risk child and not-at-risk child persists over the life-course. The losses that stunted children face in terms of reduced learning ability is compounded over time, and the gap between a stunted and non-stunted child persists and widens as the child ages. A stunted child likely continues to learn less per year, failing to catch up to their non-stunted peers—illustrating that stunting has long-term consequences for future human capital potential. These cumulative losses in learning mean that even if a nation is committed to ensuring that all children receive both a primary and secondary education, a stunted child may not be able to make the most of that investment because they may not be able to learn as much as their non-stunted peers, leading to a life-long deficit. As such, preventing stunting in young childhood is imperative to protect learning ability and human capital in the long term.

Why is This Model Relevant?

The PROFILES model that estimates human capital losses or gains in terms of learning ability related to stunting is particularly relevant now because as child mortality declines globally, there is an opportunity and a need to focus on the long-term effects that result from stunting in childhood. In developing countries, how well children learn in school and beyond and how much they earn in the future is associated with stunting. Children's future quality of life and ability to contribute at higher levels to their society is partly contingent on being well-nourished during the first 1,000 days.

> To support evidence-based country-level nutrition advocacy, FANTA developed a model that estimates human capital losses in terms of reduced learning ability related to stunting and human capital gains in terms of improved learning ability if stunting prevalence is reduced.

Global evidence establishes that to effectively prevent stunting, a broad public health approach that covers all pregnant and lactating mothers and children in the first 1,000 days is essential (WHO 2014b). Stunting is largely the result of poor infant and young child feeding, poor hygiene practices, and lack of access to clean water and sanitation facilities, which requires programs that are intensively focused on children under 2 at the community level. Despite the global interest in addressing stunting, intensive efforts across multiple levels and by various stakeholders are required not only to support national-level policy changes but also community-level implementation of interventions and services that need to be intensive and frequent in order to effectively improve infant and young child feeding and hygiene practices and that expand access to clean water and sanitation to prevent stunting. This requires advocacy to create an enabling environment for political commitment, multi-sectoral collaboration, and integrated service delivery.

The World Health Assembly has set the goal of reducing the number of children under 5 who are stunted by 40 percent by 2025 (World Health Organization [WHO] 2014a) and USAID, as described in their Multi-Sectoral Nutrition Strategy, seeks to reduce stunting by 20 percent over the next 5 years (USAID 2014). Country-level advocacy to promote a multi-sectoral approach is essential to address the multiple causes of stunting, which will enable countries to mitigate the harmful effects on their population and fulfill their national commitments to the World Health Assembly targets to reduce stunting and child mortality. In addition to the existing models in PROFILES that estimate the impact of stunting on mortality and economic productivity, the new model, which estimates human capital losses or gains related to stunting, is a useful tool for advocacy.

How Does the Model Work?

The basic approach in PROFILES is to provide two scenarios: a status quo scenario and an improved scenario. The status quo scenario assumes there will be no change in the current situation throughout a chosen time period (e.g., 10 years) for which to calculate estimates, aside from projected changes in population size and structure, and the prevalence of stunting remains unchanged each year. In contrast, in the improved scenario—with results estimated for the same time period—it is assumed that the prevalence of stunting is reduced. For the improved scenario, it is necessary to set targets for the reduction in prevalence of stunting; these targets are discussed and agreed upon by participants during PROFILES workshops, taking into account various national priorities and development objectives. The improved scenario assumes a linear reduction in prevalence levels with a gradual improvement in nutritional status from the first year (when prevalence equals that in the status quo scenario) to the last year when the target prevalence is reached.

Models in the PROFILES spreadsheet workbook, rely on coefficients based on the scientific literature to show the association between a nutrition problem and an outcome of interest. To create the stunting and learning model, FANTA reviewed peer-reviewed literature that quantified the association between stunting and learning. The 2007 *Lancet* series on child development by Grantham-McGregor et al. 2007 estimated deficits in learning ability related to stunting based on findings from the Philippines as described in an article by Glewwe et al. (2001), which analyzed data from the Cebu Longitudinal Health and Nutrition Survey that followed Filipino children (including sibling pairs) from birth through the end of their primary education.[1] This article provided the necessary information to generate the coefficient for the new model. The article's multivariate regression analyses included an assessment of the relationship between nutritional status expressed as height-for-age z-score and learning ability (also referred to as learning productivity) as reflected in achievement test scores. The authors found that the direct effect of better nutritional status—a 1 standard deviation (SD) unit increase in height-for-age z-score—on learning ability per school year was equivalent to spending 8 additional months in school. Therefore, using the 10 months described as equivalent to a standard school year in the article, FANTA utilized the coefficient of 8 out of 10 months or 0.8 grade equivalents gained per school year per 1 SD unit (i.e., 1 z-score) improvement in the mean height-for-age z-score to calculate the impact of stunting on learning ability. A key concept behind this model is that the losses in brain function/optimal development, as described in Figure 1, are cumulative and may impact a child throughout their life course.

