Chapter 7

Evidence of Impact of Interventions on Growth and Development during Early and Middle Childhood

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INTRODUCTION

Worldwide patterns of linear growth faltering, based on data from many low- and middle-income countries (LMICs) (Victora and others 2010), indicate deterioration of child nutritional status, on average, from age 0 to 24 months; after this period, nutritional status levels off or slightly reverses (for example, Prentice and others 2013; Stein and others 2010). Analyses of the five countries in the Consortium of Health-Orientated Research in Transitioning Societies (COHORTS) study found that low birth weight or undernutrition at age two years (or both) were associated with shorter adult height, less schooling, and lower economic productivity (Victora and others 2008). The 2008 *Lancet* series on nutrition argued that height-for-age is the best nutritional predictor of adult human capital (Victora and others 2008).

These results influenced prioritization of global efforts to combat undernutrition in the first 1,000 days, from conception to age 24 months. More broadly, these 1,000 days are seen as a critical period for establishing the physical, cognitive, and socioemotional foundation for later life (Walker, Wachs, and others 2011) and are viewed as the period of greatest plasticity (Gluckman and others 2009). As reviewed by Halfon and others (2014), new approaches to life course development have integrated biological systems, drawing from genetics as well as epigenetics, with social and behavioral models. The approach in this chapter unites economic theory with health science.

We use the lifecycle approach to assess the benefit-cost ratios of interventions in nutrition and child development in LMICs, where undernutrition is a risk factor, with a focus on the first five years of life. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017).

Birth weight and linear growth in the first two years are associated with many beneficial outcomes later in life (Adair and others 2013). The 2013 *Lancet* nutrition series also acknowledged the need to address both undernutrition and increased obesity in LMICs (Black and others 2013), recognizing that there is a high prevalence of both conditions and that the conditions often are linked. The 2013 series connected the importance of prenatal nutrition and adolescent girls' nutrition (Bhutta and others 2013). Women's height affects risks for pregnancy complications (Toh-Adam, Srisupundit, and Tongsong 2012) and low birth weight (Black and others 2013); given associations of birth weight with subsequent undernutrition (Christian and others 2013), these findings bring the discussion full circle. Thus, the 1,000-day window could be made much longer—even going back to mothers' childhoods.

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Children's early years are critically important for cognitive, language, and socioemotional development, and strong evidence indicates that the window of influence extends well beyond the first 1,000 days. Protective and risk factors for undernutrition are often similar to the factors influencing cognitive and socioemotional development (Walker, Wachs, and others 2011). For example, shared risk factors include intrauterine growth retardation, nutrient deficiencies, and social and economic conditions. Risks specific to poor cognitive development include inadequate learning opportunities and inadequate quality of caregiver-child interactions. Shared protective factors include breastfeeding and maternal education.

The overlapping risk factors, timing of peak vulnerabilities, and the possibility that early deficits have long-lasting impacts have motivated interest in interventions that integrate nutritional and other approaches to promote overall child development (Alderman and others 2014). Ideally, policies and programs must move from a focus on single issues to a wider-reaching, more integrated approach across the life course, which would allow for each child to develop as well as possible and mitigate the impact of constraints under which their development may be occurring (Fine and Kotelchuck 2010). Such integration, however, requires clearer understanding of individuals' developmental timing and age-dependent responses to external factors (Wachs and others 2014). Cognitive functions, receptive and expressive language, and socioemotional skills develop at different ages (Grantham-McGregor and others 2007). Development in brain structure and function supporting acquisition of cognitive, language, and socioemotional skills is most rapid during early childhood, with continued development in later years for many skills.

The early years, beginning in utero and extending to age 36 months, are the best stage in which to prevent stunting. The debate continues as to whether children who become stunted before age 24 months can catch up later in their lives. Population averages from cross-sectional data show some limited catch-up in height-for-age z scores, though average height deficits widen beyond age two years into adulthood (Leroy and others 2014; Lundeen and others 2014). Longitudinal studies report considerable individual movements in both directions between stunted and nonstunted status after age 24 months that are associated with family and community characteristics, suggesting potential for catch-up or prevention of faltering (Crookston and others 2013; Lundeen and others 2013; Mani 2012; Prentice and others 2013; Schott and others 2013). Catch-up may, however, have some risks; for example, weight gain on small frames has been associated with subsequent obesity and adult chronic diseases (Monteiro and Victora 2005; Yajnik 2004, 2009).

As with malnutrition, cognitive delays can occur throughout infancy, childhood, and adolescence, understood in this volume as birth through age 19 years. Measurable differences in receptive language by socioeconomic groups are apparent in preschool children ages three to five years (Paxson and Schady 2007; Schady and others 2015); differences in cognitive ability have been observed even in the first two years (Fernald and others 2012). Early life stress—often toxic if extreme—can also have difficult-to-reverse lifetime consequences (Shonkoff and Garner 2012). Individual responsiveness to interventions implemented after initial developmental insults are widely debated (see chapter 8 in this volume, Watkins and others 2017).

