (Croft, Marshall, and Allen 2018). The DHS Program uses the direct estimation method.

6.1.4 How do HMIS capture child mortality?

Like maternal mortality, deaths of newborns, infants, and children are typically captured in HMIS. However, variations exist in the categorization of these deaths. For example, a review of 24 countries' HMIS found that countries may capture data for early deaths (within the first 7 days), deaths within the first 28 days, or both, or (as in the case of India, Haiti, Mozambique, and Tanzania) they may simply register newborn deaths without these categorizations (MCSP 2018).

The WHO has published guidelines on the core child mortality indicators it recommends being captured by routine HIS (WHO 2019c).

Box 6.2 Health facility-based maternal mortality terms and definitions

Neonatal deaths in health facility: The number of newborns who die in a health facility in the first 28 days. This includes any neonatal death in a facility during the first 28 days, regardless of if was pre-discharge after birth or during a re-admission for an illness.

Child deaths in health facility: The number of children between 1 month and 9 years who die in a health facility, disaggregated by age groups (1-59 months, 5-9 years).

Stillbirth rate in health facility: Stillbirth as a percentage of all births in health facilities. Disaggregated by fresh, macerated. The WHO stresses the importance of this indicator as a measurement of quality of labor and delivery care at the facility (WHO 2019c).

Amouzou et al. (2013) investigated completeness of reporting of child death in HMIS in Malawi—a country where facility delivery is common—and tested a method of adjusting HMIS recorded deaths to create a national estimate of all under-5 deaths. The authors drew from a special household survey in two districts that included a full birth history, with place of death recorded, which was considered the gold standard for comparison. Not only did they find that between 2005 and 2011, an average of only 56%-59% of child deaths occurred in a health facility; they also found that facilities largely under-recorded these deaths in

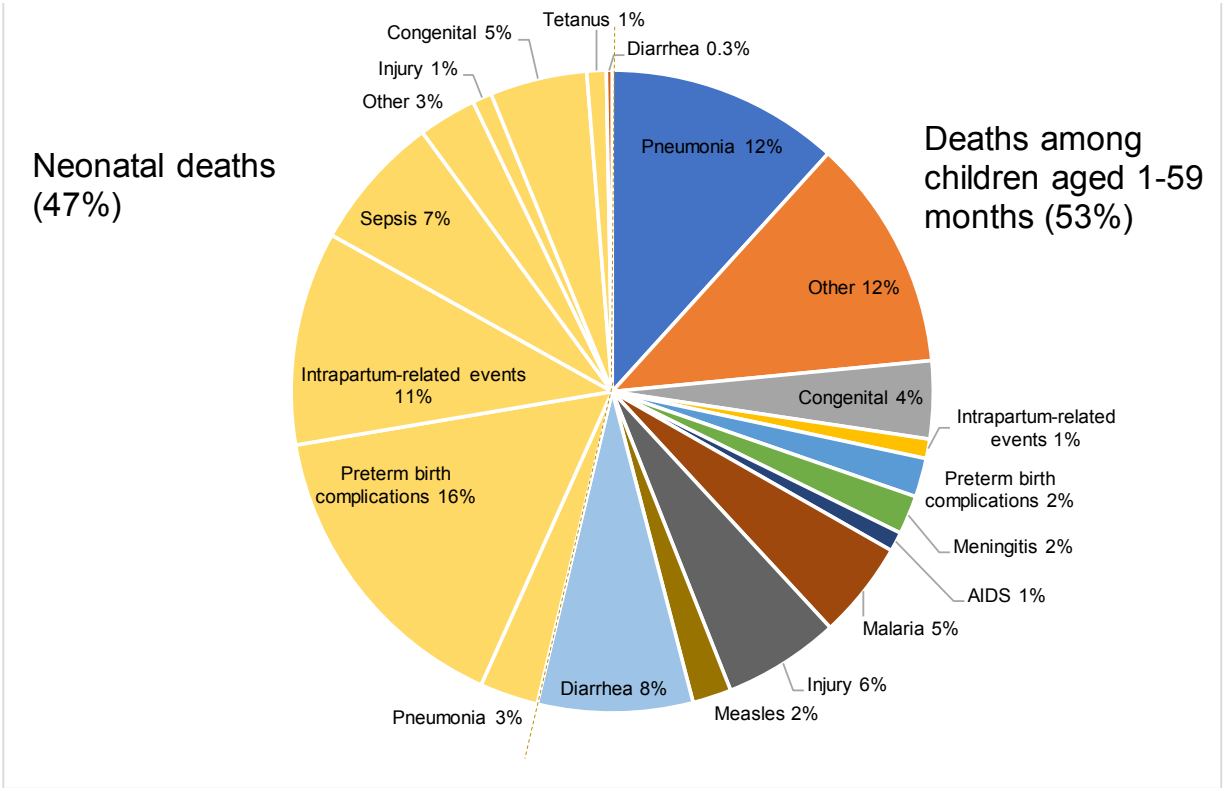
[12] Some previous surveys (including those conducted in the former Soviet republics, Nepal, the Philippines, Vietnam, Pakistan, and Ghana) employed a pregnancy history, which is a complete listing of all pregnancies a woman has ever had. These include pregnancies that ended in miscarriage, abortion, stillbirth, and live birth. All DHS-8 surveys following the 2019 questionnaire revision will also include a full pregnancy history.

HMIS. Adjusted facility records revealed mortality rates that were half of those produced using the gold standard survey (Amouzou et al. 2013). The authors noted that, at the time, only deaths among inpatients in hospitals were typically reported in HMIS, although they also noted the possibility that deaths occurring in facilities were over-reported in the gold standard survey owing to social desirability bias (Amouzou et al. 2013).

6.2 Causes of Under-5 Mortality

Of the leading causes of under-5 mortality (i.e., preterm birth complications, acute respiratory infections, intrapartum-related complications, congenital anomalies, and diarrhea), neonatal deaths alone accounted for nearly 47% of all under-5 deaths worldwide in 2017, according to the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME 2019). Infectious diseases are another major contributor to under-5 mortality, accounting for a full one-third of under-5 deaths. These causes, along with many others, are depicted in Figure 6.1.

Figure 6.1 Global distribution of causes of death among children under age 5, 2018



Source: UN IGME (2019)

Regional disparities in child survival exist: children in sub-Saharan Africa and southern Asia continue to face the highest mortalities within the first 5 years of life, accounting for 52.4% and 28.1% of the global share of under-5 deaths, respectively (UN IGME 2019). These regional disparities are also seen for the underlying causes of under-5 mortality. In sub-Saharan Africa, for example, the leading causes of under-5 deaths were reported as pneumonia (16.6% of under-5 deaths), preterm birth complications (12.1%), and intrapartum-related events (11.5%) (Liu et al. 2016). In southern Asia, however, the leading cause of under-5 mortality was preterm birth complications (25.3%), resulting in the region's overall higher proportion of

neonatal deaths (57%). Further, these causes vary from country to country within these regions. Although pneumonia was the leading cause of under-5 deaths in Benin, Central African Republic, Equatorial Guinea, Somalia, Angola, Democratic Republic of Congo, Ethiopia, Nigeria, Tanzania, and Chad, malaria was the leading cause in Mali and Sierra Leone (Liu et al. 2016).

6.2.1 How do household surveys capture the causes of child death?

Most household surveys do not assess cause of death of children. Verbal autopsy was formerly an optional DHS module that surveys could include to collect data on cause of death for newborns and children under 5. Although it is not a standard component of surveys, the module is maintained (periodically reviewed and updated), and countries can still choose to adapt its questions. Some Bangladesh DHS surveys have included verbal autopsies for households that have experienced a death of a child under 5 (4 weeks to 5 years old) and deaths of newborn children (under 4 weeks); Nepal DHS surveys have also included a verbal autopsy for newborns.

6.2.2 How do HMIS capture the causes of child death?

The WHO recommends reporting cause of death based on the International Classification of Diseases (WHO 2018b). However, like maternal cause of death, child cause of death is rarely reported (MCSP in press). Although child deaths are typically captured by HMIS, the underlying causes are rarely documented. The MCSP's review of HMIS data availability was limited to the labor and delivery register and monthly facility reports (excluding other potential newborn death registers), revealing that only eight of 24 countries analyzed had identified and recorded the causes of newborn deaths, typically with very limited options. Ethiopia, for example, provided prematurity, infection, asphyxia, congenital malformation, and "other" as the only available options. This contrasts with the more open-ended approach of other countries, such as Malawi, whose HMIS allows for the recording of specific newborn complications (e.g., asphyxia, prematurity, and sepsis) (MCSP 2018). As HMIS expand and evolve, they will be an appropriate place to hold information about causes of newborn, infant, and child deaths.

6.3 Morbidity

The burden of diseases or other conditions that can lead to child mortality, including pneumonia, diarrhea, malaria, and preterm births, can be tracked alongside mortality to help understand the key issues that affect mortality.

6.3.1 How do household surveys capture child morbidity?

DHS surveys routinely collect several indicators concerning child morbidity. These include prevalence of malaria, prevalence and treatment of acute respiratory infection, prevalence and treatment of fever, and prevalence and treatment of diarrhea (Croft, Marshall, and Allen 2018). DHS surveys also collect information, based on mothers' reports or birth records, on size at birth, with small size being a risk factor for multiple causes of neonatal and child mortality. Malaria prevalence among children is collected in DHS Malaria Indicator Surveys. The prevalence of stunting and wasting is also collected in DHS surveys and is discussed in detail in Chapter 7.

6.3.2 How do HMIS capture child morbidity?

The WHO recommends a core set of indicators to be tracked at the facility level, as well as additional indicators to be considered. Among the core indicators used to monitor morbidities and risk factors are documented birthweight and low birthweight (under development). Additional interventions for morbidities include pneumonia diagnosis and treatment, diarrhea treatment, malaria diagnosis and treatment, childhood tuberculosis diagnosis and treatment, and malnutrition. Interventions for morbidities alone, as reported in HMIS, do not provide enough information to calculate incidence or prevalence of morbidities in a population, as there is no capture of appropriate denominators or community cases that do not report to facilities (see Chapter 3). According to MCSP, some countries report on case management of child illness at the community level, specifically referral to facilities for danger signs; however, this information is typically not aggregated into HMIS platforms (MCSP in press).

The WHO also made recommendations for including auxiliary indicators that can provide information about or inform an understanding of child health and morbidity. Among these indicators is the percentage of births that are preterm (under 37 weeks of gestation) out of all facility births. As preterm birth is an underlying condition for many child health morbidities and causes of death, preterm births provide critical information for contextualizing child mortality. Despite the importance of this information, capturing accurate gestational age is often challenging in LMICs (Hodgins 2018). Routine health systems also capture morbidities such as wasting, which contributes to multiple causes of death and is described in detail in Chapter 7.