In addition to this coefficient, the model also uses country-specific stunting prevalence among children 24–35 months of age,[2] and information on age at enrollment in primary school and number of years of school as specified by country-specific education policy. The 24–35 month age group is used because it represents the age when stunting generally is most prevalent and usually irreversible. Age at enrollment in primary school refers to the age at which students are expected to enroll in primary school per the government policy. The model considers future

[1] Information about the Cebu Longitudinal Health and Nutrition Survey is available from UNC Carolina Population Center (at http://www.cpc.unc.edu/projects/cebu).

[2] Defined as the percentage of children with a height-for-age z-score below -2 SD units from the median of the WHO 2006 standard population.

Information Needed to Generate PROFILES Estimates

Every model in PROFILES utilizes the following information to generate estimates:

- A **time period** is needed to determine the number of years for which the estimates should be calculated (e.g., 10 years).
- **Prevalence information** provides the magnitude of the nutrition problem (for example, percent of children 24–35 months who are classified as moderately and severely stunted). Current prevalence information is needed to serve as a baseline for the equations in the model.[1] Stunting prevalence is often included in nationally representative household surveys such as the Demographic and Health Survey or Multiple Indicator Cluster Surveys.
- **Targets** are set to determine what the goal should be with regard to prevalence of the nutrition problem at the end of the given time period (e.g., reduce stunting prevalence from 40 percent to 18 percent). The targets reflect the proportion by which the nutrition problem will be reduced over the chosen time period and therefore influences the outcome of interest.[2]
- **Demographic information** serves as the basis for the population projections by providing population size and structure.
- **Mortality, economic, employment, or education-related information** provides details to estimate the outcome of interest. For the stunting and human capital model, education information is required, but mortality, economic, or employment information is not (however, such information is utilized in other PROFILES models). This information is needed to compute the consequence of the nutrition problem on the outcome of interest. Education information is usually available from the Ministry of Education or from official documents.

[1] PROFILES uses the best available, recent information on point prevalence, which is the prevalence at a point in time, often referred to as a snapshot of a population.

[2] It is important to note that specific nutrition interventions are not entered into the model to develop the PROFILES estimates. Rather, the improvement in the nutrition situation is based on the expectation that if nutrition interventions that are known to be effective are implemented at scale they will succeed in reaching the stated targets.

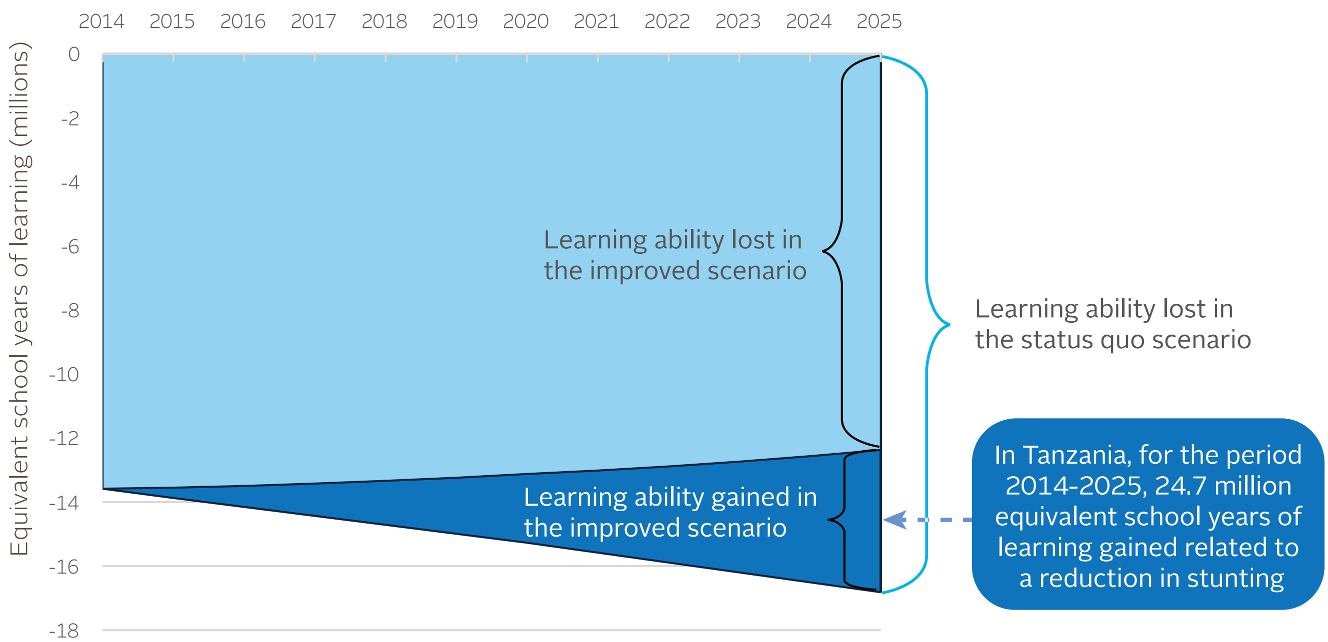
learning ability—taking into account discounting[3] and expected mortality—related to stunting for each year when children are supposed to attend school according to a country's education policy. Because the coefficient used for this model relates learning to the mean height for age z score, PROFILES calculates a mean z-score (based on the stunting prevalence) for both the status quo and improved scenarios to calculate the estimates for this model.

