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Underlying Determinants of and Solutions for Malnutrition in Low- and Middle-Income Countries

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LEARNING OBJECTIVES

- Describe the purpose of the Sustainable Development Goals and understand systems approaches to nutrition
- Define the concept of nutrition-sensitive approaches and provide examples from sectors such as agriculture, education, and social safety nets that tackle underlying determinants of malnutrition
- Discuss challenges of implementing nutrition-sensitive approaches and measuring progress to address malnutrition in all its forms

Case Study: Double Burden of Malnutrition in Egypt

Egypt is struggling with the double burden of malnutrition: 21% of children under the age of 5 are stunted, 8% are wasted, and 15% are overweight.[1] This reflects a decline in childhood stunting (down from 35% in 1988), yet the current rates are 20% higher than expected for a country with Egypt's GDP.[2] These trends also reflect a rapid increase in overweight; 85% of adult women are overweight or obese, compared to 58% in 1992.[1] The double burden is present not only at a national scale but also at the household and individual levels: in 2014, 34% of children who were stunted were *also* overweight.[2]

What kind of underlying determinants account for Egypt's declining yet stubbornly high rates of undernutrition and rising rates of overweight and obesity? Egypt has seen marked improvements in its health systems infrastructure over the past few decades, but some things lag behind. Whereas urban residents have almost universal access to improved toilet facilities, 14% of rural residents lack access.[1] Rural areas are more likely to see childhood stunting, whereas urban residents are more likely to be overweight,[1] have diets higher in fat,[3] and consume more convenience foods.[4] Egyptian diets are trending toward more fats, meat, and dairy.[3] Convenience foods such as sugary cakes and cookies are commonly given to children under 2, and these foods have even been found to be perceived as "ideal" complementary foods by some caregivers.[4]

Nutrition in Egypt is also interwoven with larger issues of equity, stability, and agricultural production. Egypt is ranked at 134 out of 144 countries on the Global Gender Gap Index.[5] Only 25% of women participate in the labor force compared to 80% of men, and women's literacy rates lag 15%

behind men's.[5] This is important in light of the fact that the children of women with higher educational attainment are less likely to be stunted.[1] When the global price of staple grains spiked in 2007–2008, soaring prices for bread in Egypt prompted riots that were interlinked with underlying political unrest in what was known as the Arab Spring. Like many countries, food prices in Egypt are influenced by global trends. Egypt imports the majority of its food supply, and the country's dependence on the River Nile for agricultural irrigation poses some unique susceptibilities to climate change.

Addressing both undernutrition and overweight in Egypt will require multisectoral approaches that address many of the "building blocks" described in this chapter—food production, systems infrastructure, health systems, equity and inclusion, and peace and stability. Any approach will also need to be context specific, as Egypt displays remarkable heterogeneity across its geographic and social contexts.

Addressing Underlying Determinants of Nutrition in LMICs Requires Systems Approaches

The Sustainable Development Goals (SDGs)

The **Sustainable Development Goals**—the SDGs—call on the world to approach development differently—that is, to see development across the goals as part of an *integrated whole* and that each goal, working in tandem with the other goals, is essential in order to achieve meaningful, impactful development (figure 13.1). The goals call for all people to work collectively and to do so in a *universal way*, one that ensures no one is left behind on the path toward sustainable development. Nutrition is central to this path. The main architects of the SDGs intended to create a universal agenda and roadmap that was relevant for every country, in contrast to the Millennium Development Goals, which focused on countries dealing with absolute poverty. With this grand agenda, the SDGs also bring significant implications for how to achieve nutrition for everyone.

The SDGs focus on areas such as climate change and natural resources, economic growth, peace, infrastructure, education, and women's empowerment. Many of these areas serve as core underlying determinants of sound nutrition, or are impacted by nutrition. Additionally, two of the SDG targets directly relate to nutrition: SDG 2.2 and SDG 3.4, as box 13.1 illustrates.

Addressing Nutrition-Related SDGs Requires Systems Thinking

Many systems, sectors, disciplines, and actors must come together if the world is to address the multiple burdens of malnutrition. As stated in a letter to *The Lancet* about the SDGs, "system[s] thinking requires a change in mindset: recognizing that the whole is greater than the sum of its parts and contrasting with a traditional, reductionist approach."[6] This allows for a different way of interlinking, analyzing, and solving challenges that moves away

Figure 13.1. Sustainable Development Goals.

from traditional problem-solving in which a complex system is divided into smaller, more digestible parts in isolation.

A **system** can be defined as a network of interconnected parts that operate toward a purpose.[7] The characteristic of interconnectedness is key: changing one part of the system affects other parts. Systems can be categorized by their complexity. A **simple system**, for example, may have just a few elements, and the relationship between those elements may be stable and predictable. An example of a relatively simple system is an automobile: when you press the gas pedal, a throttle valve opens to allows air into the engine. In this way, the gas pedal and the engine are connected in a (hopefully!) predictable way. On the other hand, a **complex system** may have many elements, and the relationships between these elements may be unknown, unpredictable, or they may adapt over time. For example, body weight is not influenced by a single element such as caloric intake; the effect of caloric intake on body weight may be influenced by hormonal signals and changes in the body's metabolic processes over time, and these factors may be further influenced by human behavior and other environmental factors. Table 13.1 shows additional characteristics of complex systems, with examples that draw from the chapter. Using **systems thinking** to address nutrition in low- and middle-income countries (LMICs) involves acknowledging that different components of the system are interconnected and leveraging the interconnectedness of the components rather than ignoring it (see box 13.2).