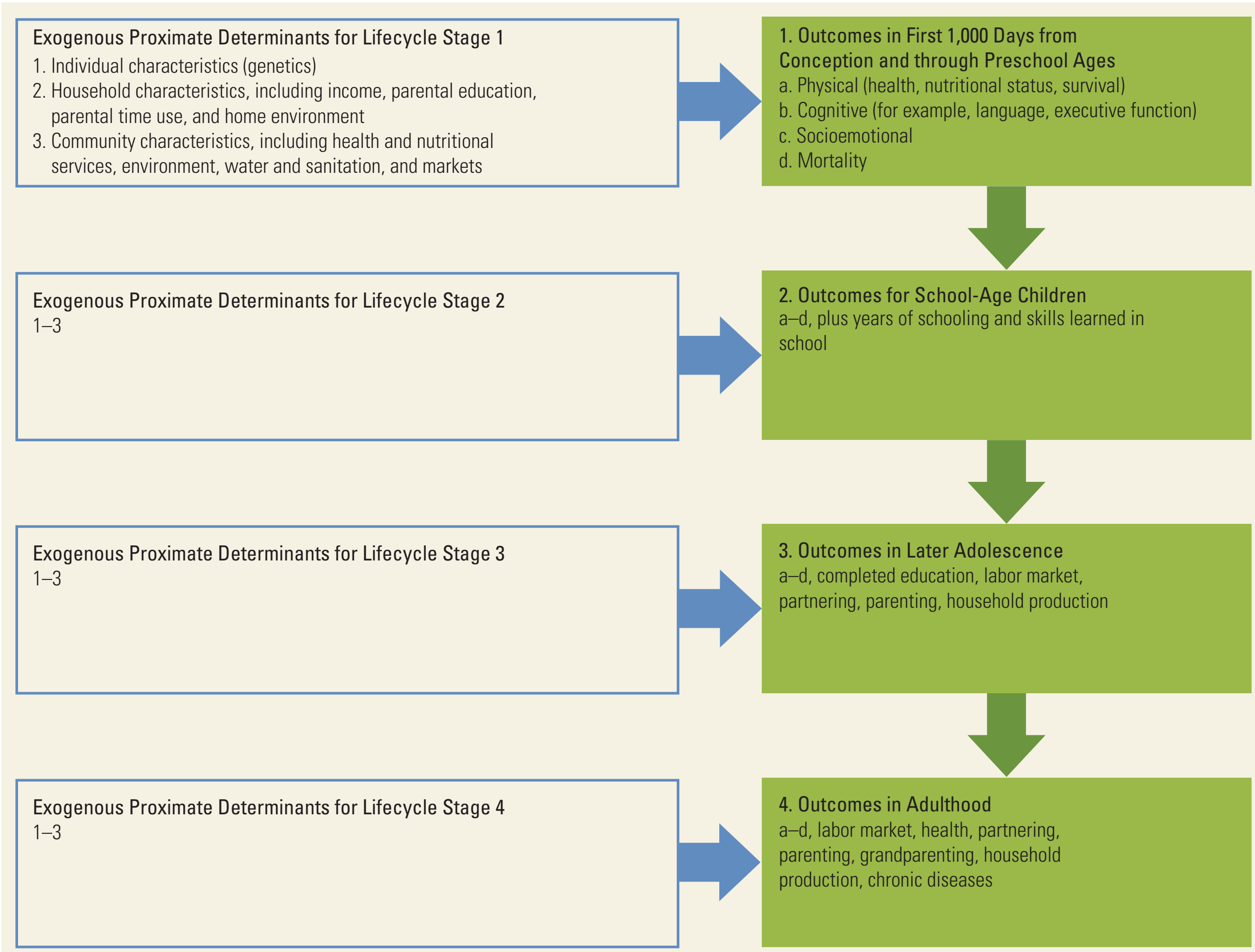
More than 3 million children younger than age five years died in 2011; half of these deaths were associated with fetal growth restriction, suboptimal breastfeeding, stunting, wasting, and vitamin A and zinc deficiencies (Black and others 2013). Given that about 75 percent of child deaths before age five years occur in the first year, addressing catch-up growth beyond the 1,000-day window is driven less by concern for mortality risk and more by concerns relating to later-life consequences for survivors.

Some evidence indicates that skill accumulation is more plastic than physical growth; skills such as executive function—a component of cognitive function—and socioemotional development have time paths different from those of conventional cognitive abilities (Borghans and others 2008). Still, very little is known about time paths of effective interventions for addressing nutritional, cognitive, and socioemotional development, particularly in LMICs. Maximum gains relative to costs, particularly for cognitive and socioemotional developmental outcomes, are likely to require early investment, followed by appropriate nutritional and educational investments and continued support for effective parent-child interaction over childhood and adolescence. Determining which later-life interventions cost-effectively reduce consequences of early malnutrition or cognitive delay is important if efforts at prevention fall short, as they already have for hundreds of millions of children.

LIFECYCLE FRAMEWORK FOR ASSESSMENT OF BENEFITS AND COSTS OF INTERVENTIONS TO SUPPORT CHILD DEVELOPMENT

The lifecycle framework highlights the age dimension for both outcomes and determinants of child and adolescent development. Figure 7.1 presents such a

Figure 7.1 Physical Growth and Other Developmental Outcomes within a Lifecycle Framework



framework, with three formative stages extending from conception through childhood and adolescence, continuing to an adult stage.[1]

- Lifecycle Stage 1 from conception through preschool age
- Lifecycle Stage 2 primary and early secondary school ages
- Lifecycle Stage 3 late adolescence
- Lifecycle Stage 4 adulthood.

Individuals who survive each stage continue on to the next stage, as indicated by the green arrows in the figure (see also Nandi and others 2017, chapter 27 in this volume). The sections in this chapter and in chapter 8 (Watkins and others 2017) present evidence of opportunities for interventions in the first three lifecycle stages—preschool, school-age, and late adolescence—including evidence on costs, returns to investments, and implications for tradeoffs.

The lifecycle could be divided into fewer or more stages, but the pattern by which actions in one stage influence both outcomes in that period and in subsequent stages, either directly or indirectly, is generalizable. Moreover, the timing of exit from one stage and entry into the subsequent one is itself partially dependent on earlier outcomes and concurrent decisions; for example, entry into school depends in part on nutritional status (Alderman and others 2001; Glewwe, Jacoby, and King 2001); entry into the labor force depends on both physical stature and schooling achievement (Pitt, Rosenzweig, and Hasan 2012; Yamauchi 2008). Even transitions that are biological, such as menarche and the beginning and duration of the adolescent growth spurt, are partially dependent on earlier health outcomes and on behavioral and hormonal responses to cultural and environmental contexts.

Broadly speaking, the outcomes in each lifecycle stage can be classified into three categories: physical growth, cognitive development (including language, executive function, mathematics, and reasoning), and socioemotional development. The relevant outcomes of these categories vary at the different stages. The risk of early mortality is particularly relevant in the first stage; school attainment is most relevant in the second and third stages; and employment is most relevant in the third and fourth stages. Establishing priorities for investment or integrating mortality with other outcomes, such as improved development for survivors, is particularly challenging without a common metric. Most other outcomes can be assessed by measuring their financial value relative to their cost, but there is no consensus on how to make such an assessment for mortality. A wide range of estimates of the value of averted mortality have been proposed. These, however, range from the cost of the cheapest alternative for averting mortality to what compensating differentials individuals require to assume more risk, for example, based on wage tradeoffs (Summers 1992; Viscusi and Aldy 2003).

Usefulness of the Lifecycle Framework

A particular conceptual value of a lifecycle model is that it can illustrate how inputs in one stage influence outcomes in later stages. For example, higher stocks of health (or health skills) in one stage may create even higher health later. Cunha and Heckman (2007) term this process *self-productivity*. Similarly, the model can highlight cross-productivities in which better health in one stage increases cognitive skills in the same or subsequent stages. Cross-productivities may also occur if cognitive skills in one period enhance socioemotional skills in another (Helmers and Patnam 2011), or if dimensions of health in one period influence other developmental dimensions subsequently. The model also describes what Cunha and Heckman (2007) call *dynamic complementarities,* by which higher health or skills in one stage lead to greater returns to investments in subsequent stages.