6.4 Interventions and Sources and Availability of Data for Interventions

This section describes critical health interventions captured in household surveys, periodic health facility surveys, and routine health facility information systems. These interventions are ordered by the type of information they provide—whether they reflect coverage, availability and readiness, or service delivery (Box 2.1).

6.4.1 Interventions

Estimates for each of these interventions can be obtained through different sources, including household surveys (e.g., DHS surveys), health facility surveys (e.g., SPA surveys), or routine health facility data (HMIS or LMIS). Table 6.1 lists the interventions and data sources for procuring information about each intervention, based on whether the indicators are recommended by WHO and UNICEF (WHO 2019c) or whether they are currently collected (MCSP in press). The interventions address cause-specific neonatal and child mortality and are included in the LiST framework. Appendix Figures A.2 and A.3 demonstrate the pathways between these interventions, intermediate risk factors, and cause-specific mortality.

Table 6.1 Interventions to prevent child mortality, potential data sources for indicators, and denominators for indicators

Intervention[1]	DHS	SPA	Recommended for routine health facility data[1]
Antenatal			
Folic acid	(A)	(H)	
		(I)	
Prevention of mother-to-child transmission—testing		(H)	(K)
Syphilis detection (and treatment)		(H)	(K)
Neonatal care			
Postnatal care for the baby	(B)	(H)	(L)
Early initiation of breastfeeding	(B)	(H)	
Antibiotics for premature rupture of the membranes		(H)	(M)
Neonatal sepsis care		(H)	
Neonatal resuscitation		(H)	
Supportive care for prematurity		(H)	
Kangaroo Mother Care		(H)	
Cotrimoxazole[2]		(H)	
Vaccinations			
Measles vaccine	(C)	(H)	(N)
Haemophilus influenzae type b vaccine	(C)	(H)	(N)
Diphtheria tetanus pertussis vaccine	(C)	(H)	(N)
Rotavirus vaccine	(C)	(H)	(N)
Pneumococcal vaccine	(C)	(H)	(N)
Nutrition			
Zinc supplementation		(H)	
Exclusive and continued breastfeeding	(D)		
Breastfeeding promotion	(B)	(H)	
		(I), (J)	
Vitamin A supplementation	(E)	(H)	
		(J)	
Medication			
Vitamin A for measles[3]	(E)	(H)	
		(J)	
Oral and parenteral antibiotics	(F)	(H)	(M)
		(J)	(O)
Oral rehydration solution	(F)	(H)	(M)
			(O)
Zinc for diarrhea	(F)	(H)	(M)
		(J)	(O)
Antiretroviral treatment and prevention of mother-to-child transmission		(H)	
Insecticide-treated nets/Antimalarial			
Artemisinin-based combination therapy or antimalarial drug	(F)	(H)	(M)
		(J)	(O)
Insecticide-treated nets	(G)	(H)	(M)
		(I), (J)	(K), (P)

Denominators

A) Number of women with a live birth in the past 3-5 years[4]
B) Number of most recent live births in the 2 years preceding the survey
C) Children at appropriate age for a specific vaccine
D) Number of youngest (last-born) children born in the 2 years preceding the survey who are living with their mother
E) Number of living children 6-59 months of age
F) Children under age 5 who had related illness in the 2 weeks preceding the survey
G) Net possession is calculated among de facto households; net use can be calculated among de facto household members, including among pregnant women and children
H) Number of facilities with relative service
I) Number of antenatal attendees observed
J) Number of children observed attending facilities for sick child visits
K) Number of first-visit antenatal clients at facilities reporting into HMIS
L) Census-based estimates of number of births or number of facility-based deliveries
M) Number of facilities reporting into HMIS/LMIS
N) Estimated number of children in target age group (using census estimation or first diphtheria tetanus pertussis visit from facility data)
O) Number of children observed attending facilities for sick child visits at facilities reporting into HMIS
P) Estimated number of surviving infants (live births – infant deaths)

Coverage Availability or readiness Service delivery Under development No information

[1] Includes health management information systems and logistics management information systems only.
[2] Although provision of cotrimoxazole is not a recommended core indicator, MCSP documents that in 24 countries, eight countries with a higher burden of HIV/AIDS include this information in their registers or summary forms (MCSP 2018).
[3] Vitamin A for measles is a curative intervention; however, this information is not widely collected or available. As a proxy for this indicator, LiST uses percent of children age 6-59 months receiving two doses of vitamin A in 12 months (preventive Vitamin A supplementation), as supplementation has been shown to reduce mortality from measles (WHO 2019d). This table reflects the ability of DHS, SPA, and HMIS sources to collect this proxy.
[4] DHS-7 and prior phases collected maternal health care seeking for most recent pregnancies resulting in a live birth in the past 5 years, with the exception of Bangladesh, where it was the past 3 years. DHS-8 will collect information for maternal health care seeking in the preceding 3 years only and among both live births and stillbirths.

Table 6.1 excludes maternal interventions that also influence child mortality, including family planning, tetanus toxoid vaccination, IPTp, balanced energy supplementation, and multiple micronutrient supplementation; data sources for these interventions are described in Table 5.1. Also excluded is labor and delivery management, which includes skilled birth attendance and is vital for child survival; however, this indicator is also described in Chapter 5. Supplementary feeding with or without nutrition education and treatment for moderate and severe acute malnutrition are excluded as they are discussed in detail in Chapter 7 and included in Table 7.1. Finally, malaria vaccine, indoor residual spraying, and calcium supplementation are excluded as they are not assessed by any data source included in Table 6.1.

6.4.2 Coverage

The DHS Program collects and reports data on coverage of folic acid uptake during pregnancy, postnatal care, early initiation of breastfeeding, childhood immunizations, vitamin A supplementation, exclusive breastfeeding, and care seeking and treatment of child illnesses including fever, malaria, and diarrhea (Table 6.1). These indicators reflect care seeking and do not confirm diagnoses of a disease. Given the complexity of diagnoses and poor recall of diagnosis and treatment, valid indicators of antibiotic treatment for childhood pneumonia, for example, cannot be collected through household surveys (Hazir et al. 2013).

In DHS-8, counseling on infant and young child feeding (IYCF) will also be included. Countries' HMIS rarely capture information on counseling for IYCF. Some countries provide information on practices of exclusive breastfeeding and complementary feeding. However, nutrition counseling and IYCF are likely too complex to be well measured by HMIS (MCSP in press) and do not have clear denominators. That is, counseling on exclusive breastfeeding pertains only to mothers of children under 6 months, while counseling on continued breastfeeding and complementary feeding is relevant for mothers of children age 6-23 months; IYCF data captured in HMIS generally do not specify the child's age.

For many indicators, both DHS and HMIS data can be used to calculate coverage of postnatal care and child immunizations, using denominators of either population-based estimates or facility-based deliveries or first vaccination (diphtheria tetanus pertussis) coverage—if coverage is nearly universal, the facility-based numerator for initial facility contact can also serve as a denominator for certain indicators (see Chapter 3). The overlapping coverage indicators in DHS and HMIS data are:

- Postnatal care for the newborn
- Child immunizations

6.4.3 Availability and readiness

SPA surveys as well as other periodic health facility assessments have the capacity to capture availability and readiness to provide critical interventions, while LMIS and other routine health systems can capture availability of medicines or commodities. SPA surveys, where available, capture whether facilities provide most of the interventions listed in Table 6.1. As mentioned, the interoperability between service provision data in HMIS and supply availability in LMIS is lacking in many countries.

6.4.4 Service delivery

Both SPA and HMIS data capture many service delivery indicators, including the provision of services by a health provider to those in need of the services. Additionally, DHS data capture service delivery as it relates to counseling about breastfeeding, which is based on a woman's report of content of postnatal care. SPA data capture service delivery related to care provided during observed antenatal visits, including provision of folic acid, breastfeeding counseling, and provision of ITNs, if applicable. SPA surveys also capture the content of sick child visits, for which data can be used to calculate the quality of treatment for child illness such as pneumonia, diarrhea, and malaria. However, as SPA surveys capture a sample of clients attending facilities, these data cannot be used to assess the quantity of services delivered within a population or over time (i.e., coverage). That is, HMIS do not capture enough information to calculate the denominator or disease incidence, as HMIS typically rely on data from facility visits only, thus not capturing disease among those who do not seek care at a facility. The WHO has recommended core service delivery indicators for HMIS related to childcare, including treatment for childhood illness.

Additionally, breastfeeding initiation within 1 hour—a critical intervention known to reduce neonatal mortality—is recommended, although the indicator is still under development (WHO 2019c). Regarding malaria, distribution of ITNs was recorded in 16 of the 24 countries' summary forms and registers. Again, however, there was little consistency in how each country recorded this information, with the data capturing whether malaria testing was performed, the result of the test, or whether malaria treatment was provided. The availability of these data is directly linked to malaria burden and thus indirectly to under-5 mortality.

Further, although Table 6.1 presents the recommended indicators, a review of HMIS in 24 countries across sub-Saharan Africa and southeast Asia revealed that although all countries reported the availability of digitized data of national-level newborn health indicators, the availability of specific indicators varied greatly (MCSP 2018). Similarly, a forthcoming review of HMIS for child health indicators found variability in reporting of child health indicators.

6.5 Considerations for Contextualizing Survey-based Estimates of Under-5 Mortality

In some cases, survey-based estimates of under-5 mortality may fall outside of expected ranges, especially if progress toward reducing mortality is not achieved as expected. HMIS provide another vantage point against which these estimates can be triangulated to better contextualize the estimates, as described above. This section describes considerations that are warranted when conducting these triangulation exercises.

6.5.1 Varying definitions and limitations of capturing child mortality

Both household surveys and HMIS can be used to estimate child mortality, and information gleaned from the two sources can be compared for trends. However, point estimates will differ as a result of differences in calculation and in the limitations and biases of the different sources and trends between household and HMIS mortality may also diverge. There is concern regarding the introduction of selection bias when calculating child mortality using HMIS birth and death data collected at the facility level, as described by Hill (2013). Specifically, it becomes impossible to know whether the women who visit facilities are representative of all mothers, making it far more difficult to draw conclusions about the true under-5 mortality rate. Thus, trends will likely not be parallel. Additionally, poor documentation may further bias

an already unrepresentative sample in HMIS. As use of facilities increases over time, the number of deaths occurring at facilities (rather than in the community) will rise.

Using household survey data, both direct and indirect methods of estimating child mortality face limitations. For example, the direct method is limited by the omission of deceased children and age heaping at 12 months of age13, and the indirect method is limited by the omission of live births and having to hold to the underlying assumptions of the method (Silva 2012). Because of the limitations and assumptions involved with the use of the indirect method, The DHS Program utilizes the direct estimation method to calculate infant and child mortality (Croft, Marshall, and Allen 2018). In previous phases of The DHS Program, national estimates were calculated using 5-year periods, while disaggregated child mortality rates were calculated using 10-year periods. Since DHS-7, 5-year periods have been used for disaggregation by sex and urban-rural residence in addition to the national estimates (Croft, Marshall, and Allen 2018).