Box 13.1. Selected SDGs Directly Related to Nutrition

2.2: By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons

- **2.2.1:** Prevalence of stunting (height for age <–2 standard deviation from the median of the World Health Organization [WHO] Child Growth Standards) among children under 5 years of age
- **2.2.2:** Prevalence of malnutrition (weight for height >+2 or <–2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)

3.4: By 2030, reduce by one-third premature mortality from noncommunicable diseases through prevention and treatment and promote mental health and well-being

- **3.4.1:** Mortality rate attributed to cardiovascular disease, cancer, diabetes, or chronic respiratory disease

Table 13.1. Characteristics of Complex Systems

Characteristic of complex systems	Description	Example
Bidirectional feedback	Two components may affect one another	Undernutrition makes children more susceptible to infectious disease, and infection makes children more susceptible to undernutrition.
Time-delayed responses	Some impacts may not be felt immediately	Exposures to undernutrition during gestation or early life can increase the likelihood of obesity or chronic disease in later life.
Nonlinear relationships	A small change in the system may produce disproportionately large effects	Multiple interventions may produce outcomes that are greater than the sum of their parts. For example, combining micronutrient supplementation with psychosocial stimulation may have synergistic effects on children's cognitive development.
Convergence	Many routes may lead to the same outcome	There is not just one reason that a household could experience increased income; possible sources of income generation include trading high-value agricultural crops or participating in a social safety net program.
Divergence	One route may produce many outcomes	In households where livestock is kept separate from living quarters, raising chickens could help nutritional status through intake of animal-source foods or income generation. But in households where livestock is not separate from living quarters, children's exposure to *Campylobacter* could increase risk of environmental enteric dysfunction and impaired growth.

Box 13.2. Addressing Obesity in LMICs Requires Systems Thinking

Obesity poses a major challenge to the health systems of low- and middle-income countries (LMICs) that are simultaneously struggling with undernutrition and infectious disease. Obesity is an example of a health problem that is created by complex systems and underlying drivers and that requires systems thinking to solve.[38,39] Using systems thinking to address obesity in LMICs means acknowledging the underlying factors that drive obesity, planning interventions that work at multiple levels, and being aware of unintended consequences that may result from single interventions. Although individual-level factors such as knowledge and individual behavior are important, interventions that focus solely on individuals are unlikely to be successful in the absence of efforts to also address societal shifts toward sedentary work and leisure, built environments and food environments, and the larger social and economic factors that shape the architecture of consumers' choices within these environments.

Take, for example, the issue of young children in LMICs consuming packaged convenience foods. These foods are highly palatable, socially desirable, rich in calories and sugar, and largely devoid of the micronutrients frequently lacking in the diets of low-income populations. The convenience of these foods appeals to families with less time to prepare food, such as families with women entering the workforce. These foods are also typically cheaper than nutrient-rich, perishable foods such as fruits, vegetables, and animal-source foods, owing to their shelf stability; this is especially important in rural areas, where fresh seasonal fruits and vegetables are less likely to survive transport without cold storage. Interventions to decrease consumption of packaged convenience foods among youth can include efforts to change individual choice, but they should also address the relative price and accessibility of more nutritious options, factors that increase the desirability of these foods (such as food advertising targeted toward children), and the underlying conditions that affect food-related behaviors and physical activity (such as employment and neighborhood safety and walkability).

It is difficult to characterize food environments in LMICs as they vary by setting, but there are a number of common challenges. Many LMICs are experiencing patterns of rapid urbanization. Many families leaving rural areas are discontinuing agricultural livelihoods, and in urban areas they are more likely to engage in sedentary occupations.[40] Urbanization also means that women are more likely to enter the formal workforce, which may change their caregiving behaviors. Easy access to convenience foods is one manifestation of rapidly changing food systems in LMICs. LMICs are seeing a rapid proliferation of modern retail outlets rather than traditional markets, increased availability of processed foods, and a trend away from preparing food at home.[41] What is unique and concerning about LMICs is that these changes are still taking place in settings with high rates of micronutrient deficiencies and impaired physical growth, which some characterize as the triple burden of obesity, micronutrient deficiency, and undernourishment.[42]

Addressing obesity in LMICs requires a range of systems-oriented interventions. It should be noted that when intervening on underlying causes, it can be more challenging to demonstrate impact. For example, whereas a sugar-sweetened beverage (SSB) tax (a more proximal intervention) can be studied to assess whether increased prices decrease SSB purchases, for a more distal intervention like investing in urban planning to promote neighborhood safety and walkability, it can be challenging to attribute changes in health outcomes to the intervention. However, this should not be a reason to disengage from the work, but rather it should reinforce the need for research methods, including those from systems science, that are designed to embrace the complexity of the issue.

The Importance of Nutrition-Sensitive Approaches

What Are Nutrition-Sensitive Approaches?