Dynamic complementarities have important implications from an economic efficiency perspective: more investments should be targeted to those with better initial health and greater skills, although doing so would widen disparities as children age. This is not only a possible outcome of decisions by governments, but may also pertain to households' investments in siblings. Given dynamic complementarities, do households invest more in their children who have higher potential, or do they seek more equity and compensate by investing more in "less productive" children? However, whether dynamic complementarities predominate is an empirical issue—there may be dynamic substitution if investments in one period have a greater return when provided to children with worse outcomes in the earlier period. Whether governments or households prefer strategies that reinforce earlier differentials, or whether they prefer to invest to compensate for disparities, is also an empirical question.

This framework also helps deepen our understanding of how short-term health shocks may affect future outcomes. If dynamic complementarities are strong, then moderate shocks to children's health in early life may lead to major differences in schooling and other later outcomes if nothing is done to compensate for these shocks. Similarly, self-productivity is consistent with long-term impacts of early-life nutritional deficits, morbidity, inadequate stimulation, and toxic stress (National Scientific Council on the Developing Child 2014).

To quantify the links in the framework illustrated in figure 7.1, the challenge imposed by the multiple proximate determinants of the outcomes of interest in each lifecycle stage must be addressed. With the rare exception of randomized controlled trials or transitory natural experiments that alter one of them, these determinants are likely to be highly correlated across different lifecycle stages. Accordingly, the causal effects of growth in one period on outcomes in subsequent stages may be overstated because this approach attributes to the previous stage the effect not only of growth in that stage on subsequent growth (the green arrow) but also the effects of correlated determinants across stages (the blue arrows).

Additionally, it is difficult to separate the physical, cognitive, and socioemotional dimensions of growth over the lifecycle. For example, to examine the impact of an investment in physical growth, either the investment has to affect only physical growth, or else other dimensions of child development need to be controlled. Randomized controlled trials or natural experiments directed only at physical growth with impacts measured over multiple lifecycle phases might permit such an assessment to be made, but such studies are rare. If observational data are used, and channels for the impacts of investment other than physical growth are not controlled for in the analysis, the impacts of physical growth are likely to be misrepresented because physical growth will almost certainly be positively correlated with impacts of the investment through other channels. Since one of those channels is cognitive development, for example, identifying the impacts of physical growth as distinct from the impacts of cognitive development is challenging.

Prioritization of Interventions

Prioritization of interventions involves an understanding of these causal impacts, as well as the costs of these interventions, in the context of LMICs. The costs of interventions include the total resource costs of changes in the boxes on the left-hand side of figure 7.1, where resource costs mean the use of resources for this intervention that have value in other uses. Many interventions have resource costs for both public sector providers and private individuals. If parents have to take their children to health clinics to receive interventions, resource costs are incurred in the form of transportation costs and the costs of the parents' time, in addition to the public resource costs of the clinic. In addition, there are likely to be distortion costs from raising funds to finance public expenditures; these distortion costs have been estimated to be approximately 25 percent of public expenditures (Devarajan, Squire, and Suthiwart-Narueput 1997). If only service provider costs are incorporated into the analyses, total resource costs are likely to be understated.

A further consideration related to costs may be the budget envelope, that is, the short-term constraint on available revenue or line item for a sector. Policy makers may perceive that the budget envelope constrains their choices so that, for example, increases to public sector expenditures on one item, such as preschool programs, must come at the expense of other items, such as primary school teacher salaries, even if the benefit-cost ratios of both options are considerably greater than one. The budgetary process imposes a constraint on their choices that, from their perspective, is an additional cost component. The impact of the budget envelope is particularly likely to affect new initiatives because endowment effects and vested interests may make it difficult to reduce public sector expenditures on items purchased in the past even if their benefit-cost ratios are smaller than those of proposed new interventions. Although the budget envelope does not represent real resource costs, it may be a real constraint on public sector choices, especially for new initiatives.

Policy makers who think they are constrained by budget envelopes have incentives to offload real program costs onto private entities, to the extent possible. For example, if new services are provided and a choice is made between expenditure of public sector funds to improve households' access to those services and higher private transportation costs to be borne by those households, the constraint imposed by budget envelopes creates incentives to choose the latter even if those costs are borne by very poor people. This last point is related to a more general distortion present in many policy discussions that wrongly equate public sector expenditures with real resource costs, ignoring the fact that important components of real resource costs may be private sector costs and that components of public sector expenditures such as transfers may not be real resource costs. Considerations such as budget envelopes and endowment effects should not be confused with real resource costs, even though they may have implications for real resource costs.

In addition, because of the interest in longer-term impacts, it is important to recognize that the timing of both impacts and costs matters if there is an advantage to obtaining returns earlier rather than later because the returns can be reinvested to generate further returns. This is particularly important if early-life interventions have impacts decades later through their effects on adult productivity and chronic diseases. In this context, the intertemporal discount rate used may make a considerable difference. Hoddinott, Alderman, and others (2013) provide a scenario in which the benefit-cost ratio for reducing stunting in Bangladesh is 17.9 with a 3 percent discount rate, but this ratio declines to 8.9 with a 5 percent discount rate, and 3.3 with an 8 percent discount rate.

Finally, the framework in figure 7.1 is context dependent. Resources, environments, policies, cultures, and markets are likely to vary considerably, and careful assessment is needed within the particular context for which an intervention is being considered.

QUANTIFYING THE MODEL: ILLUSTRATIONS OF BENEFIT-COST RATIOS AND RELATIVE RATES OF RETURN FOR INTERVENTIONS FOR DIFFERENT AGES IN A LIFECYCLE FRAMEWORK

The benefits and costs or, equivalently, internal rates of return from interventions are needed to guide decisions about choices among different interventions to mitigate inadequate child development versus other possible interventions. We illustrate some dimensions of benefit-cost ratios with an example of interventions to prevent or reduce inadequate physical growth early in the preschool stage of the lifecycle, and then we discuss a well-known stylized characterization of relative rates of return to investments over the lifecycle.

Benefits over the Lifecycle: An Illustration

On the benefit side, including all the important impacts is critical—which means that different types of benefits need to be expressed in the same terms—as is accountng for the fact that some impacts may be realized only years after the intervention and need to be discounted to the present to obtain present discounted values (PDVs). Table 7.1 illustrates moving one child out of low–birth weight (LBW) status in a low-income country, based on the best estimates of causal links over the lifecycle. The major impacts include three from the

Table 7.1 Estimates of Present Discounted Values of Seven Major Impacts of Moving One Infant Out of Low–Birth Weight Status in a Low-Income Country

	Present Discounted Value (2004 US$)		
Impacts	**3% annual discount rate**	**5% annual discount rate**	**10% annual discount rate**
Reduced infant mortality	95	99	89
Reduced neonatal care	42	42	42
Reduced costs of infant and child illness	36	35	34
Productivity gain directly from increased adult height	152	85	25
Productivity gain from increased schooling and cognitive ability	367	205	60
Reduced costs of chronic diseases	49	15	1
Intergenerational effects	92	35	6
Total benefits	832	516	257

Source: Based on Alderman and Behrman 2006.

preschool lifecycle stage and four from the adult lifecycle stage. The adult stage includes the productivity impacts that encompass intermediate effects through channels such as schooling without double-counting; for example, the productivity gains from increasing adult height must be additional to those from increasing cognitive skills (Alderman and Sahn 2016). All of the impacts have been put into the same terms (U.S. dollars), with the most contestable value being that for averted mortality in the preschool stage, for which case the cost of vaccinations, the cheapest alternative means of averting mortality, was used (Summers 1992). The PDVs of total benefits vary a fair amount with the discount rates because of the gains from being able to reinvest returns that are realized sooner rather than later and are half as large using a 10 percent discount rate than when using a 5 percent rate, and are 39 percent smaller using a 5 percent discount rate than when using a 3 percent rate.