6.5.2 Cause of death and morbidity data

Examining both cause of death and diagnoses of patients treated for specific morbidities will provide information about the most common and severe morbidities. Obtaining such information from HMIS data can point to specific interventions to examine in terms of coverage, readiness, and quality to further help contextualize mortality in a country. However, as mentioned, classification of death is rare and difficult to capture; these systems are prone to errors due to incorrect use of garbage codes or misclassification of causes, especially as HMIS become more complex and burdensome for the health provider.

When examining cause of death structure to understand estimates of all-cause child mortality, it is important to examine trends in many causes, as child mortality is complex. Examining trends in any one cause will not yield sufficient information. For example, 45% of under-5 deaths occur during the neonatal period. The largest cause of neonatal mortality is preterm birth, to which more than one-third of neonatal deaths and 18% of all under-5 mortality are attributed. However, research shows that neonatal mortality is not decreasing as rapidly as under-5 mortality (Hug et al. 2019; Lawn et al. 2012). Thus, the trends in one of the largest causes of under-5 mortality will not necessarily parallel all under-5 mortality.

Additionally, because there are so many causes of mortality, related morbidities and other related information are also difficult to accurately capture. Household data are not necessarily well-suited for identifying prevalence of specific diseases. This is because (a) many of the diseases assessed are highly seasonal and will fluctuate based on the season and period of data collection and (b) the survey instruments do not have the specificity to identify difficult-to-diagnose diseases such as pneumonia and should not be used even as a proxy for pneumonia prevalence (Hazir et al. 2013; WHO 2019c).

HMIS data have the capacity to inform such understanding, but several factors must be considered when exploring related information in HMIS. Although HMIS information can include facility or community-based case management of specific illnesses, these indicators do not reflect the population-level burden of disease. For example, the WHO-recommended indicator for pneumonia diagnosis and treatment is the number of children correctly diagnosed with pneumonia who receive treatment (WHO 2019c). The

[13] Heaping is the tendency to report ages (or age at death) in whole numbers, typically those ending in 0 or 5, if precise age is unknown; research on household survey data quality has also identified heaping at 12 months of age among reported cases of child deaths (Pullum 2006).

denominator for this indicator is the number of children diagnosed with pneumonia. However, this indicator is based only on those who sought care in facilities or from associated community health workers who reported through HMIS. Consequently, the information cannot be used to provide population-based estimates of the proportion of children with pneumonia (in a given time period) who received antibiotic treatment.

Additionally, the definitions of childhood illnesses used in HMIS registers and summary forms vary substantially across and within countries, as well as between community and facility levels. For example, reporting of what is considered pneumonia is extremely varied, with options including "suspected pneumonia," "pneumonia," "acute respiratory infection," and "cough and fast breathing" (MCSP in press). Further, although some countries track screening and diagnoses for major illnesses, fewer report on treatment (MCSP in press); countries that don't track treatment often use number of cases as a proxy for treatment, which isn't always accurate. Without consistent definitions, it is difficult to make comparisons or understand the extent of case management at subnational or cross-national levels.

6.5.3 Examining and triangulating indicators related to multiple interventions

Given the numerous causes of child mortality, many interventions are available to prevent mortality or treat risks or illnesses that may lead to death. These interventions are implemented at varying levels of care (from individual to national). The health systems interventions that save the most lives are neonatal-related, including labor and delivery management, care for prematurity, and supportive care for sepsis and pneumonia; the most powerful interventions for children age 1-59 months include vaccinations, oral rehydration therapy, antimalarial treatment, and antibiotics (Marchant et al. 2016).

When triangulating to contextualize trends in mortality, it is important to consider how the time frame for calculating each indicator may affect any inferences about the data. Under-5 mortality rates are typically calculated using a 5-year reference period. Interventions to prevent or reduce mortality may use a shorter reference period; for example, vaccinations are calculated using a 1-year reference period beginning one year before the survey. Meanwhile, vaccination coverage according to HMIS data is likely to be calculated using even shorter reference periods. Additionally, there is likely a lag in the effect of increased vaccination on mortality, and changes would not be witnessed at the population level immediately.

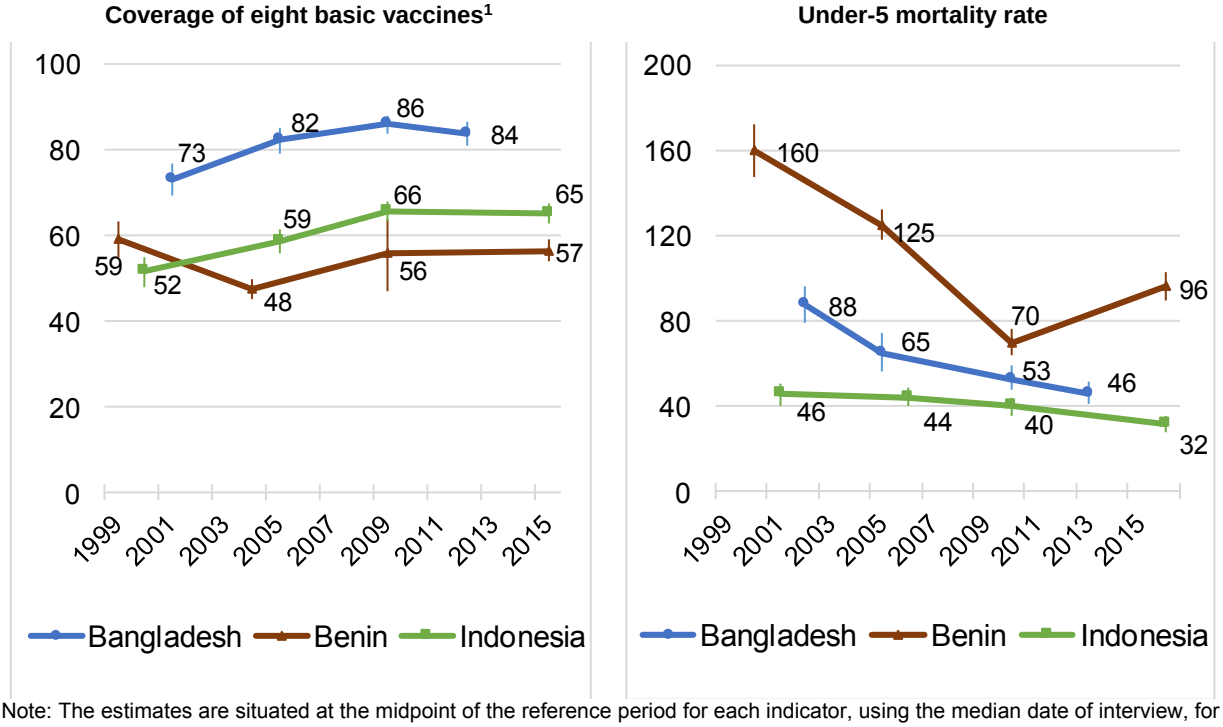
Coverage

More information about a health system's capacity to address underlying causes of mortality can be drawn from examining the extent of and trends in use of health services. For example, increasing coverage of childhood vaccinations has been linked to large reductions in mortality among children under 5 (McGovern and Canning 2015). Of all the health systems interventions, immunizations have contributed to the largest reduction in mortality, although this amounts to only approximately 20% of the total reduction in child mortality between 1990 and 2010 (though these reductions were much larger prior to 1990) (Bishai et al. 2016). Regardless, to contextualize trends in child mortality with HMIS data, a first step should be to examine trends in immunizations.

Theoretically, there should be an inverse relationship between coverage of immunization and mortality. However, as Figure 6.2 shows, the estimates do not always align in this way. Figure 6.2 represents estimates of coverage of all eight basic vaccinations and under-5 mortality based on DHS data (but can be

supplemented with vaccination coverage information garnered from HMIS data). As explained in the footnote of the figure, estimates are situated at the midpoint of the reference period for each indicator. Because vaccinations use a 1-year reference period, the midpoint is shifted to 18 months preceding the median date of the survey. Estimates for under-5 mortality rates, which use a 5-year reference period, are shifted 2.5 years prior to the survey.

Figure 6.2 Coverage of basic child vaccinations and under-5 mortality rate



Note: The estimates are situated at the midpoint of the reference period for each indicator, using the median date of interview, for each survey. The survey dates are as follows: Bangladesh 2004, 2007, 2011, and 2014; Benin 2001, 2006, 2011-12, and 2017-18; Indonesia 2002-03, 2007, 2012, and 2017.

[1] The indicator for all eight basic vaccinations is the percentage of children age 12-23 months who had received all eight basic vaccinations: bacille Calmette-Guerin, diphtheria tetanus pertussis (three doses), polio (three doses), and measles.

In the first decade of the century in Bangladesh, coverage of vaccinations increased by more than 10 percentage points and under-5 mortality rates decreased significantly. A similar inverse relationship appeared in Indonesia in the respective periods. In Benin, however, the trends were curious; an inverse relationship was not witnessed. Although vaccination coverage decreased early in the first decade, mortality dropped sharply in the second half of the decade. Even more curiously, mortality surged while vaccinations increased only slightly and then plateaued. In the case of Benin especially, it will be important to evaluate other factors and sources of information to better understand these unusual trends.

Availability, Readiness, and Service Delivery

Quality of care includes components of service delivery and can be examined in tandem with service coverage and the availability and readiness of facilities to provide services; this is done to understand the extent to which critical services are available and provided after a person in need of a service makes contact with the health system. For example, reduction of neonatal mortality is largely attributable to improved quality of care during labor and delivery, as well as intensive neonatal care for babies with complications and preterm delivery (Lee et al. 2011). Examining service delivery, especially around delivery care and care

for newborns, may help to contextualize neonatal and child mortality. If postnatal coverage is high, but provision of critical newborn interventions at the point of delivery fall short, this could help to explain unexpectedly high rates of neonatal mortality.

However, for indicators related to treatment of specific diseases (e.g., pneumonia), the estimates of service delivery may be misleading without an appropriate denominator. Pneumonia treatment data from service statistics lack information in both the numerator and denominator to adequately portray pneumonia treatment on a population level. Given that HMIS data are often based only on public facilities, and in some cases community-based care, care seeking at private or informal outlets is omitted. Further, there is no available information about the true population affected by pneumonia, and the proportion of the population affected by pneumonia is likely to change as other interventions increase. That is, pneumonia can be prevented with vaccination against Haemophilus influenzae type b, pneumococcus, measles, and pertussis. An increase in pneumonia treatment can reflect several issues—more care seeking, more care seeking at public facilities (versus private), better treatment, better reporting, or a higher incidence of pneumonia. Without an appropriate numerator (all children treated for pneumonia at any facility) and denominator (number of children in need of treatment), it is impossible to understand the rise in the number of cases treated. Similarly, a decrease in the number of cases treated may not necessarily mean poor quality at public facilities; decreases in volume could indicate an overall reduction in incidence or an increased use of the private sector or community health workers. Thus, one cannot conclude that higher levels of mortality are explained by a decrease in pneumonia treatment without also examining changes in incidence of pneumonia or prevention of diseases that cause pneumonia.