Nutrition-sensitive approaches are approaches that attempt to address the underlying determinants of malnutrition, such as those listed in figure 13.2. Figure 13.2 is an adaptation of the classic UNICEF model of the determinants of undernutrition and undernutrition-related mortality. This rendition depicts the key immediate and underlying causes of malnutrition at the household level as in the UNICEF model. But, whereas the original UNICEF model then depicts "basic causes" such as country-level conditions that shape household conditions, we have substituted "the SDG building blocks" (which are discussed in depth later in the chapter) to provide more specificity about what conditions can be addressed in order to support improved underlying household determinants. Both interventions on the underlying determinants and on the building blocks can be thought of as nutrition-sensitive approaches. Nutrition-sensitive approaches have indirect causal associations with reductions in malnutrition, meaning they impact malnutrition indirectly through mediating mechanisms, rather than directly impacting malnutrition. These approaches include interventions on agriculture and food systems; water, sanitation, and hygiene (WASH); social protection; women's

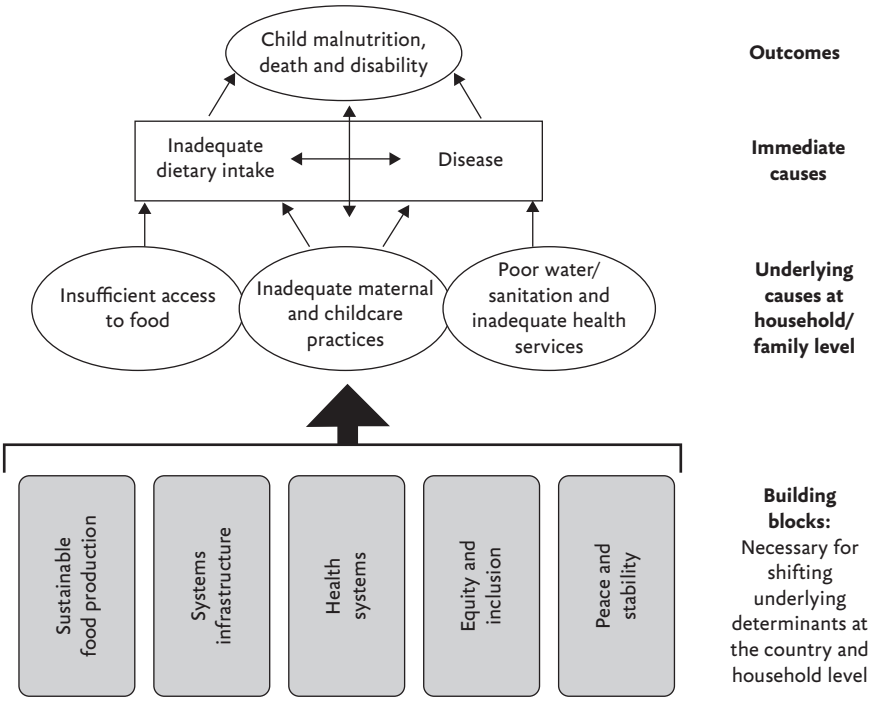

Figure 13.2. Conceptual diagram. *Source:* Adapted from the UNICEF Conceptual Framework[11] and the 2017 Global Nutrition Report.[12]

empowerment; and early childhood development programs. Nutrition-sensitive approaches can serve as delivery platforms for nutrition-specific interventions, which are focused on the more immediate causes of malnutrition shown in figure 13.2, such as inadequate dietary intake or infectious disease. Yet, little research has identified the ways in which individual interventions contribute or interact with larger multisectoral collaborations, nor has it examined the most efficient and systematic measurements to evaluate outcomes when nutrition-specific and nutrition-sensitive approaches are considered as a "package."[8]

Nutrition-sensitive interventions are vital because it is estimated that if nutrition-specific interventions were scaled up to 90% in the 36 countries with the highest burden of stunting, only 20% of stunting would be addressed.[9] In countries that have more successfully addressed undernutrition, much of the reductions have come from nutrition-sensitive approaches. An analysis of stunting rates in 116 countries between 1970 and 2012 showed that key drivers of stunting reductions were safe water access, sanitation, women's education, gender equality, and the quantity and quality of the food supply.[10]

Below we briefly discuss some of the pathways through which nutrition-sensitive approaches can impact malnutrition outcomes.

Ways That Nutrition-Sensitive Approaches Can Address Undernutrition

Given the importance of addressing underlying determinants of undernutrition, what do nutrition-sensitive approaches look like?