The estimated impacts shown in the table are primarily from productivity gains with 3 percent and 5 percent discount rates (62 percent and 57 percent of the total benefits, respectively). Productivity gains remain a substantial part of the total (33 percent), even with the 10 percent discount rate, because these gains are realized each year during the working lives of surviving adults. If these economic productivity gains were ignored by focusing only on direct health impacts, overall benefits would be substantially underestimated.

Finally, even though the early-life origins of chronic diseases have received increasing attention in recent decades, the estimated PDV of gains from this source are relatively small—5.9 percent of the total benefits with a 3 percent discount rate, 2.9 percent with a 5 percent discount rate, and 0.4 percent with a 10 percent discount rate—because the impacts (assumed equal to a decade of income) are obtained late in the lifecycle and so are discounted considerably to obtain their present values.

The relevant costs include the intervention-provider resource costs, the private resource costs, and the distortion costs of using taxes to fund public expenditures on the program. The total resource costs are not the same as public budget expenditures, which ignore private and distortion costs and tend to underestimate the resource costs; they also can include considerable transfers, such as in-kind transfer or conditional cash transfer programs and so might overstate resource costs.

Benefit-cost ratios are the PDV of benefits divided by the PDV of costs. If the ratio exceeds 1.0, then the expected PDV of benefits exceeds the PDV of costs, and the intervention is warranted. Because both the benefits and the costs tend to vary substantially by context, the benefit-cost ratios related to the impacts in table 7.1 are likely to vary greatly across LMICs. An alternative means of summarizing such information is the internal rate of return, which is defined as the discount rate that makes the benefit-cost ratio exactly equal to one.

Relative Rates of Return to Human Capital Investments over the Lifecycle

A well-known example of relative rates of return to investments in skills formation over the lifecycle is described by Cunha, Lochner, and Masterov (2006), who found declining rates of return to age-specific investments in human capital as a child's age increases. Accordingly, investments before birth appear to have higher returns than investments in the first two years of life, which appear to have higher returns than preschool programs directed toward children ages three to five years. These, in turn, appear to have higher returns than additional years of schooling, which also have higher returns than postschooling job training. A key implication is that interventions should be concentrated early in life, when the highest overall returns are obtained, until reaching a point at which diminishing marginal rates of return make investments later in life relatively more productive. Current human capital investment levels may yield declining rates of return, but optimal investments would yield equal rates of return for all age levels.

The stylized returns of Cunha, Lochner, and Masterov (2006) and the myriad discussions the returns have engendered raise the question, why do the rates of return differ so much by age? If private rates of return are so high for early-life investments, why do families not take immediate advantage of such high-return opportunities? Is it because of lack of knowledge or credit market constraints? Perhaps private rates of return are not as high as social rates of return because of positive externalities. If so, then another set of questions arises: Why does public investment not follow? Is it lack of knowledge, high discount rates for policy makers because of political cycles, the combination of the budget envelope and endowment effects, or a concern that the evidence is too thin or is based on studies from distant countries? Again, understanding why the age pattern of rates of return exists, as well as clarifying the extent to which they differ from private and social perspectives, would be very useful for developing effective policy responses, such as whether emphasis should be placed on enhancing information, improving capital markets, subsidizing providers of services relevant to early-life development, increasing the direct public provision of services relevant to early-childhood development, empowering mothers, or other possibilities.

Many presume that such age patterns of rates of return to investments in human skills prevail in many LMICs. There does seem to be some support for relatively high rates of return on investing in nutrition and stimulation during the first 1,000 days of life (Gertler and others 2014; Hoddinott and others 2008; Hoddinott, Alderman, and others 2013; Hoddinott, Behrman, and others 2013), as well as for investing in preschool programs across a number of countries for children ages three to five years (Engle and others 2011) in some settings. Nevertheless, the age pattern of rates of return is much less well documented for most LMICs than for the United States. For example, it would be desirable to be able to base policy recommendations for other LMICs on more extensive information than on the available very careful analysis of a few small special samples from Guatemala, Jamaica, and the United States, or on analyses of cross-country data such as in Engle and others (2011). The available evidence is insufficient to indicate a wide range of possible heterogeneous investments. This concern pertains to average returns across subpopulations as well as any complementarities of inputs and the possibility that the return to an investment in one stage depends on investments in previous stages.

Benefit-Cost Ratios for Investments in Nutrition

We document the recent prevalence of nutritional deficits to establish that they are major problems and turn to estimated benefit-cost ratios of interventions designed to reduce some of these deficits.

Table 7.2 gives the prevalence, by world region, of key indicators of preschool-age malnutrition based on the most recent data available from the United Nations Children's Fund before the February 2014 conference for the third edition of *Disease Control Priorities*: low birth weight; whether exclusively breastfed for the first six months of life; and, for children younger than age five years, moderate and severe underweight, severe underweight, wasting defined as weight-for-height, overweight or obese, and stunting. Although availability of data on these indicators has improved considerably in recent decades, substantial data problems remain that are discussed in the original sources. For example, China is not included in the East Asia and Pacific and World aggregates for the last five indicators (although we have included values for China for other indicators when available), and coverage in some cases is otherwise limited. Table 7.3 gives further estimates and projections, from 1990 to 2020 and by major region, of the prevalence—and number of children affected (in millions)—of overweight/obesity and stunting among children younger than age five years.