6.6 Recommendations for Contextualizing Survey-based Estimates of Under-5 Mortality

To summarize, this section presents recommended steps and considerations for contextualizing child mortality when estimates are unexpected.

6.6.1 Examine trends in mortality from multiple sources

Although household-based estimates are considered the gold-standard estimates of child mortality in the absence of complete CRVS systems, additional information can be gleaned from other data sources. Triangulating institutional child mortality estimates with estimates from household surveys can provide additional context. This exercise can be conducted for all under-5 mortality as well as for neonatal mortality and infant mortality, where possible, to better understand the issues driving all under-5 mortality. However, care should be taken to account for biases that may exist in both household survey data and, separately, in HMIS data relating to child mortality. Thus, to further contextualize mortality, estimates can be obtained from sophisticated statistical models that draw from multiple sources of data, such as those produced by the Institute of Health Metrics and Evaluation's Local Burden of Disease project, which examined the geographic distribution of 123 million neonatal, infant, and child deaths between 2000 and 2017 (Burstein et al. 2019), and the UN IGME, which provides annual estimates of child mortality rates (UN IGME 2019). In the case of Benin, examining the UN IGME mortality estimates in fact shows that Benin's 2011-12 DHS survey considerably underestimated the under-5 mortality rate.14

[14] https://childmortality.org/data/Benin

6.6.2 Examine cause of death and morbidity

Examining the cause of death structure alongside common morbidities can help inform overall estimates of mortality and provide insight into specific interventions to examine when contextualizing mortality within a country. The limitations of HMIS are such that, without an appropriate denominator or harmonized definitions, they cannot estimate disease prevalence or incidence; however, they can provide information about what areas within the health system to further explore. As this information becomes more widely included and documented, future efforts to triangulate can use these data to understand mortality in a country.

6.6.3 Examine the health service environment using a variety of indicators

A conversation about the causes of child mortality and the national and global efforts to reduce it is incomplete without considering the use of services alongside information about readiness of the health system, both to prevent and to treat these causes. In addition to examining how coverage for contact with the health system has changed over time, according to both HMIS and DHS sources if possible, it is important to consider the capacity for diagnosing and adequately treating conditions once contact is made. In order to contextualize child mortality, we recommend examining HMIS data for gaps in ability to deliver services, taking a cause-specific approach for more granularity. Considerations should be made for the varying reference periods for each indicator examined.

6.6.4 Consider how other factors not captured by HMIS may inform estimates

- Under-5 mortality is affected by many associations between various risk factors and interventions. In 1984, a novel framework was developed by Mosley and Chen to illustrate the interactions at play between child survival and its proximate determinants (Mosley and Chen 2003). The framework groups the determinants into five major categories: maternal factors, environmental contamination, nutrient deficiency, injury, and personal illness controls. According to LiST, the various causes of death that comprise under-5 mortality (e.g., meningitis, pneumonia, pertussis, diarrhea, injury, AIDS, measles, and malaria) are all modulated by risk factors that include small for gestational age, maternal age, birth order and birth interval, preterm birth, stunting, wasting, exclusive breastfeeding, and diarrhea incidence. Bishai et al. (2016) note that half of the reductions in mortality observed between 1990 and 2010 were due to improvements outside of the health sector.

7 ACUTE MALNUTRITION AND RELATED INTERVENTIONS

Acute malnutrition is a form of undernutrition resulting from inadequate food intake or disease. It is caused by recent rapid weight loss or the inability to gain weight and can result in an increased risk of mortality, morbidity, and delayed cognitive development (UNICEF 2013). Providing reliable estimates of acute malnutrition is important for appropriately targeting and investing in nutrition and health interventions, and for monitoring progress. Globally, about 7.3% of children under 5 were estimated to be wasted in 2018, with more than half of those cases occurring in South Asia and close to one-quarter in sub-Saharan Africa (UNICEF et al. 2019). The Global Nutrition Targets 2025 and SDGs for 2030 call for achieving a prevalence of wasting of less than 5% globally (WHO 2014).

The purpose of this chapter is to illustrate ways in which routine health statistics can be used to better contextualize survey-based estimates of acute malnutrition. The chapter describes indicators of acute malnutrition collected in population-based household surveys and related data available in HMIS that are compiled from health facilities. It outlines factors to be considered when triangulating survey-based estimates of acute malnutrition with HMIS and other routine data sources. The examples provided in this chapter are illustrative pending the release of WHO-UNICEF guidance on a core set of routine HMIS nutrition indicators.

7.1 Wasting Definition and Data Sources

7.1.1 Wasting definition

Acute malnutrition is defined by the presence of wasting using weight-for-height (WHZ) or middle upper arm circumference (MUAC) information or by assessing bilateral pitting edema. Table 7.1 provides indicator definitions and thresholds for acute malnutrition. In this report, the focus is on using data to contextualize WHZ estimates because this is the indicator used to define wasting in DHS surveys and to track global targets.

7.1.2 How do household surveys capture acute malnutrition?

Nationally representative, household surveys most commonly used to generate estimates of wasting are DHS surveys, MICS, and surveys using the standardized monitoring and assessment of relief and transitions (SMART) approach. DHS surveys and MICS typically collect weight and height data while the SMART approach is typically designed to collect weight and height along with MUAC and, in some surveys, presence of bilateral pitting edema. Measuring bilateral pitting edema is not recommended as a standard part of population-based surveys to avoid misdiagnosis; if measured, specialized training is required (WHO and UNICEF 2019).

Table 7.1 Indicator definitions and thresholds for wasting/acute malnutrition

Indicator	Definition[1]	Population[2]	Thresholds (%)[3]
Moderate wasting/moderate acute malnutrition	% WHZ < -2 and >= -3 or % MUAC 115 mm to <125 mm	Children age 0-59 months (WHZ) or Children age 6-59 months (MUAC)	
Severe wasting/severe acute malnutrition	% WHZ < -3 or % MUAC <115 mm or presence of bilateral pitting edema		
Wasting/acute malnutrition	% WHZ < -2 or % MUAC <125 mm		Very low: <2.5 Low: 2.5 to <5 Medium: 5 to <10 High: 10 to <15 Very high: >=15

Note: MUAC = mid-upper arm circumference; WHZ = weight-for-height z-score.
[1] The WHZ index measures weight in relation to body height or length compared to the World Health Organization (WHO) Child Growth Standards. Estimates for WHZ exclude children with implausible WHZ (<5 or >5 standard deviations of the median).
[2] Globally agreed upon cutoff for MUAC in children younger than 6 months is not available.
[3] Global thresholds are based on WHZ < -2.
Sources: (Cashin and Oot 2018; de Onis et al. 2019; UNICEF et al. 2019; WHO 2000)

Weight and height data for children under 5 in household surveys are collected by a trained member of the data collection team.[1] Children younger than 24 months are measured lying down, and standing height is measured for children 24 months and older (WHO and UNICEF 2019). Weight is measured to a 100-gram minimum graduation using a digital precision scale (WHO and UNICEF 2019). MUAC is assessed by measuring the shape of the upper arm using a non-stretchable insertion tape. The tapes are generally graduated in millimeters. Bilateral pitting edema is an indication of excess fluid in the tissues and is assessed by placing pressure on the bottom of the feet and observing if there is pitting after pressure is removed (Cashin and Oot 2018).

7.1.3 How do HMIS capture acute malnutrition?

Acute malnutrition estimates in HMIS are usually obtained from data collected for screening and growth monitoring purposes. The WHO recommends acute malnutrition be assessed by WHZ and MUAC in facilities and by MUAC in the community (WHO 2013) (Box 7.1). Unlike in population-based surveys, clinical assessment of bilateral pitting edema is also recommended to identify acute malnutrition in both the facility and community settings.

WHO guidance on a core set of routine nutrition data indicators and their definitions is forthcoming. A review of 24 countries' HMIS showed that at this time less than half of the countries aggregated information on the number of children receiving nutritional screening based on weight, height, or MUAC assessment at the facility or community level. Further, currently, very few countries can report on the percentage of children with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM) defined by MUAC or WHZ through their HMIS (MCSP in press). For countries that reported data on nutritional screening, they were most likely to report measurements attained by MUAC, followed by weight and then height. Only two countries reported on the number of children who had their height and weight measured in forms that could be aggregated.

Box 7.1 Potential HMIS data for assessing acute malnutrition

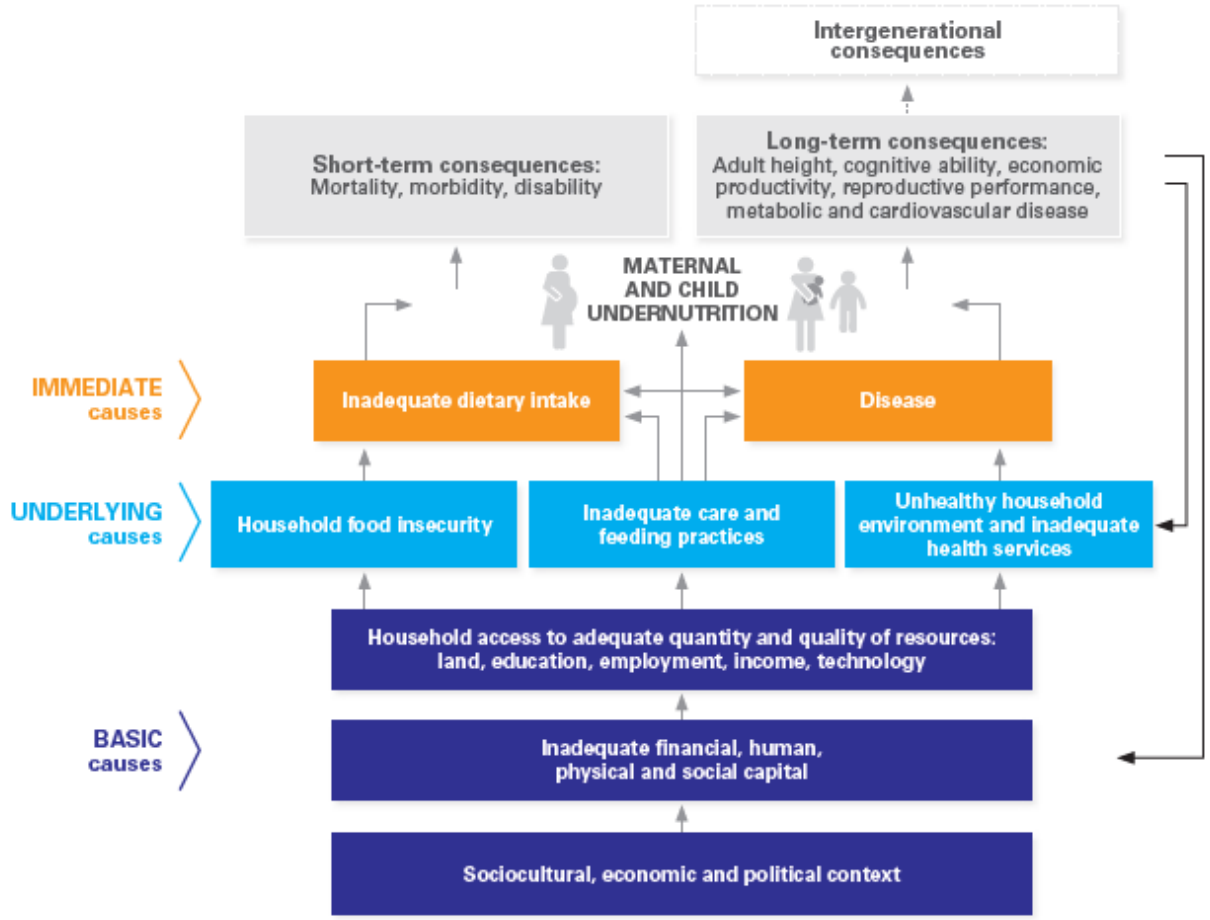
- Percentage of children identified as wasted using weight for height/length among children assessed at health facilities, including other service points as relevant
- Percentage of children identified as wasted using mid-upper arm circumference among children assessed in the community or at health facilities, including other service points as relevant

Note: Global recommendations on routine collection of acute malnutrition are under development.