Agriculture

It is clear that agriculture and nutrition are linked: in order for nutritious foods to be consumed, they must first be cultivated, distributed through supply chains, and made available for purchase at an affordable price. Food producers in many LMICs are predominantly smallholder farmers with limited financial capital.[13] When it comes to food producers, there are two main pathways through which agriculture can impact nutrition: producers can grow a greater quantity and diversity of foods for their own consumption, and they can grow a greater quantity and diversity of foods to generate income through trade or exchange. Some interventions for **homestead food production**—in which participants are given resources and training to create or improve existing systems of household crop production, animal husbandry, or aquaculture—have shown improvements in outcomes such as dietary diversity, consumption of animal-source foods, and income.[14] Homestead food production is not the only way to intervene at the level of agriculture; equally important are efforts to improve the micronutrient content of the food supply through biofortification (i.e., selectively breeding for

crops with greater micronutrient content)[15] and to strengthen the supply chains through which food is distributed.[16,17]

Improving Health through Water, Sanitation, and Hygiene (WASH)

Childhood infection and undernourishment are linked in a vicious cycle: as discussed in chapter 9, infection exacerbates undernutrition, and children who are undernourished are more susceptible to infectious disease and may take longer to recover.[18] In the past decade, a new direction in child nutrition research has examined the interplay between improving infant and young child feeding and the WASH environment to address a condition known as environmental enteric dysfunction.[19] Environmental enteric dysfunction is a condition of subclinical infection hypothesized to be associated with chronic exposure to poor sanitary environments. A key mechanism by which children develop environmental enteric dysfunction is that many infants and young children in low-resource, rural settings are frequently in contact with soil that has been contaminated with fecal microbes from livestock, and children of this age engage in exploratory mouthing behaviors as part of their sensorimotor development.[20] Some interventions have sought to improve household WASH conditions by improving access to clean water, providing physical infrastructure such as latrines, and promoting maternal hand washing and sanitary food preparation. These interventions may decrease levels of fecal contamination in the larger household environment, but decreasing levels of fecal contamination in areas immediately surrounding children—including their hands—is more challenging. The concept of "baby WASH" describes targeted efforts to reduce the ingestion of fecal microbes by children under 2 years of age,[21] and baby WASH interventions are now being integrated with early childhood development interventions.

It is estimated that environmental enteric dysfunction may contribute substantially to the child stunting burden through increasing gut permeability to infections and by contributing to chronic inflammation and decreased nutrient absorption, all of which may impair growth.[22] Approximately one-tenth of the world's population lives in conditions of extreme poverty in which conditions of poor sanitation and hygiene are prevalent,[23] and children are more likely to experience environmental enteric dysfunction during critical periods of physical and cognitive growth. Some data suggest that in addition to undernutrition, childhood stunting and repeated gut infections also place individuals at an increased risk for obesity in later life.[24]

Education and Early Child Development

Higher educational attainment for girls is linked with delayed first marriage, lower fertility rates, and greater empowerment, all of which have the potential to improve the nutritional status of infants, girls, and women.[25] There are many ways that higher parental educational attainment can lead to posi-

tive nutritional outcomes for children—education can enable higher potential for household income, higher levels of nutritional knowledge, and better performance of protective caregiver behaviors such as ensuring that children receive immunizations and micronutrient supplementation.[26]

In addition to the educational status of caregivers, the educational experience of children is also important, especially during periods of early childhood development. The first 1,000 days of life (conception through 2 years of age) is an especially important period for physical and cognitive development. Intervention studies have demonstrated that when children receive both nutrition interventions and increased psychosocial stimulation—referring to physical, sensory, and emotional input through play and other activities—they see synergistic benefits for both physical and cognitive development.[27]

Social Safety Nets

There is a strong, well-documented link between poverty and undernutrition. When households have enough resources, they are able to live in improved sanitary conditions, achieve higher educational attainment, access health services, and purchase nutrient-rich foods (which may be more expensive than starchy staples or convenience foods).[28] **Social safety net programs** are programs intended to provide basic goods, services, or care to individuals in need in order to protect against poverty and hardship. In the context of nutrition, the most relevant social safety nets might be programs that provide cash or food to low-income households. Programs that transfer food can take many forms, including school feeding programs or distributing rations of micronutrient-fortified foods (such as corn–soy blends) during emergency situations. Programs that transfer cash can take the form of subsidizing the cost of food (such as India's National Food Security Program, in which eligible households can purchased staple grains at subsidized prices), unconditional cash transfers, and conditional cash transfers. With conditional cash transfers, benefits are not received unless certain criteria are met; for example, a family may have to agree to immunize children or enroll children in school. In general, while cash transfer programs have been shown to have a consistently positive impact on some determinants of childhood nutrition such as dietary diversity and the physical and mental health of caregivers, outcomes related to improvements in child growth have been mixed.[28,29] Conditional and unconditional cash transfer programs are discussed at length in chapter 16.

Challenges of Nutrition-Sensitive Approaches

Even though the majority of reductions in undernutrition are associated with observed changes in underlying causes such as poverty, education, and sanitation, implementing nutrition-sensitive approaches does not always

guarantee that there will be quick, measurable improvements in nutritional status. There are two major challenges: measurement and implementation.

Nutrition-sensitive approaches pose several measurement challenges. One measurement challenge is the choice of outcome. Stunting—height-for-age more than 2 standard deviations below the WHO Child Growth Standards median—has been chosen as an indicator of chronic undernutrition. It is difficult to shift population-level rates of stunting within the course of a single intervention, and given the multigenerational influence of maternal stunting on children's nutritional status, it can be difficult to achieve full growth potential within a single generation.[30] Additionally, efforts to reduce stunting may be most effective during the first thousand days of life—conception through 2 years of age—as this is a critical window for growth and development (although efforts outside of this window can also have an impact).[31] We could choose more proximal indicators that are likely to be more responsive to interventions, such as dietary diversity or protective behaviors (e.g., responsive feeding). But more proximal indicators may not always translate into impact. For example, a homestead food production intervention may improve dietary diversity; but if the increased dietary diversity is not also linked to improvements in child growth and other health outcomes, has the intervention created true health impact?