Low Birth Weight

Low–birth weight (LBW) babies (less than 2,500 grams) face a greater risk of dying in their early months and years compared with normal birth weight babies; if LBW babies survive, they have greater risks of cognitive disabilities, impaired immune function, diabetes, and heart disease later in life (UNICEF 2006b, n.d.; UNICEF and WHO 2004). The prevalence of LBW varies considerably across regions: South Asia's rate of 27 percent is almost twice the rate in Sub-Saharan Africa (15 percent), which is the region with the second-highest rate. Approximately 19.5 million LBW babies are born annually, half of whom are born in only three countries: India (38.0 percent), Pakistan (7.7 percent), and

Table 7.2 Children's Nutritional Status in Major World Regions, Most Recent Available Data

Region or subregion	Low birth weight (< 2,500 grams, %)	Exclusive breastfeeding of children for first 6 months (%)	Children Younger than Age Five Years: Underweight (moderate and severe, %)[a]	Underweight (severe, %)	Wasting (moderate and severe, %)[a]	Overweight/obese (%)[a]	Stunting (moderate and severe, %)[a]
Sub-Saharan Africa	15	—	21	7	9	7	40
East and Southern Africa	14	41	18	5	7	5	40
West and Central Africa	15	20	23	8	12	9	39
Middle East and North Africa	12	29	8	—	9	12	20
South Asia	27	38	33	14	16	3	39
East Asia and Pacific[b]	6	43	6	4	4	5	12
China	3	—	4	—	2	7	10
Latin America and the Caribbean	9	—	3	—	2	7	12
Central and Eastern Europe/Commonwealth of Independent States	6	22	2	—	1	16	12
High-income countries	7	—	2	—	2	15	7
Least developed countries	17	—	23	7	10	4	38
World[b]	14	—	16	10	8	7	26

Sources: For low birth weight, http://www.childinfo.org/low_birthweight_profiles.php; for exclusive breastfeeding, http://www.unicef.org/progressforchildren/2006n4/index_breastfeeding.html; all others, http://www.childinfo.org/malnutrition_nutritional_status.php A1. (All accessed January 11, 2014; all last updated February 2013.)

Note: — = not available.

a. Regional averages for underweight (moderate and severe), wasting (moderate and severe), overweight/obese, and stunting (moderate and severe) are estimated using statistical modeling of data from the UNICEF and WHO Joint Global Nutrition Database, 2011 revision (completed July 2012). The severe underweight indicator was not included in this exercise; regional averages for this indicator are based on population-weighted averages calculated by UNICEF. "Moderate" ("severe") is defined as more than 2 (3) standard deviations from the age-gender-specific reference median (below the medians except for overweight/obese).

b. Data exclude China for last five columns (children younger than age five years).

Nigeria (3.9 percent) (UNICEF 2013). Trend analysis is complicated by the lack of comparable estimates over time, both within and among countries. A population-weighted average for available surveys shows that the incidence of LBW remained unchanged from the 1990s to 2010 for both Sub-Saharan Africa and Asia (UNICEF 2013).

Breastfeeding

Exclusive breastfeeding in the first six months of life stimulates babies' immune systems, protects them from diarrhea and acute respiratory infections—two of the major causes of infant mortality in LMICs—and improves their responses to vaccination (UNICEF 2006a). Particularly in unhygienic conditions, breast milk substitutes carry high risks of infection that can be fatal for infants. Yet only slightly more than one-third of all infants in LMICs are exclusively breastfed for the first six months of life. There is a fair amount of variation in the prevalence of breastfeeding, from 20 percent and 22 percent, respectively, in West and Central Africa and Central and Eastern Europe to 38 percent to 43 percent in South Asia, East and Southern Africa, and East Asia and Pacific.

Underweight

Globally, 16 percent of children younger than age five years are moderately or severely underweight. The high prevalence of moderate and severe underweight of 33 percent (14 percent for severe) in South Asia stands out in comparison with other regions; Sub-Saharan Africa (with West and Central Africa a little higher) is next, with 21 percent. All other regions have prevalence of less than 10 percent; the lowest is 2 percent to 3 percent for Central and Eastern Europe/Commonwealth of Independent States and Latin America and the Caribbean.

Table 7.3 Estimated Prevalence and Number of Children (Millions) Younger than Age Five Years Who Are Overweight/Obese or Stunted in Major Regions, 1990–2020

	Overweight/Obese				Stunted			
	1990	2000	2010	2020	1990	2000	2010	2020
Prevalence (%)								
Africa	4.0	5.7	8.5	12.7	40.3	39.3	38.2	37.1
Asia	3.2	3.7	4.9	6.8	48.6	37.7	27.6	19.0
Southern and Central Asia	2.3	2.9	3.5	4.3	60.7	48.4	36.4	25.9
LAC	6.8	6.8	6.9	7.2	23.7	18.1	13.5	10.0
All developing countries	3.7	4.5	6.1	8.6	44.4	36.1	29.2	23.7
Global	4.2	5.1	6.7	9.1	39.7	32.9	26.7	21.6
Children younger than age five years (millions)								
Africa	4.5	7.4	13.3	22.0	44.9	51.3	60.0	64.1
Asia	12.4	13.7	17.7	24.3	189.9	138.0	99.5	68.4
Southern and Central Asia	4.2	5.4	6.6	8.0	110.1	90.9	69.0	48.4
LAC	3.8	3.8	3.7	3.5	13.2	10.2	7.2	4.9
All developing countries	20.7	25.0	34.7	49.9	248.4	199.9	167.2	137.9
Global	26.9	31.4	42.8	59.4	253.0	203.8	171.4	142.0

Sources: de Onis, Blössner, and Borghi 2010, 2011.
Note: LAC = Latin America and the Caribbean. Overweight/obese is defined as > 2 standard deviations from weight-for-height median. Stunting is defined as more than two standard deviations below the height-for-age median.

Wasting

Children who suffer from wasting are at substantially increased risk of severe acute malnutrition and death. Globally, 8 percent of children suffer from wasting. South Asia has the highest prevalence of wasting (16 percent), and the highest prevalence of underweight (33 percent). Sub-Saharan Africa has 9 percent prevalence of wasting, the second-highest rate.

Obesity

Increasing trends in child overweight/obesity have occurred in the past two decades in most regions. Globally, an estimated 42.8 million (7 percent) of children younger than age five years were overweight or obese in 2010, a 59 percent increase from an estimated 26.9 million in 1990. Projections are for a further increase of 39 percent from 2010 to 59.4 million in 2020, of which 49.9 million are projected to be in LMICs. Latin America and the Caribbean had the highest prevalence in 1990, at 6.8 percent, which increased slowly to 6.9 percent in 2010 and is projected to be 7.2 percent in 2020. Other LMIC regions had much more rapid increases in the past two decades; Sub-Saharan Africa was notable because of the increase from 4.0 percent in 1990 to 8.5 percent in 2010, projected to be 12.7 percent in 2020. Throughout the period 1990–2020, Southern and Central Asia has the lowest prevalence, but still has substantial increases from 4.2 million in 1990 to 8.0 million projected for 2020.