7.2 Causes of Wasting

In 1991, UNICEF established a framework for the immediate, underlying, and basic determinants of childhood malnutrition (Figure 7.1). The immediate and underlying causes are influenced by individual, household, and contextual factors. Figure 7.2 illustrates some of these factors (Akombi et al. 2017; Emergency Nutrition Network 2018; Fernandez, Himes, and Onis 2002; Harding, Aguayo, and Webb 2018; Khan, Zaheer, and Safdar 2019; Mishra et al. 2019).

Figure 7.1 UNICEF conceptual framework

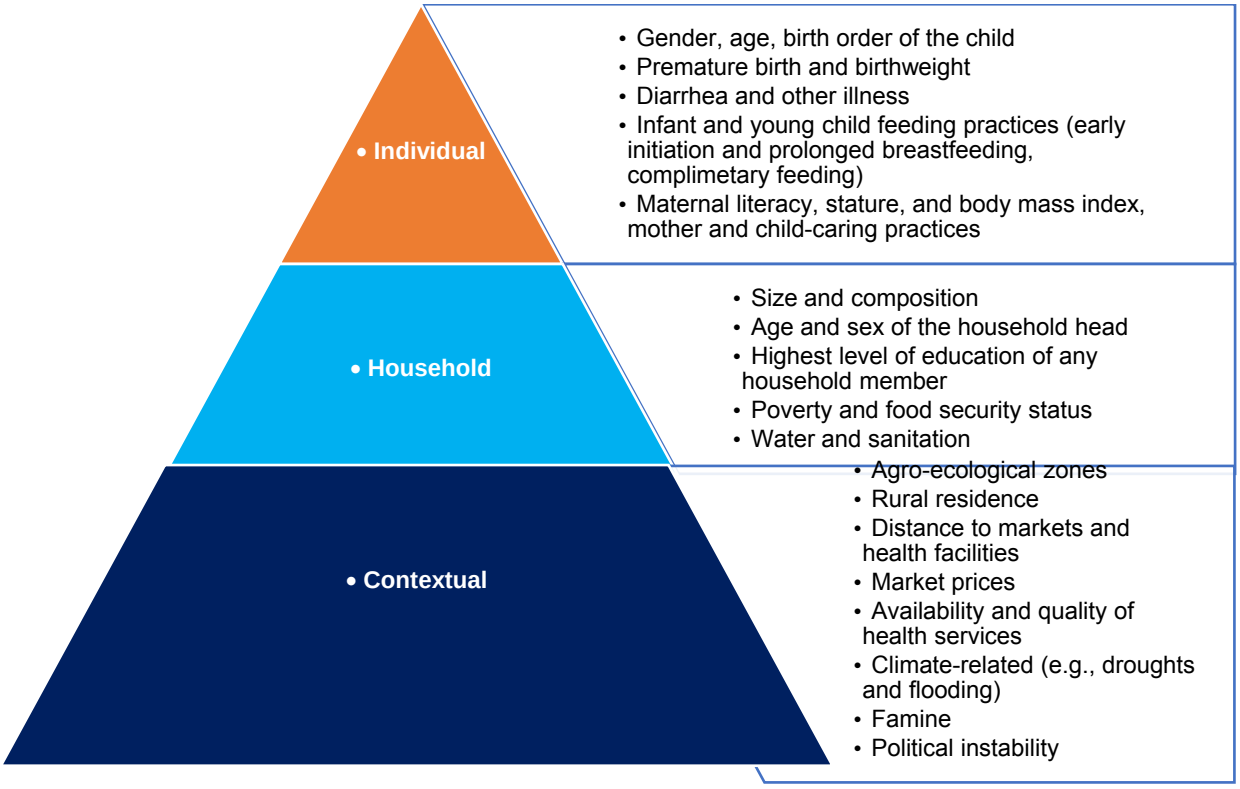


The black arrows show that the consequences of undernutrition can feed back to the underlying and basic causes of undernutrition, perpetuating the cycle of undernutrition, poverty and inequities.

Source: Adapted from UNICEF, 1990.

Source: UNICEF (2013)

Figure 7.2 Examples of individual, household, and contextual factors related to the immediate, underlying, and basic causes of acute malnutrition

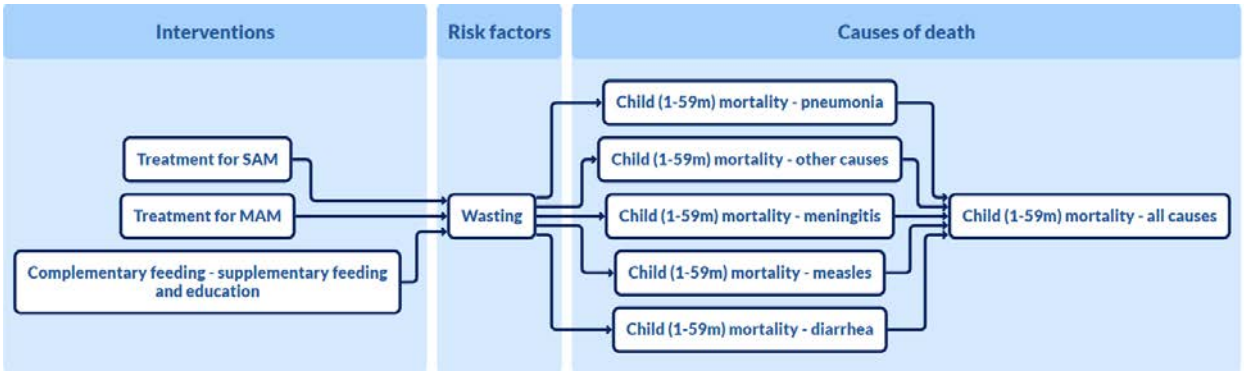


7.3 Interventions and Sources and Availability of Data for Interventions

7.3.1 Interventions for wasting

The WHO underscores the need for countries to integrate preventive services with treatment services to successfully reduce wasting (WHO 2014). The LiST Visualizer model for wasting includes one nutrition-specific preventative intervention and two treatment-based interventions: one for MAM and one for SAM (Clermont and Walker 2017). The LiST Visualizer model requires an effect estimate when building the model, so all included interventions have been shown to impact wasting based on systematic reviews and meta-analyses (Clermont and Walker 2017). Figure 7.3 illustrates the interventions included in the LiST Visualizer model for wasting.

Figure 7.3 Nutrition-specific interventions that directly impact wasting, LiST Visualizer



Source: LiST Visualizer

The preventive interventions included in the LiST model are appropriate complementary feeding practices, supplementary feeding, and nutrition education. This is based on a systematic review showing improvements in WHZ among children who received complementary food supplementation (Panjwani and Heidkamp 2017). Provision of complementary food supplementation included ready-to-use therapeutic food, local cereal and protein blends, insect meal, and small-quantity lipid-based nutrition supplements. Types of nutrition education included delivery of complementary feeding and responsive feeding messages in clinics or counselling at homes. It was not possible to distinguish between interventions in which the caregivers received nutrition education and those in which they received no nutrition education in this review.

Treatment for acute malnutrition begins with screening for and identifying children with SAM or MAM through community and facility-based channels. Children with SAM without complications are treated as outpatients, whereas those with complications, bilateral pitting edema, or a poor appetite are treated as inpatients. Treatment typically consists of ready-to-use therapeutic foods, fluid management, antibiotics, and high-dose vitamin A supplementation (if not included in therapeutic food formula). Management of MAM depends on whether it is in a food-secure or food-insecure population (Lenters, Wazny, and Bhutta 2016). Caregivers of children with MAM should be counseled on providing the children with local nutrient-dense foods and implementing other appropriate IYCF practices. In some food-insecure contexts, providing supplementary foods may also be required to meet dietary needs.

The LiST Visualizer model only includes interventions with clear evidence and an associated effect size. The bidirectional nature of wasting and disease incidence makes it difficult to model (and wasting has been included as a cause of child mortality in the LiST model) (Akombi et al. 2017; Troeger et al. 2018). However, to our knowledge, there are no systematic reviews that show an impact of disease- or illnesses-related interventions on wasting. For instance, a recent review on water, sanitation, and hygiene found no effect on wasting estimates (Gera, Shah, and Sachdev 2018). In the absence of systematic reviews, the LiST Visualizer model excludes nutrition-sensitive interventions that may be associated with wasting (other than those provided as part of SAM treatment, such as antibiotics). Thus, potential risk factors such as diarrhea and pneumonia are not included in this section. In section 7.4.3, disease prevention and treatment along with other factors that may help contextualize wasting estimates are discussed.

7.3.2 Sources and availability of data

Estimates on the coverage and performance of nutrition-specific interventions can be obtained through household surveys, program evaluation data, special surveys, and in some cases routine health facility data. Table 7.2 shows the DHS, SPA, and routine data sources for the interventions reported in the LiST Visualizer model.

Table 7.2 Nutrition-specific interventions for acute malnutrition, potential data sources for coverage indicators, and denominators for indicators

Intervention	DHS	SPA	Recommended for routine health facility data
Treatment for moderate acute malnutrition		(B)	
Treatment for severe acute malnutrition		(B)	
Supplementary feeding	(A)		
Nutritional education	(A)	(B)	
		(C)	
Denominators			
(A) Number of last-born children age 6-23 months who are living with their mother (B) Number of facilities with relative service (C) Number of children observed attending facilities for sick child visits			
Coverage Availability or readiness Service delivery Under development No information			

In LiST, preventive services for wasting rely on a proxy indicator of continued breastfeeding, appropriate quantity of diet, and appropriate diversity of diet in children age 6-23 months. However, as of 2019, DHS surveys have included coverage data on growth monitoring and nutrition counselling, which can be considered in conjunction with the current proxy. SPA surveys do not include data on IYCF practices; however, they do provide information on nutrition education, including the availability of IYCF counselling guidelines, provider training on IYCF, and observation of and client exit interviews for breastfeeding counselling during antenatal care and IYCF counselling during sick child care.