Another measurement challenge of nutrition-sensitive approaches is the complexity of causal pathways. The previous section described different categories of nutrition-sensitive approaches, and these interventions are highly interlinked. For example, if a family has increased income—either from selling high-value agricultural products or benefitting from a social safety net program—they may be able to build a concrete floor, which may reduce children's exposure to enteric infection. This synergistic impact of nutrition-sensitive approaches is a positive, but it also poses a measurement challenge; in this example, would a positive outcome be attributed to the income, the high-value agricultural products, the social safety net program, or the concrete floor? Does it matter whether the net increase in income is stemming from high-value agricultural products or a social safety net program?

One of the key challenges of implementing nutrition-sensitive approaches is that it is difficult to intervene in ways that truly alter underlying conditions. Although many observational studies have found associations between poor sanitary conditions and nutritional status, experimental studies in which communities are randomized to receive interventions for improved WASH conditions in Bangladesh,[32] Kenya,[33] and Uganda[34] have struggled to demonstrate that the WASH interventions improve nutritional status. This does *not* mean that WASH truly has no impact on nutrition; rather, it reflects the difficulty of creating meaningful improvement WASH conditions in ways that produce substantial reductions in environmental enteric dysfunction and impaired growth. WASH interventions raise an important question: if

the nature of common interventions does not meaningfully alter underlying conditions that lead to environmental enteric dysfunction in children, what *would* meaningfully alter these underlying conditions? Some would argue that broader efforts to alleviate poverty would more effectively enable people to improve their standard of living, but broad-based poverty alleviation efforts are also challenging to implement. One such example was the Millennium Villages Project, which worked in 10 countries in sub-Saharan Africa to help rural areas achieve economic development through simultaneous interventions in infrastructure, entrepreneurial opportunities, education, agriculture, and health—an attempt at a multisectoral approach to development. While the villages saw improvements in agriculture and maternal health, they did not achieve all desired outcomes, such as improvements in poverty and malnutrition. The Millennium Villages Project is an example of not only the potential of such multisectoral interventions but the immense challenges of implementing them.[35]

Another challenge of implementing nutrition-sensitive approaches is that they are highly context specific. Between any two settings, there is huge variation in the underlying nutritional challenges and in how an intervention would play out given those challenges. For example, a social safety net program that provided food and conditional cash transfers to rural communities in Mexico resulted in both positive changes (e.g., improved dietary quality at the household level) and unfavorable changes—participants who were overweight or obese at the beginning of the program showed an increase in their caloric consumption because the program's in-kind transfers included many energy-dense, nutrient-poor foods.[36]

A further challenge of implementation is that some interventions involve tradeoffs with other interventions. For example, the presence of animals poses a tradeoff: although livestock can be a source of income (if they are sold) or micronutrients (if animal-source foods are consumed), they also create an environment that increases the risk of environmental enteric dysfunction, as described in the section on WASH interventions above. Raising chickens, for example, is frequently promoted as part of homestead food production interventions, but chickens are a prime source of *Campylobacter*, which is linked to environmental enteric dysfunction.[37]

It should be noted that for most of the nutrition-sensitive approaches described in this chapter, results have displayed remarkable heterogeneity in their impact across a range of outcomes. For example, homestead food production interventions have shown mixed results in terms of their ability to improve dietary intake, micronutrient status, and growth. The context of the intervention matters: in settings where health systems infrastructure is weak and the burden of infectious disease is high, even the most rigorously implemented agricultural strategies will find it difficult to improve nutritional status.[14] Heterogeneous results do not indicate that an intervention is not

worth doing, but they reinforce that it is important to carefully document research methods and findings to inform adaptations to other contexts.

Nutrition and the Building Blocks of the SDGs

This section walks through each of the SDG building blocks in figure 13.1. The building blocks reflect specific conditions that can be addressed in order to improve the underlying household determinants of malnutrition. How do we ensure that the SDGs are meaningful for nutrition? First, we must have integrated action. In the Global Nutrition Report, a standalone, independent report that is published every year on the global status of nutrition, a roadmap was created to demonstrate integrated action using the SDGs as a framework.[12] Each SDG was accounted for by asking: How can nutrition action help achieve this goal? And how does each goal influence nutrition?

The report outlined five areas where there are shared SDG agendas with nutrition. These five areas are depicted as "building blocks" in figure 13.1. First, nutrition can help deliver on more sustainable food production, which includes climate change objectives and more species diversity on land and seas. Second is the infrastructure agenda. Nutrition can improve the "gray matter infrastructure," or brainpower, that builds knowledge-based economies vital for national futures. As discussed in chapter 11, the chronic undernutrition that results in physical growth stunting also contributes to developmental stunting, which impacts nations' human capital. We also need systems infrastructure such as technological systems, roads, sanitation, and electricity to deliver services including food, water, and energy to both rural and urban places. Third, the health agenda is indivisible from nutrition. Moreover, better nutrition would reduce the burden on health systems. Yet health systems could do much more to prevent and treat undernutrition and diet-related noncommunicable diseases including interventions such as exclusive breastfeeding promotion or the management of cardiovascular disease. Fourth, addressing poverty, quality education, gender equality, and decent work will further move the world toward equity and inclusion and will influence nutrition through a variety of pathways, such as impacts on family planning and reproductive health, increased incomes for food purchasing and knowledge about healthy eating, and greater participation of women in nutritional decision-making. Fifth, nutrition is essential for peace and stability, and vice versa. The impacts of conflicts and social unrest on undernutrition are increasing.[38] Investing in food security and the fair distribution of natural resources is critical for both nutrition resiliency and reduced fragility.