Stunting

Globally, 26.7 percent of children younger than age five years were stunted in 2010, an estimated 171.4 million children. Southern and Central Asia and Sub-Saharan Africa have particularly high prevalence rates of between 36 percent and 38 percent. However, although prevalence in these two regions is similar for 2010, the trends are different. For Sub-Saharan Africa, the prevalence of 40.3 percent in 1990 (44.9 million children) declined very slowly to 38.2 percent in 2010, and it is projected to be 37.1 percent by 2020 (64.1 million). In contrast, in Southern and Central Asia, the prevalence in 1990 was much higher at 60.7 percent, an estimated 110.1 million stunted children, yet the rate dropped to 36.4 percent (69 million) in 2010; it is projected to be 25.9 percent (48.4 million) in 2020.

Benefit-Cost Estimates for Nutritional Interventions

Some consensus exists on the benefits of specific nutritional interventions. Often using meta-analyses of controlled trials, reviews such as Bhutta and others (2013) indicate the expected changes in outcomes of stunting or anemia for a given intervention. A body of evidence exists on the costs for achieving such outcomes (Horton and others 2010). These costs, as well as the expected outcomes, can be combined to calculate the relative cost-effectiveness of approaches to achieving a desired improvement in nutrition. However, to estimate a benefit-cost ratio, one needs to convert the multiple relevant outcomes into the same metric as the costs. As indicated in the example in table 7.1, doing so usually involves summing over different outcomes. Some of these, such as a reduction in resources used to care for illness, can be directly assessed in monetary terms. Others, such as increased labor productivity, require estimates of the degree to which the change in nutritional status leads to an increase in earnings, as well as assumptions about the productivity of those not in wage jobs. Most such estimates are based on indirect inference—the changes in schooling or learning attributable to improved nutrition combined with the impact that such increases in learning will have on earnings, often derived from separate studies.

One study, however, has been able to track individuals from the time they participated in a community-randomized program of supplemental feeding when they were infants and toddlers to their adult years about 35 years later (Hoddinott and others 2008; Hoddinott, Behrman, and others 2013). This study found that men who had received better (protein-enriched, higher energy) supplements before age three years earned, on average, 44 percent higher wage rates later in life; this finding confirms that the body of indirect estimates of returns to nutrition programs based on changes in schooling or cognitive ability discussed in the following sections is in keeping with direct longitudinal evidence.

Table 7.4 lists some estimated benefit-cost ratios for nutritional interventions for preschool children based on Behrman, Alderman, and Hoddinott (2004). The benefits are calculated along the lines of those in table 7.1. Details, including the cost assumptions, are given in the original source, as are some sensitivity analyses (including varying the discount rate between 3 percent and 5 percent) that result in a range of estimates. These interventions can be divided into three groups according to the aim:

- Reduce LBW
- Directly improve infant and child nutrition
- Reduce micronutrient deficiencies.

For each group, estimates are provided for three interventions. Some points to note concerning this table are the following: the benefit-cost ratios are sensitive to the underlying assumptions, so some of the ranges are large; the benefit-cost ratios vary a fair amount within each group, for example, 0.58–35.20 for reducing LBW; and many of these benefit-cost estimates are substantially greater than 1.0, suggesting that even if there is some further discounting to account for uncertainty in such estimates, a number of these interventions merit serious consideration in contexts in which the nutritional deficiencies they are intended to address are prevalent. Table 7.5 provides similar results using different discount rates.

Table 7.4 Benefit-Cost Estimates for Nutritional Interventions for Preschool Children with Discount Rates of 3 Percent to 5 Percent

	Benefit-cost ratio
1. Reducing LBW for pregnancies with high probabilities of LBW	
1a. Treatments for women with asymptomatic bacterial infections	0.6–5.0
1b. Treatment for women with presumptive STD	1.3–10.7
1c. Drugs for pregnant women with poor obstetric history	4.1–35.2
2. Improving infant and child nutrition in populations with high prevalence of child malnutrition	
2a. Breastfeeding promotion in hospitals in which norm has been promotion of use of infant formula	5.6–67.1
2b. Integrated child care programs	9.4–16.2
2c. Intensive preschool program with considerable nutrition for poor families	1.4–2.9
3. Reducing micronutrient deficiencies	
3a. Iodine (per woman of childbearing age)	15.0–520.0
3b. Vitamin A (per child younger than age six years)	4.3–43.0
3c. Iron (pregnant women)	6.1–14.0

Source: Based on Behrman, Alderman, and Hoddinott 2004.
Note: LBW = low birth weight; STD = sexually transmitted disease.

Table 7.5 Sensitivity of Nutritional Intervention Benefit-Cost Ratios to Different Discount Rates and Values of Disability-Adjusted Life Years

Intervention	Discount rate 3%; DALY value of US$1,000	Discount rate 6%; DALY value of US$1,000	Discount rate 3%; DALY value of US$5,000	Discount rate 6%; DALY value of US$5,000
Community nutrition education and promotion	12.5	7.5	62.5	37.5
Vitamin A and zinc supplementation	17.3	10.0	86.5	52.0
Salt iodization	30.0	12.0	30.0	12.0
Iron fortification	8.0	7.0	8.0	7.0
Anthelmintics at preschool	6.0	2.4	6.0	2.4

Source: Based on Horton, Alderman, and Rivera 2009.
Note: DALY = disability-adjusted life year.

Additional estimates of benefit-cost ratios for nutrition interventions in the first 1,000 days that increase preschool linear growth (height) are provided in table 7.6. These ratios are based on recent estimates by Hoddinott, Alderman, and others (2013). On the cost side, Hoddinott, Alderman, and others (2013) provide two sets of estimates of budgetary costs per child—as opposed to costs compiled from ingredients or inputs—to provide 10 evidence-based interventions to reduce stunting and micronutrient deficiencies in children in their first two years of life. On the benefit side, Hoddinott, Alderman, and others (2013) first multiplied the point estimate of the increase in per capita permanent income (consumption) from reducing stunting by 0.20 in recognition of the estimate by Bhutta and others (2013) that this package of interventions will reduce stunting by 20 percent and then assumed that only 90 percent of these income gains are realized.

The first data column in the table reproduces the resulting benefit-to-budgetary-costs ratios using the generally higher cost estimates based on Bhutta and others (2013). However, the procedures in this particular approach underestimate benefits because they include only income or consumption benefits (and not, for example, benefits from averting mortality and resource costs saved as a result of reduced morbidity), and they underestimate resource costs because they do not include private costs and market distortion costs, in particular, the cost of raising revenue to finance the intervention. They also do not exclude the transfer component of public expenditures and so may overstate public sector resource costs; however, for the interventions considered, these transfer components probably are relatively small. Therefore, the second data column includes adjustments to benefits—an increase of 20 percent to represent social benefits beyond increases in income—as well as an increase in costs of 50 percent to represent private costs and another 25 percent to represent distortion costs. The resulting benefit-cost ratios make interventions to reduce stunting still appear to be an attractive investment given that all the estimates are greater than 1.0, and all except the Democratic Republic of Congo are greater than 6.0, with a median of 12.4 (the estimate for the median country, Bangladesh). The range of estimates also is considerable, from 2.4 for the Democratic Republic of Congo to 33.1 for Indonesia, suggesting that context is important for evaluating such interventions.