Treatment services for SAM are commonly assessed through the semi-quantitative evaluation of access and coverage (SQUEAC), simplified lot quality assurance sampling evaluation of access and coverage (SLEAC), and the simple spatial survey method (S3M) (Isanaka et al. 2018; Myatt 2008; Myatt et al. 2012; UNICEF 2015), all of which require a substantially smaller sample size than traditional household surveys. The SQUEAC method provides semi-quantitative coverage data and barriers to program performance and is generally used to collect data on small catchment areas. Under this method, data are collated from secondary data sources (e.g., from program monitoring; health records; and agriculture, food, labor, and disease calendars) and qualitative data are collected. To obtain coverage estimates, Bayesian analysis can be performed using data from multiple sources coupled with primary data from a small sample. The SLEAC method is intended to capture a wider geographical area than SQUEAC (i.e., usually a district or districts) and is focused on obtaining semi-quantitative coverage estimates. This method uses a systematic spatial sample or quadrats at the first stage of sampling and then identifies current and recovering SAM cases. Similar to SLEAC, S3M is used for wider-scale coverage estimates, but sampling differs in that the first stage of area sampling uses a triangular sampling grid.

SPA surveys include information on whether a facility provides diagnosis or treatment for child malnutrition, has data on inventory (e.g., weight scales, height measurement devices, and tapes for measuring MUAC), and monitors growth as part of curative care services.

Box 7.2 provides potential performance data that can be collected as part of HMIS for the treatment of SAM and MAM, but very few countries report these data in their HMIS (MCSP in press).

Box 7.2 Potential HMIS data for assessing performance of management of acute malnutrition

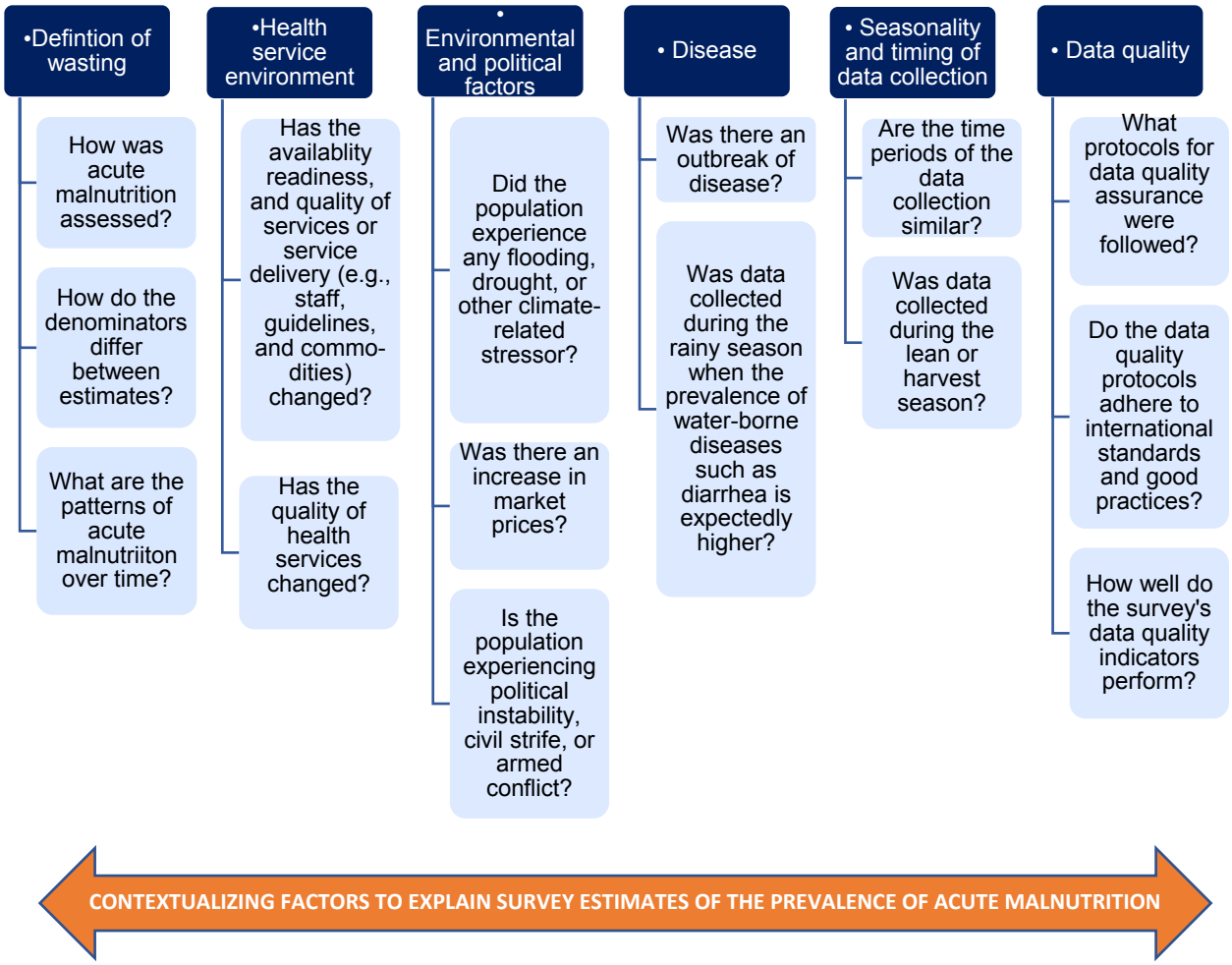
- Percentage of health facilities delivering severe acute malnutrition treatment
- Number of stock outs (break of 1 week or more) of ready-to-use therapeutic food
- Percentage of cases with severe acute malnutrition who have been supported by services
- Percentage of children enrolled in treatment discharged as cured
- Percentage of children enrolled in treatment discharged defaulted
- Percentage of children enrolled in treatment who died

Note: Global recommendations on the routine monitoring of acute malnutrition are under development.

7.4 Considerations for Contextualizing Survey-based Estimates of Wasting

In some cases, survey-based estimates of acute malnutrition can be higher or lower than expected. Because routine data are collected on acute malnutrition and its contributing factors, results can be triangulated with the objective of validating trends over time and contextualizing indicator estimates from household surveys. Figure 7.4 illustrates key factors that can be considered when contextualizing survey-based estimates of wasting.

Figure 7.4 Key factors to help contextualize survey-based estimates of the prevalence of acute malnutrition



7.4.1 Definitions of wasting

HMIS capture anthropometric data on WHZ and MUAC through screening and growth monitoring activities, and these data can be used to help understand estimates of acute malnutrition from household surveys. However, several differences between data sources need to be accounted for when triangulating estimates of wasting derived from household surveys and HMIS.

Comparing wasting estimates using different definitions (e.g., comparing WHZ to MUAC) is problematic because MUAC and WHZ often produce different estimates of acute malnutrition. A recent analysis found that the median proportion of children identified as wasted was higher by WHZ alone than by MUAC using population-representative surveys in humanitarian settings (Leidman et al. 2019). Research has shown that MUAC tends to identify more girls, more stunted children, and younger children than WHZ (Berkley et al. 2005; Bilukha and Leidman 2018; Roberfroid et al. 2015). Differences in classification are not fully understood and there are no adjustments that can be applied to offset these differences

Routine, data collected on WHZ will likely have as the denominator, children that access health facilities, since this is typically where weight and height measurements are performed. Consequently, issues with

coverage bias need to be considered. Further, weight and height data may be prone to substantial measurement error in a facility setting (Laar et al. 2018). MUAC, on the other hand, is often used for screening and referral because it is simpler than weighing and measuring children and because some studies suggest that MUAC is a better predictor of child mortality than WHZ (Berkley et al. 2005; Briend et al. 2012; Burrell, Kerac, and Nabwera 2017; Myatt, Khara, and Collins 2006). Thus, routine estimates of wasting using MUAC will likely have a denominator closer to the general population (e.g., total number of children screened in a catchment area). Despite this advantage, if not accounted for, MUAC data introduce the potential for double counting; this is because children may be screened on a routine basis through active screening in the community and passive screening in facilities, and most HMIS do not track individuals longitudinally.

Changes in how routine data are collected or the quality of the data collection system can also influence trend data and should be accounted for. For instance, if the number of well children being measured increases, this may suggest improvements in the prevalence of wasting; however, in actuality the change could be due to improved reporting at the facility level, resulting in children who were not previously captured making it into the denominator.

Survey-based and routine wasting prevalence estimates should not be directly compared due to differences in how acute malnutrition is assessed and differences in denominators. Nevertheless, estimating the marginal difference between wasting estimates over time between the two data sources may provide some insight into the validity of wasting estimates.

7.4.2 Examine the health service environment

The prevalence of acute malnutrition can be also be understood in the context of availability, readiness, and quality of services or service delivery. Data on availability or readiness, such as distance to the nearest health facility, existence of community-based acute malnutrition programs, and stock outs of ready-to-use therapeutic foods shape the ability of households to seek treatment for wasted children. LiST interventions are coverage indicators that provide information on the extent to which children are receiving preventive and treatment services. The quality of health services includes information such as trained health personnel and treatment cure rates. All of these factors impact the ability to prevent, diagnose, and treat acute malnutrition; in turn, these data can be helpful in contextualizing survey-based estimates of acute malnutrition. For example, higher-than-expected rates of wasting may be related to a sudden decrease in the availability of child curative services. Alternatively, lower-than-expected wasting rates may be explained in the context of an increasing number of health facilities gaining access to weighing and measuring equipment (service availability) and better guidance and training on growth monitoring (service delivery or quality).

There are several caveats when using routine data on preventive interventions to contextualize survey-based estimates of the prevalence of wasting. First, in the LiST model, supplementary feeding and nutrition education interventions are combined. The evidence is based on heterogenous nutrition supplementation interventions, some of which included nutrition education and others which did not, whereas interventions that provided education alone were not shown to be associated with wasting (Clermont and Walker 2017). Thus, nutrition education data alone may provide little benefit when contextualizing wasting estimates (Clermont and Walker 2017). Second, preventive services for wasting may not be well captured in HMIS data since this intervention is commonly addressed through community-based channels and countries are

less likely to collect and report data through HMIS data at the community level. Third, the quality of nutrition education is difficult to capture because data are usually reported by the service providers themselves. Lastly, there is a potential to double count preventive services that are provided both in the community and at health facilities. For treatment-based interventions, the use of rapid assessments (e.g., SQUEAC, SLEAC, and S3M) on the coverage and performance of programs to treat SAM (and potentially MAM) may provide important information, but it is often impossible to validate these results against other data and these data are most often collected in emergency settings.