Sustainable Food Production

With an expected global population of 10.5 billion by the year 2050, it is essential that we produce food in a way that truly sustains us, now and

into the future. Food production includes crops, animal agriculture, and aquaculture.

Do we produce enough food to feed the world now? According to FAO Food Balance Sheets,[39] we produce enough food globally to provide an average of 2,884 calories and 81 grams of protein per person per day, excluding some losses and nonfood uses such as livestock feed and biofuel. Though this global average production surpasses the daily needs of a typical adult, it is clear that the food we produce is not allocated in ways that prevent undernutrition and micronutrient deficiency in all populations. Food is not distributed equally between countries (e.g., per capita caloric availability is 3,768 kcal/day in Austria, compared to 1,930 kcal/day in Zambia), nor is it distributed equally within countries. Furthermore, it is not just about the number of calories available; the quality of the food supply—including whether food is safe from foodborne illness, free of mycotoxins and other contaminants, and rich in diverse food sources of micronutrients—is also important. For example, 65% of protein intake originates from plant sources and 35% from animal sources worldwide, but these proportions are nearly reversed in the United States;[40] whereas plant-based protein sources are rich in fiber and beneficial phytochemicals, for many micronutrients of public health concern (such as iron and zinc), animal sources provide greater density and bio-availability.[41]

In addition to the fact that our current global population is not served well, the ways we produce food now may threaten our future ability to do so. **Sustainability**, in broad terms, refers to the capacity to meet current goals without compromising future capacity. There are a number of ways that current methods of food production, in both high-income countries and LMICs, are unsustainable. In terms of agricultural production, major issues include expanding agricultural land use,[42] soil erosion,[43] and dependence on synthetic fertilizers sourced from finite resources. As an example of the latter, nutrients commonly applied to soil to enhance fertility include nitrogen, phosphate, and potassium. Although the global supply of nitrogen is basically unlimited in its atmospheric form, "fixing" atmospheric nitrogen to convert it into ammonia—the form that plants can utilize—is done through the Haber Bosch process, which relies on hydrogen derived from finite resources such as fossil fuels.[44] Additionally, phosphorous is derived from phosphate rock, which is another finite resource.[44]

Complementary to terrestrial food production are marine resources, which include fish, mollusks, crustaceans, algae, and aquatic plants such as seaweed. The global stock of capture fisheries (which refers to wild-caught fish) peaked in 1996 and has since gradually declined,[39] and aquaculture (breeding in controlled environments) provides more than half of the global supply of fish for human consumption.[45] There is remarkable heterogeneity in aquacultural species and practices. Issues that influence the sustainability

of marine resources include overfishing, pollution, and ocean acidification, which results from increased atmospheric carbon dioxide. Also relevant is the choice of fish feed—using small, wild-caught fish is not sustainable given the growing global demand for fish, yet switching to crop-based feed ingredients such as soy has the potential to place further strain on agricultural resources.[46]

Many of these issues are likely to be exacerbated by climate change. **Climate change** entails shifts in global climate patterns linked to solar output or altered atmospheric composition; increased levels of greenhouse gases (including carbon dioxide, methane, nitrous oxide, and fluorinated gases) contribute to atmospheric warming, which affects ocean temperatures, sea level, precipitation patterns, and extreme weather events. As a result of climate change, access to food may be limited due to conflict over scarce land and water resources.[47] Food prices may increase due to volatility in food production resulting from unpredictable climate patterns.[48] The protein and micronutrient content of certain staple grains may decline given increased atmospheric carbon dioxide.[49] Susceptibility to infectious disease, which is linked to undernutrition, may be heightened due to changes in precipitation patterns, displacement, and crowding.[50] Aquaculture may be impacted by direct physical effects of climate change (e.g., changes in sea level and ocean temperatures) and biological responses to these physical effects (e.g., changes in the locations and abundance of different species and pathogens).