A generic concern for these estimates is that the underlying data are often from small-scale studies. Both benefits and costs are likely to change as programs scale up (Alderman, Behrman, and Puett 2017; Menon and others 2014); benefits for hard-to-reach subpopulations may be higher or lower than for the general population, but costs are more likely to increase as programs expand coverage. This is a generic concern, but it is more likely to affect more personnel-intensive programs, such as counseling, relative to micronutrient fortification or supplementation. This is also a concern for most, although not all, estimates of returns to stimulation and preschool.

Benefit-Cost Ratios for Investment in Early Childhood Cognitive and Socioemotional Development

Overview of Programs and Interventions

Disparities in children's development emerge early and are driven by risks associated with poverty that include inadequate nutrition, low maternal education, lack of stimulation, and low levels of maternal well-being. As exposure to risks increases, both in number and duration, low-income children fall further behind more advantaged groups. Without appropriate investments from both their families and the state, children do not

Table 7.6 Benefit-Cost Ratios for Moving Child from Stunting at 24 Months to Not Stunted, in 17 Selected Heavily Burdened Countries

Region	Country	Ratio of income benefit to budgetary cost (Hoddinott, Alderman, and others 2013)	Adjusted benefit-cost ratio[a]
Sub-Saharan Africa	Congo, Dem. Rep.	3.5	2.4
	Madagascar	9.8	6.8
	Ethiopia	10.6	7.3
	Uganda	13.0	9.0
	Tanzania	14.6	10.1
	Kenya	15.2	10.5
	Sudan	23.0	15.9
	Nigeria	24.4	16.9
Middle East and North Africa	Yemen, Rep.	28.6	19.8
South Asia	Nepal	12.9	8.9
	Myanmar	17.2	11.9
	Bangladesh	17.9	12.4
	Pakistan	28.9	20.0
	India	38.6	26.8
East Asia	Vietnam	35.3	24.5
	Philippines	43.8	30.4
	Indonesia	47.7	33.1

Sources: Based on estimates from Hoddinott, Alderman, and others (2013), with cost and intervention data from Bhutta and others (2013).
a. Adjustments include increasing benefits by 20 percent to represent nonincome consumption benefits and increasing costs by 50 percent to represent private costs and by 25 percent to represent distortion costs.

acquire the skills needed to benefit fully from formal education when they enter primary school. Lower ability at school entry is associated with lower achievement and increased drop out (Grantham-McGregor and others 2007), leading to continuing and, in some cases, widening inequality, as well as forgone productivity.

The range of programs to improve child cognitive development in LMICs during the period between birth and the initiation of primary schooling is reviewed in Engle and others (2007) and in Engle and others (2011) and includes programs to promote better parenting and mother-child interaction through home visits by community health workers or by means of group sessions with mothers. Consistent evidence from several countries indicates that interventions that improve parent-child interaction and stimulation benefit children's development; the most current evidence is from interventions delivered through home visits by trained community health workers (Attanasio and others 2014; Hamadani and others 2006; Powell and others 2004; Yousafzai and others 2014). Some evidence indicates that these early interventions have sustained benefits for cognitive ability and behavior around the age of school entry (Grantham-McGregor and others 1997; Walker and others 2010) and adulthood (Gertler and others 2014; Walker, Chang, and others 2011). Evidence for benefits from other approaches to delivering parenting support, such as through community groups, is also emerging (Singla, Kumbakumba, and Aboud 2015). Center-based approaches, for example, community day care, have been implemented, particularly in Latin America and the Caribbean, with variable benefits depending on program quality (Grantham-McGregor and others 2014). There is, however, a lack of information to guide successful scale-up, including resources required, and more analysis of the implementation process as promising programs are expanded is particularly urgent.

A subset of interventions that enhance child stimulation also provides nutritional supplements, often targeted to children who were born with low birth weights or were stunted. These interventions generally led to improvements in cognitive outcomes and socioemotional development, and sometimes in nutritional outcomes. There is, however, little evidence of synergy between stimulation and nutrition interventions in their outcomes (Grantham-McGregor and others 2014) in the small-scale programs that have been extensively studied, but combining these two types of interventions does not reduce the expected impact of either intervention when delivered independently. There may be synergies in costs if there are economies of scope because some common infrastructure can support both interventions.

Attendance at preschool for children ages three to six years increases development and readiness for formal schooling (Engle and others 2011). The proportions of children in the appropriate age range enrolled vary widely, with an average of 17 percent of children enrolled in low-income countries and 54 percent in middle-income countries (UNESCO 2014). Within regions and countries, lower-income children are less likely to be enrolled (Engle and others 2011). In addition to the need for increased access is a need for investment in improving quality, with improvements in structure (for example, infrastructure, class size) and process (for example, quality of caregiver-child interaction, developmentally appropriate activities); evidence suggests that improvement in process is more critical (Berlinski and Schady 2015).

Rates of Return to Preschool and Early Child Development Programs

Jamaica. An important and influential longitudinal study from Kingston, Jamaica, tracked a cohort of 129 stunted children since they were ages 9–24 months for more than 20 years; the children were initially randomly assigned to four different groups, three of which involved interventions that lasted two years.

- The first group received weekly one-hour home visits from community health workers, who taught parenting skills and encouraged mothers to interact and play with their children in ways that would develop their children's cognitive and socioemotional skills.
- The second group received weekly nutritional supplements of 1 kilogram of a milk-based formula.
- The third group received both home visits and nutritional supplements.
- The fourth group (the control group) received neither.

Gertler and others (2014) directly assessed the impact of these interventions on young adult earnings. Although the children in the home visit stimulation treatment arms were stunted at the time of recruitment into the study, they were able to close the wage gap with a matched nonstunted comparison group. More specifically, the analysis attributed a 25 percent increase in earnings to the stimulation interventions; in contrast, the nutritional arm of the intervention did not close the earnings gap. The authors contend that this increase due to stimulation was larger than that reported in the few similar interventions from the United States. Although the research design was not set up to assess the relative value of cognitive and socioemotional gains, measures on both of these dimensions of development were improved in the intervention. In addition to the earnings benefit, the intervention also reduced violent behavior (Walker, Chang, and others 2011) and so provided a social benefit, which is not often measured in rates of return.