7.4.3 Other key factors for contextualizing survey estimates of acute malnutrition

Several other factors not included in the LiST Visualizer model may help contextualize survey-based estimates of the prevalence of acute malnutrition:

- **Seasonality and timing of data collection:** Comparing prevalences of acute malnutrition over time and between surveys conducted in the same year but in different seasons is challenging since the prevalence of wasting often fluctuates and changes quickly during the calendar year (UNICEF et al. 2019) and differs by season. Seasonality impacts food security, with different patterns in the lean season than in the rainy season; wasting is expected to be higher during the lean season (WHO 2014), although this relationship is not consistently observed (Young and Marshak 2017). In some contexts, acute malnutrition is observed to peak twice—once after the dry season and once after the lean season (FAO and Tufts University 2019). Therefore, estimates of wasting using household surveys can be influenced by seasonality and the timing of the surveys (Brown, Black, and Becker 1982), which may often coincide with periods of food insecurity and disease (Emergency Nutrition Network 2018).

- **Environmental and political factors:** Estimates of the prevalence of acute malnutrition are better understood in the context of environmental factors such as droughts, flooding, and famine and political factors such as armed conflict. Estimates of the prevalence of acute malnutrition may also vary between different agro-ecological zones (Chakona and Shackleton 2018). Food security can impact acute malnutrition (Altare, Delbiso, and Guha-Sapir 2016) and, in some cases, independently of household wealth (Ali et al. 2013). The Famine Early Warning Systems Network (FEWS NET) is a leading provider of early warning and analysis on acute food insecurity. Interpreting the prevalence of acute malnutrition in the context of data on food insecurity and famines for FEWS NET can be helpful for contextualizing results.

- **Nutrition-sensitive interventions:** Nutrition-sensitive interventions influence the underlying determinants of nutrition and likely have an indirect impact on reducing acute malnutrition, especially if they are implemented within the 1,000-day window covering pregnancy and the first 2 years after birth (UNICEF 2013). Examples of nutrition-sensitive interventions include disease prevention and treatment; water, sanitation, and hygiene programming; and nutrition-sensitive agriculture. The coexistence of poor nutrition and disease leads to what is commonly referred to as a "vicious cycle" whereby inadequate nutrition impairs immunity, increases the risk of infection, and, in turn, creates greater nutritional requirements consequent to the infection (Schaible and Kaufmann 2007). For instance, a spike in the prevalence of measles, diarrheal diseases, respiratory illnesses, and malaria can contribute to a higher prevalence of acute malnutrition, as seen in refugee settings (Toole and Malkki 1992). Disease surveillance, especially data on incidence, may have the greatest potential to provide

further insight into changes in wasting estimates (Akombi et al. 2017; Fernandez, Himes, and Onis 2002; Schlaudecker, Steinhoff, and Moore 2011).

- **Maternal risk factors:** Research is examining the relation between maternal health and nutritional status in the preconception and prenatal periods with the nutritional status of offspring (Eriksen et al. 2017; Owino et al. 2019). Although most studies have focused on and shown an impact on linear growth, maternal nutrition interventions have also been shown to reduce wasting at birth, and small-for-gestational age and preterm birth have been found to be associated with wasting later in life (Christian et al. 2013; Dhaded et al. 2020). Although an appreciation of interventions or other factors that improve the maternal environment are important, their effects on wasting may be slow and difficult to quantity, and thus difficult to capture.

- **Data quality:** Despite international standards for collecting anthropometric data and data quality assurance protocols, anthropometric data remain challenging to measure in the field (Corsi, Perkins, and Subramanian 2017). Data quality issues can arise at various stages including questionnaire design, sampling, training, data collection, data cleaning, and analysis (Namaste, Benedict, and Henry 2018). Some preliminary studies indicate data quality issues may inflate wasting estimates based on findings from work using simulation models (Grellety and Golden 2016). Therefore, when wasting estimates are higher than expected, the need to examine data quality may be particularly important. Both *within* survey data quality checks and comparisons *between* survey sources and over time can be performed.

- Several anthropometric data quality indicators have been recommended by the WHO and UNICEF to assess the quality of wasting estimates in population-based surveys using data internal to the household survey (WHO and UNICEF 2019). Common data quality indicators include incomplete data, implausible data, anthropometric z-score standard deviations, and age ratios and distributions (WHO and UNICEF 2019). These indicators, interpreted in combination, can provide substantial insight into the validity and accuracy of wasting estimates. Nevertheless, data quality indicators are an artifact of both measurement error and heterogeneity and should be viewed in conjunction with contextual factors.

7.5 Recommendations for Using Data to Contextualize Survey Estimates of Acute Malnutrition

To summarize, nutrition-related information from routine health statistics can be helpful in contextualizing survey estimates of the prevalence of acute malnutrition when the estimates are higher or lower than expected. Following are recommendations to consider when using HMIS nutrition data to better understand survey estimates of acute malnutrition.

7.5.1 Review trend estimates for acute malnutrition from routine data but do not make direct comparisons with survey-based estimates

Estimates of acute malnutrition between HMIS and household surveys should not be directly compared because of differences in definitions and denominators. Marginal differences over time between acute malnutrition using the different data sources may provide some insight into the validity of estimates. These differences should be examined with caution because of the many factors that influence estimates over time, such as changes in how the data are collected or the quality of the data. In addition, because household surveys are conducted infrequently (every 3 to 5 years in most countries) and capture acute malnutrition at

one point in time during the months of fieldwork, survey-based estimates of wasting do not reflect rapid fluctuations in wasting (UNICEF et al. 2019). Measures of incidence—that is, new cases of wasting—are different from measures of prevalence (Kismul et al. 2014), but data on incidence are generally not available (UNICEF et al. 2019). Although HMIS don't provide incidence data, more frequent data points can help shed light on the burden of wasting over time.

7.5.2 Assess treatment service coverage and performance indicators from routine data

Coverage and performance indicators on health services relevant for treating acute malnutrition can help contextualize estimates of the prevalence of acute malnutrition. However, without an appropriate denominator, it is difficult to ascertain from HMIS data whether changes in the number of cases receiving treatment is related to changes in coverage of services or to changes in the prevalence of wasting, which would impact the number of children needing or seeking treatment. When coverage and performance data from the SQUEAC, SLEAC, or S3M methodology exists, these data may be more informative than HMIS data, depending on the geographical scope of data collection.

7.5.3 Assess preventive services from routine data and other sources

Coverage and performance indicators of preventive services can further elucidate higher- or lower-than expected prevalences of acute malnutrition obtained from household surveys. The WHO underscores the need for countries to integrate preventive services to successfully reduce the prevalence of wasting (WHO 2014). Coverage indicators of nutrition counselling and the promotion of early initiation of exclusive breastfeeding, continued exclusive breastfeeding, and appropriate complementary feeding can be used as part of a contextualization exercise, as can changes in IYCF outcomes (Harding et al. 2018; Lester, Wazny, Bhutta, 2016). Routine data for nutrition are typically based on the population that accesses services through the health facility; thus, data on preventative services delivered through community channels may not always be available.

7.5.4 Consider data on nutrition-sensitive programming

Because of the multisectoral nature of nutrition (WHO 2014), estimates of acute malnutrition could be better understood in the context of data on nutrition-sensitive interventions. Nutrition-sensitive interventions include policies and programming to improve agriculture, social protection, education, and water and sanitation. However, the effects of nutrition-sensitive interventions on wasting are less clear than the effects of other interventions because they are indirect and more challenging to quantify (UNICEF 2013).

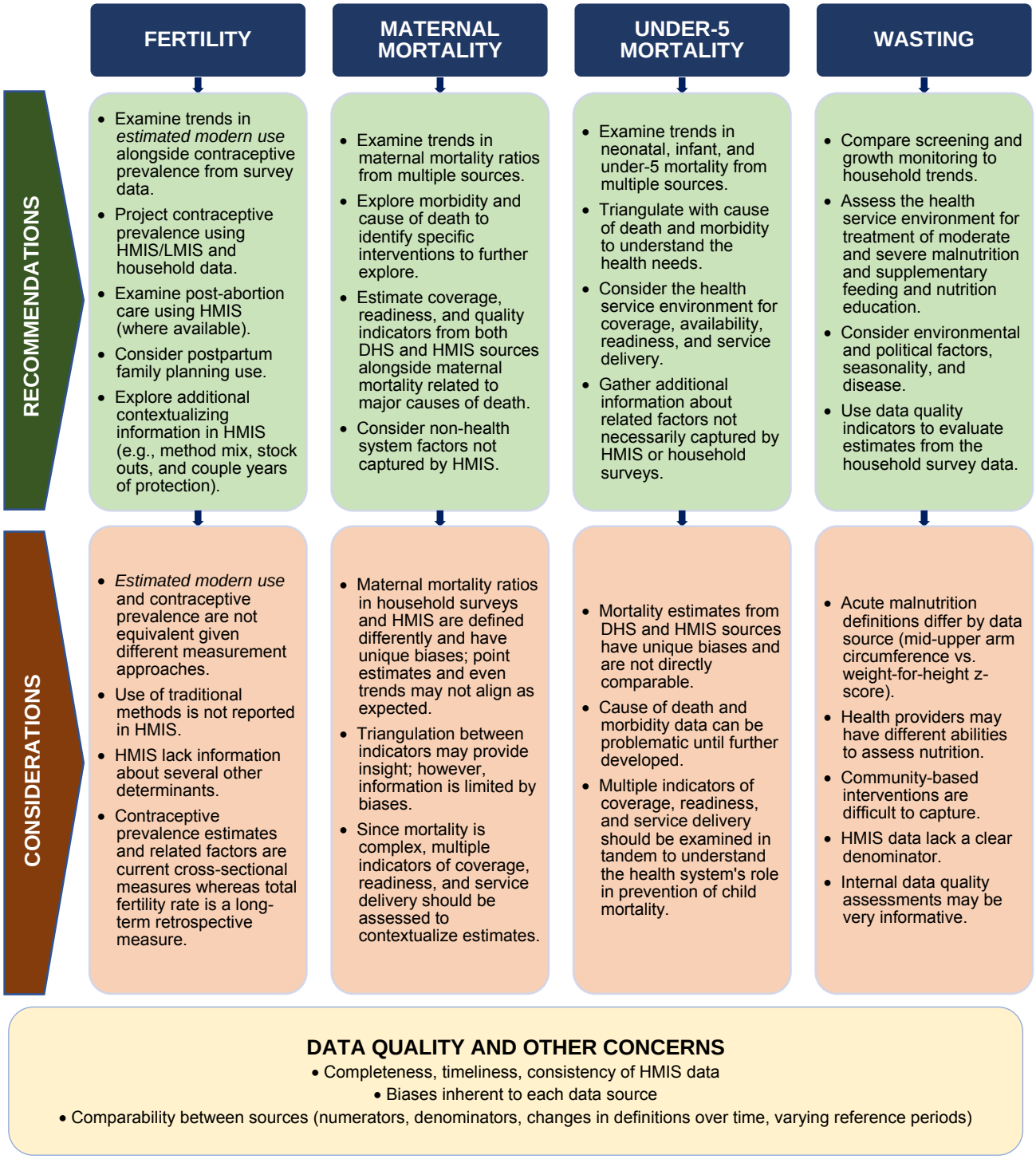
8 CONCLUSION

As countries move closer to universal care seeking at facilities, universal reporting, and universal high quality data, HMIS can provide more comprehensive information on institutional mortality, morbidity, intervention coverage, readiness, and delivery of services. Although HMIS cannot be used to validate survey estimates of RMNCH+N outcomes, given differences and biases in estimating these outcomes, these data are useful for contextualizing outcomes of household survey-based estimates.