Estimates calculated by this model refer to losses or gains in learning ability related to stunting, and the unit of measurement is "equivalent school years of learning." This unit of measurement is an aggregate of deficit or gain in children's learning ability across all the years when a child is supposed to be in school according to a country's education policy. For example, for the first year of the time period, the "equivalent school years of learning" that are lost related to stunting, is calculated as the product of the following factors: the number of children 24–35 months of age in the population, the mean height-for-age z-score for children 24–35 months (based on country-specific stunting prevalence), the coefficient (0.8 grade equivalent per school year per 1 SD unit), and the number of years children are supposed to attend school according to a country's education policy (taking into account a discount factor and expected mortality). The same calculation is made for every additional year for which estimates are calculated in each of the two scenarios. Gains in learning ability are the difference between the status quo and improved scenarios. Moreover, while the losses in this model are estimated only for the years when a child is supposed to attend school, the negative consequences extend beyond years in school and translate into reduced human capital.

Using the method described, the PROFILES stunting and human capital model calculates country-specific estimates of the number of equivalent school years of learning lost related to stunting over a certain time period (assuming that there is no change in stunting prevalence), and the number of equivalent school years of learning gained if stunting prevalence is reduced and nutritional status improves over the same time period. For example, in Figure 2, which is based on Tanzania 2014 PROFILES estimates, the light blue shaded area reflects learning ability lost related to stunting in the improved scenario, while the dark and light blue shaded areas together reflect learning ability lost related to stunting in

[3] Discounting reflects the relative value today compared to the value in the future.

Figure 2. Example, Based on the Tanzania 2014 PROFILES Estimates, of Human Capital Losses or Gains in Terms of Learning Ability Related to Chronic Malnutrition (Stunting)



the status quo scenario. Learning ability gained related to reduced stunting in the improved scenario is reflected in the dark blue shaded area. In this example for the time period of 2014–2025, it is estimated that 24.7 million equivalent school years of learning are gained related to a reduction in stunting. Among children who are in the 24–35 month age group in the year 2025, 2.2 equivalent school years of learning are gained per child related to a reduction in stunting.

How Has the Model been used to Support Country-Level Advocacy?

The model was first used in Tanzania and Uganda in 2014 as part of a broader effort to support nutrition advocacy in these countries. Tanzania government officials have used the stunting and human capital estimates (see Figure 2), along with the other PROFILES estimates to advocate for increased commitment to and investment in nutrition in multiple settings including meetings with parliamentarians and global forums such as the Scaling Up Nutrition Global Gathering in November 2014. In Uganda, the stunting and human capital estimates in addition to other PROFILES estimates have been incorporated into briefs to advocate for increased investment in nutrition at both the national and district levels.

Using this new model in PROFILES as part of a broader nutrition advocacy process to illustrate the critical link between stunting and human capital lends support to national advocacy efforts to prevent stunting and improve education outcomes and economic productivity. It provides another avenue through which to engage country governments and donors to reduce stunting, emphasizing that addressing stunting is not only critical to reducing morbidity and mortality in children around the world, but is essential to prevent poor childhood development that adversely impacts learning which can impede national economic and development goals.

For more information on FANTA's country-level nutrition advocacy activities using PROFILES, visit www.fantaproject.org/tools/profiles or email FANTA at fantamail@fhi360.org.

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