For current food production systems to be sustainable, they also need to be resilient to the short- and long-term impacts of climate change. **Resilience** is the capacity of a system to withstand and adapt to disturbances over time. Of the poorest billion global residents, 75% live in rural areas and depend on agricultural livelihoods.[51] In Asia and Africa, average farm size is quite small, and so many of these more vulnerable producers are smallholder farmers. In addition to producing food for themselves, these residents produce food for the rest of us. Ways of improving the resilience of smallholder farmers include breeding seeds that are resilient to drought or flood, increasing the biodiversity of food production, and using effective water management practices. Many of these efforts fall under the category of **climate-smart agriculture**, which describes agricultural approaches that aim to increase agricultural productivity in ways that reduce or remove greenhouse gas emissions and build resilience to climate change.[52]

Systems Infrastructure

Providing healthy, nutritious food to a growing population that increasingly lives in urban environments is another major public health nutrition challenge. Currently, 54% of the world's population live in cities. By 2045, the number of people living in cities is expected to increase by 2 billion.[53] The rapid growth in **urbanization** is concentrated in low- and middle-income

countries, which are home to over 80% of the 550 and growing "megacities" around the world with over 1 million residents. While living in urban environments is often associated with some health benefits, such as better access to health care and improved water, nutrition and physical activity patterns can be compromised, and living in urban environments is associated with increased risk of chronic diseases in some LMIC contexts.[54,55] Beyond the increased access to convenience foods described above, urbanization is associated with reduced consumption of fruits and vegetables and whole grains, and a greater consumption of sugar-sweetened beverages.[56]

A leading challenge to nutritional health in urban environments is the reliable provision of adequate and reliable **WASH infrastructure** (water, sanitation, and hygiene). Over the past 30 years, substantial improvements in WASH have been made. Between 1990 and 2015, the world saw more than a 15 percentage point increase (from 76% to 91%) in the number of people with access to an improved water source.[57] While access to an improved water source is lower in rural areas, the rate of increase in access has been faster in these areas.[57] It is clear that improving infrastructure for WASH is critical for nutrition, but as noted above, efforts to demonstrate marked improvements in child growth have thus far proven challenging. The task of scaling up WASH interventions is also challenged by the need for a high level of community participation in a breadth of sanitary practices to substantially reduce exposure to sanitation-related environmental pathogens.[58]

Beyond food production and safety through clean environments lies the need to improve the efficiency of the food system by minimizing **food loss and waste**. On a global scale, approximately one-third of all food that is produced is wasted.[59] In industrialized nations, food loss and waste are concentrated at the retail and consumer end of the supply chain. For example, food wasted at the retail and consumer levels of the supply chain in the United States contains an amount of iron equivalent to the recommended iron intake for two-thirds of the adult population.[60] In LMICs most losses occur earlier in the supply chain due to weak infrastructure for on-farm storage, food processing, and distribution.[61,62] The high rates of postharvest loss in LMICs reflect underlying challenges of rural development; if small farmers lack the resources to store food on farm for later consumption or trade it at markets, this not only exacerbates postharvest losses but it also hinders income generation and food security. Postharvest loss is disproportionately high for fruits and vegetables, which are not only perishable but also rich in micronutrients. Food loss and waste in LMICs not only makes it more difficult to meet nutritional needs, but it also has environmental impacts—when food is not consumed, the finite natural resources used to produce it are also wasted.[63]

Health Systems

Malnutrition can serve as a risk factor for both communicable and noncommunicable diseases (NCDs). In turn, ill-health can put an individual at a higher risk of poor dietary intake and compromised nutritional status.[64] Strengthening health systems is essential for building a supportive environment for integrating nutrition into existing health care prevention, treatment, and services, which includes diet counseling and education, nutritional assessment and monitoring, as well as treatment and management of disease.[64,65]

A key issue for health systems is to build the capacity among health worker professionals to address the complexity of double and triple burdens of malnutrition. Very few professionals are trained on dietary education and counseling across the life span, as one example. Further, while growth monitoring may be a core part of health visits, what to do with growth results and how to intervene is not systematically practiced. Creating an institutional culture where providers value nutrition, and understand their role in integrating nutrition as part of health care, is important in order to make a dent in the complexities of malnutrition burdens.[66]

Investments in health systems should address the current disease burden that nations face. There is a shift in disease patterns from communicable to noncommunicable diseases. While the communicable and undernutrition agenda is far from over, there needs to be more significant investments toward addressing all forms of malnutrition. Currently, less than 0.1% of the overseas development assistance goes to obesity and diet-related noncommunicable diseases and 0.5% goes to undernutrition.[12,67] Treating the burdens of malnutrition is costly for health systems and households if preventative measures are no longer an option.[68] Globally, it is estimated that from 2011 to 2025, the economic burden of noncommunicable diseases will be US$7 trillion.[69]

Equity and Inclusion

Women's Agency

As primary caregivers, mothers have potential control over factors critical for child well-being, including food preparation and storage, feeding practices, psychosocial care, hygiene and health practices, and newborn care.[70] During the period of the Millennium Development Goals, the empowerment of women became a major focus of development organizations. While various definitions of empowerment exist, recent frameworks for increasing empowerment have emerged. A recent systematic review concluded that raising maternal autonomy is an important goal for improving children's nutritional status, yet gaps in the current knowledge exist, further confounded by issues with how autonomy is measured and limitations of cross-cultural comparability.[71] While definitions of empowerment constructs vary,

most organizations seek to expand one or more of the following aspects of women's status: autonomy, empowerment, and agency. *Autonomy* is considered a multidimensional construct, consisting of dimensions such as the ability to make purchases and control resources, the ability to make decisions about health care or child care, and freedom from domestic violence.[72] *Empowerment* is the "expansion of assets and capabilities of poor people to participate in, negotiate with, influence, control, and hold accountable institutions that affect their lives."[73] Similarly, the concept of *agency* describes the ability to influence and have power to control one's life. Maternal agency applies this concept to mothers, describing that mothering can be an opportunity for empowerment and a venue for social change for women via the process of mothering.[74] More recently, the field of *capabilities* has been applied to health and nutrition.[75] The term captures the freedoms that individuals experience "to be and to act" and derives from the field of development economics. Related to nutrition, potential caregiver capabilities of interest are social support, psychological well-being, bodily integrity, and agency. These constructs collectively form a mother's capabilities to provision care for children, generally, and specific to nutrition.[76,77] The connections between women's agency and nutrition outcomes appear to be through at least three primary mechanisms: increased reproductive decision-making/control over the timing of pregnancies and family size; increased personal advocacy for antenatal care, delivery, and early child care; and increased participation in household purchasing.