HMIS data can provide information about intervention coverage, readiness, and quality of the delivery of services being provided at health facilities, which are critical factors that shape women and children's health and nutrition outcomes. HMIS indicators can be calculated as stand-alone indicators using numerators and facility-based denominators or by combining HMIS numerators with population-based denominators. HMIS data also can be included as inputs in sophisticated statistical models to produce precise estimates of coverage or outcomes. Thus, these data can provide policy and program stakeholders with powerful messages.

Future research should examine indicators from multiple data sources in parallel, by triangulation, or independently from each other and should integrate data sources when possible. Moreover, when triangulating to contextualize household RMNCH+N estimates, a holistic approach should be taken. Figure 8.1 summarizes the recommendations and considerations for each outcome.

Figure 8.1 Recommendations and considerations for contextualizing survey-based estimates of key reproductive, maternal, child health, and nutrition outcomes



In conclusion, the RMNCH+N outcomes described in this report are complex, and many factors should be considered when attempting to shed light on how a health system can measure and explain the state of the outcomes. It is imperative that several indicators—ideally the indicators most related to the most effective interventions that prevent the most common causes of death—be examined in tandem. Not only measuring the outcomes but also measuring the key determinants, causes, and interventions can provide additional context to help answer questions about why the trends in these outcomes have changed, perhaps in unexpected ways. Although it is not advisable to directly compare estimates of outcomes, given differences in data collection, we recommend examining marginal differences over time between the RMNCH+N outcomes captured by HMIS and survey-based estimates. Comparing overlapping indicators of interventions (i.e., indicators measured by multiple data sources) may also provide insight about the health system in relation to preventing maternal and child mortality and diagnosing and treating malnutrition.

Before attempting to draw conclusions from HMIS data, it is critically important to consider the completeness of reporting and the quality of the data; emerging research is beginning to document methods for correcting biases inherent to HMIS data. Any triangulations or comparisons should be made with the understanding of biases attributable to each data source. Future research should seek to integrate data to more comprehensively inform health systems. Current efforts to better define measures of effective coverage are beginning to do this, but more can be done to incorporate data from multiple sources.

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APPENDIX

Figure A.1 LiST Visualizer framework for maternal mortality

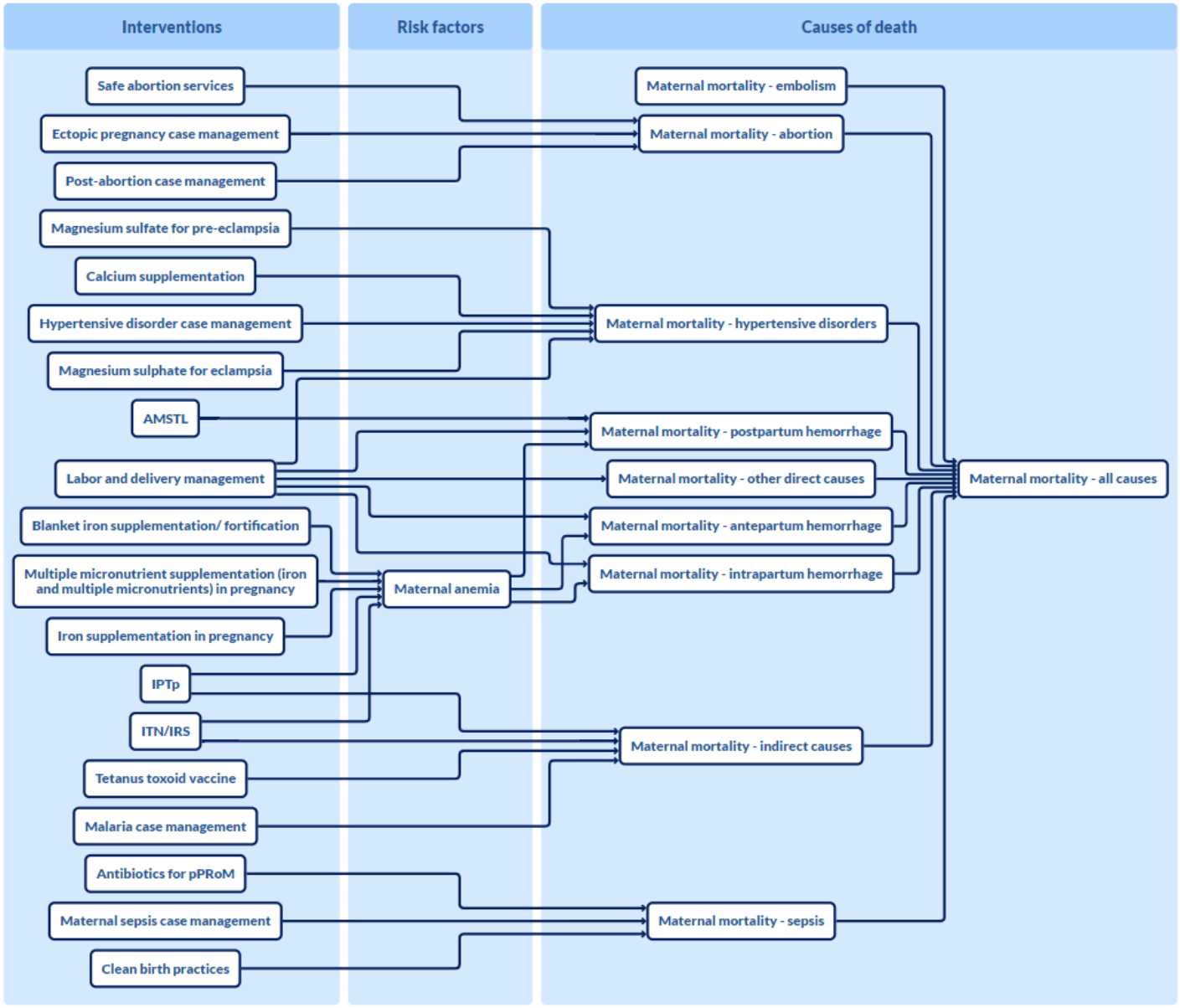

Figure A.2 LiST Visualizer framework for neonatal mortality (1-59 months)

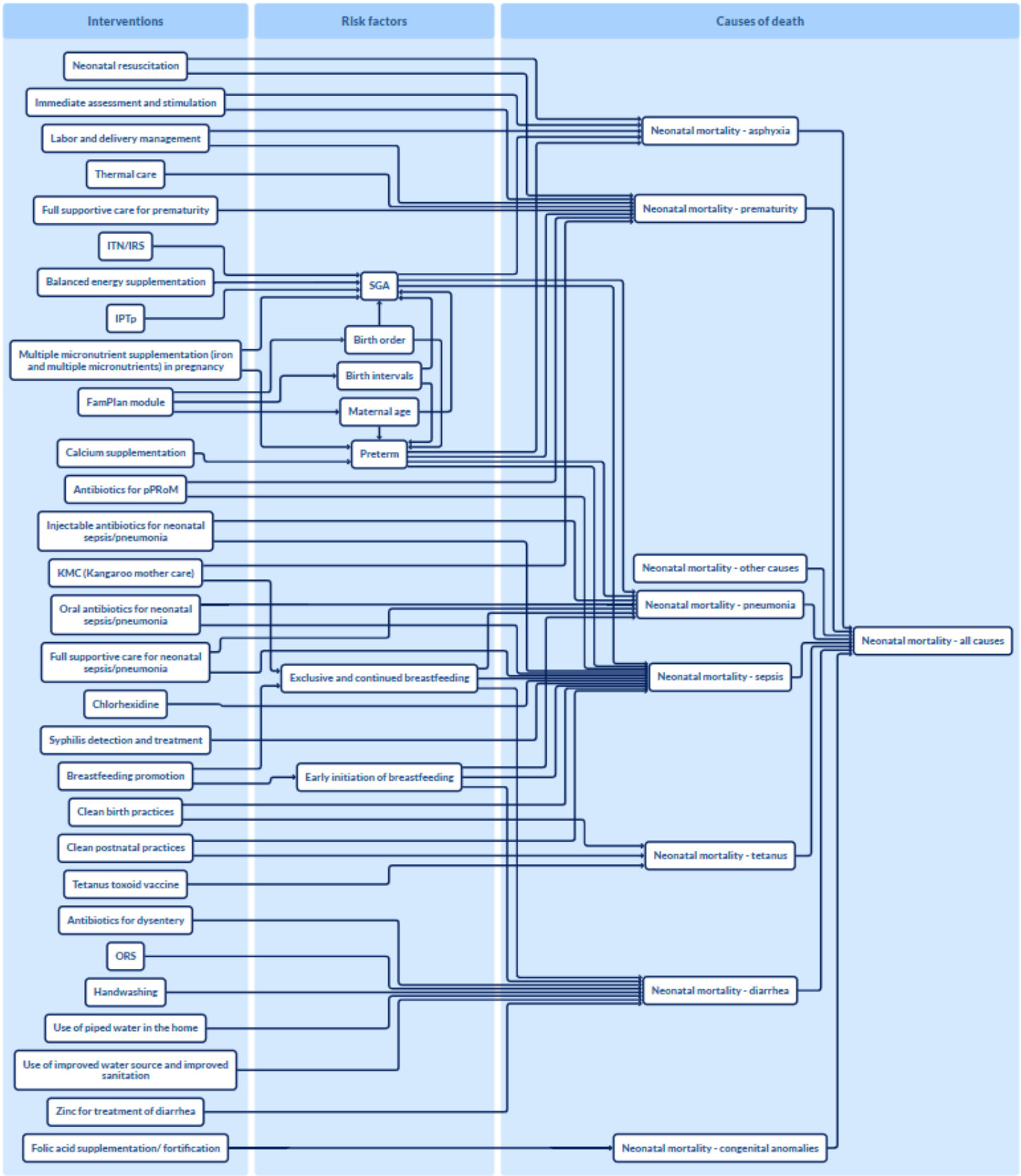

Figure A.3 LiST Visualizer framework for child mortality (1-59 months)