Education

The education of girls is a major policy objective of many development organizations. Supporting the right to education has many short- and long-term benefits—especially for girls—however, the strength of associations between education and child nutrition is particularly strong. Maternal education has robust associations with child anthropometry.[78–80] However, a threshold level of education may exist for improvements in children's nutritional status to be observed. For example, in three African countries, maternal education beyond primary school was necessary to see significant reductions in child undernutrition.[81] Interventions to improve literacy and numeracy among mothers can benefit children's dietary quality and nutritional status through increasing mother's nutritional knowledge, suggesting that supporting these specific skills can help to reduce undernutrition even if formal education cannot be improved.[82–84]

Poverty Reduction

Connected to expanding education opportunities and increasing women's autonomy, higher levels of wealth, at the country-level and individual level, are associated with substantially lower levels of undernutrition. Robust

demographic health survey (DHS) data—an initiative from the US Agency for International Development (USAID) to collect nationally representative data related to family planning, maternal and child health, gender, HIV/AIDS, malaria, and nutrition in over 90 countries—demonstrate the strong linear relationship between wealth quintile, children's dietary quality, and child anthropometry. Poverty can be reduced through a variety of measures and indeed, climbing out of poverty is one of the fastest methods for reducing undernutrition. While most nutrition interventions address more immediate or underlying causes of poor diet and nutritional status, some initiatives like conditional and unconditional cash transfer programs seek to improve nutritional status and to reduce poverty and to improve food security concurrently.[85] However, these programs have not been uniformly successful across contexts and they do not necessary address long-term intergenerational cycles of poverty.[86]

Peace and Stability

Conflict has devastating implications for nutrition and can be exacerbated by climate change and political unrest.[87] These events may cause people to move to find better prospects. Hundreds of thousands of internally displaced persons (IDPs) and millions of refugees, the majority of whom are children, are constantly on the move to flee violence, and thus have little access to stable food sources.

Conflicts seem to be related to both longer-term and short-term food insecurity and malnutrition. In fact, countries affected by conflict—and to a larger extent those in protracted crises and fragile situations—have made the least progress in reducing hunger, compared to countries not affected by conflict. Countries in protracted crisis also have a higher concurrence of children suffering from both wasting (acute) and stunting (chronic).[88]

Indeed, conflicts have increased in number and complexity.[38] Civil wars and fighting affect food security and nutrition both in the immediate term as well as long-term prospects through a variety of channels, such as economic recession and inflation, disturbances across agro-food value chains, disruption of livelihoods and social networks, and erosion of social services. These can affect availability and access to food, assets, and basic services, along with feeding, care, and hygiene practices.

Further understanding the complexities of conflict as an increasing driver of both chronic and acute food insecurity and malnutrition, along with their policy and programming implications, are essential in the efforts to bridge the divide between humanitarian and development action.

Conclusion

Malnutrition—in all of its forms—is driven by complex systems and will require systems thinking to address the underlying determinants. Nutrition-

sensitive approaches that involve multiple sectors are critically important; although they are challenging to implement and measure, they are essential for change at the level of the fundamental building blocks of the SDGs. It is impossible to separate malnutrition from the challenges of food production, systems infrastructure, health systems, equity and inclusion, and peace and stability. The SDGs provide an integrated framework for achieving nutritional goals for all populations, but to achieve the 17 goals by 2030 integrated action by many stakeholders and innovative investment will be required.

Review Questions

1. Identify an example of a nutrition-sensitive approach that can be implemented by a single sector and an example of a nutrition-sensitive approach that requires multiple sectors to implement. Describe some of the tradeoffs of both interventions.
2. Food is certainly a determinant of nutritional status, both in terms of quantity and quality of dietary intake. But there are many other factors that influence nutritional status. What are some of the other factors, besides food, that influence nutrition in LMICs?
3. One of the most commonly reported types of nutritional outcomes is anthropometric measures, such as childhood stunting or overweight/obesity (indicated by BMI). What are some of the benefits and drawbacks of using anthropometric measures as the primary outcomes for nutrition-sensitive interventions? What other types of outcomes do you think are important to consider? What are some of the challenges of using these other outcomes?
4. Let's say there is a randomized controlled trial on homestead food production and it shows no improvement in nutritional status. Does this mean that there is no link between homestead food production and nutrition? What are some of the challenges of implementing such an intervention and measuring progress?
5. For a low- or middle-income country of your choice, identify one example for each of the building blocks as it relates to nutrition.

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