Turkey. Another long-term panel following an early child development intervention in Turkey looked at the beneficiaries of an intervention in which parents were provided training to improve the home learning environment for their children (Kaytaz 2005). The benefit-cost estimates reported in this study when parental training was center based were 4.3 and 6.4, using plausible discount rates of 10 percent and 6 percent, respectively. The benefit-cost estimates for the home-based parental training using the same discount rates of 10 percent and 6 percent were 5.9 and 8.7, respectively. These benefits are based on the increase in schooling and reduced dropout rates and the expected increase of earnings that can be inferred from these changes in levels of schooling; the earnings of the beneficiaries were not collected. These estimates do not include any increased learning per year of school, and, as Kaytaz (2005) indicates, the benefits are lower-bound estimates.

Bolivia. Behrman, Cheng, and Todd (2004) analyze the impacts of Bolivia's Proyecto Integral de Desarrollo Infantil. The program, which provided feeding as well as day care to groups of up to 15 children in the homes of women in low-income neighborhoods, achieved improvements in measures of language and auditory development, psychosocial skills, gross motor development, and fine motor development, but not in height or weight. Using estimates of the expected increase of schooling that these improvements are assumed to translate into, as well as estimates of the returns to schooling of children in the country, the benefit-cost ratio ranges between 2.0 and 2.9 for children for whom the increase of schooling would be at the intermediate level through grade 8 for discount rates of 5 percent and 3 percent, respectively, and somewhat lower for children for whom the increase in schooling would be at the secondary level that goes until grade 11. The costs in this estimate include the direct program costs, the private opportunity costs of the time devoted to increased schooling, and the expected deadweight cost to the economy from raising the revenue to finance the program.

Colombia. Colombia has been running a similar publicly funded day-care program, Hogares Comunitarios de Bienestar (in fact, Proyecto Integral de Desarrollo Infantil was modeled after this program). Bernal and

Fernández (2013) reported that children ages three years and older who spent at least 15 months in the program showed improvements in both cognitive development and socioemotional skills, although no gains in nutritional status were observed. The benefit-cost ratio was estimated to be between 1.0 and 2.7, using discount rates of 8 percent and 5 percent, respectively.

Both of these studies of day-care centers in Latin America reach children up to age six years, but the centers are not structured preschool programs. Engle and others (2011) provided an order of magnitude estimate of the benefit-cost ratio for such structured preschool programs at scale. This assessment was based on an estimate of the gap between the completed level of schooling for the wealthiest quintile in a given country and that of the poorest as a function of preschool enrollment in the previous 8–12 years. This estimate provided the basis for projecting the expected increase in schooling, and the concomitant increase in earnings, due to an increase in preschool participation, controlling for country effects. Using a discount rate of 3 percent, the assessment indicated that bringing the preschool enrollment rate in all LMICs to 25 percent, starting from each country's base level, would have a benefit-cost ratio of 14.3; bringing the enrollment rate to 50 percent would have a benefit-cost ratio of 17.6. Discounting future returns at a higher rate of 6 percent would lead to benefit-cost ratios of 6.4 and 7.8, respectively.

These estimates have wide ranges and are also sensitive to assumptions about the impact of schooling on wages as well as estimates of the cost of providing this schooling, but these results are similar to program-specific estimates in the literature. For example, Berlinski, Galiani, and Manacorda (2008) presented evidence on schooling outcomes measured a decade after the expansion of preschool enrollment in Uruguay. Their data indicated that as the supply of preschool services increased between 1989 and 2000, participation in preschools increased by 12 percentage points so that well more than 90 percent of all children attended preschool by the end of the period. From their results on the influence of preschool enrollment on school achievement, as well as the cost of construction of classrooms along with local salaries for teachers, they estimated a benefit-cost ratio of 3.2 using a discount rate of 10 percent. If the discount of future earnings is 3 percent, the estimated benefit-cost ratio is 19.1.

Returns to Investments in Schooling

Most estimates of the returns to investments in schooling in LMICs are based on estimates of the association between grades of schooling attainment and the earnings of wage workers. More specifically, if one assumes that the only cost of schooling is forgone wages and that the logarithm of wages is a linear function of schooling and other variables, then the coefficient on schooling from a regression of the log of wages on schooling and those other variables can be interpreted as the private return to time spent in school (see Mincer 1974).

There are at least two problems with such estimates. The first is that they estimate only the private returns to schooling that result from increased wages, and they exclude both other private returns, such as improved health accruing to that person and his or her children, and social returns that accrue to other members of society. These omissions imply that private returns may underestimate total returns. Second, overestimation is also possible because there are other private costs beyond the time spent in school; there are also social costs, in particular, the costs that governments incur by providing schooling opportunities at little or no cost to students and their families. The second problem is that these regressions yield private rates of return to investments in schooling only if the coefficient on schooling measures the causal impact of schooling on wages, and there are several reasons why such estimates may not reflect a causal relationship.

First, regressions of wages on schooling and other variables may not lead to accurate estimates of the causal impact of schooling on wage income because random measurement error in schooling could lead to underestimates of that impact; such measurement errors are particularly likely to be a problem in data from LMICs. Moreover, unobserved factors such as ability, motivation, and family connections could determine both schooling and earnings, even after controlling for wealth and parental schooling, and lead to overestimates in rates of return to schooling. In addition, such estimates from LMICs are almost always for wage earners only, not for the self-employed. Substantial evidence suggests that the return to education among the self-employed is lower than the return to wage earners,[2] which implies that estimates based only on wage earners are likely to be overestimates in countries with large numbers of self-employed workers. Finally, even among wage earners, estimates should, in general, exclude government workers if they are to be interpreted as reflecting productivity as opposed to private returns; yet in most cases, such workers are included. The pay received by government workers with different levels of education mainly reflects government salary policies rather than the productivity of different types of workers.

Given these problems, it is not surprising that compilations of estimates often yield very different results.

Psacharopoulos and Patrinos (2004) presented compilations indicating that the rate of return to an additional year of primary education in Sub-Saharan Africa is 37.6 percent, but Montenegro and Patrinos (2012) reported a much smaller rate of return of 13.4 percent.

Two of these problems can be resolved if valid instrumental variables can be found to predict schooling. A few studies have attempted to use instrumental variable methods to obtain more accurate estimates of the impact of schooling on wages in LMICs. Duflo (2001) used a sharp increase in the construction of primary schools to estimate the impact of schooling on wages in Indonesia. Her estimates indicate that an additional grade of schooling increases wages in that country by 7 percent to 11 percent. She also noted that the instrumented results do not differ appreciably from the uninstrumented estimation. Behrman and others (2013) estimated that an additional grade of schooling increases wages by 9.8 percent in Guatemala; the main identifying instruments were student-teacher ratios, mother's height, and mother's and father's schooling. While more studies would be useful, these two studies suggest that private returns to education are approximately 10 percent in LMICs.

Whatever the impact of additional schooling on adult earnings, there remains the question of what investments may lead to an increase in schooling. School enrollment or grades of schooling completed can be increased by demand-side interventions, such as transfer programs, or by increases in the supply and quality of schooling. The former category includes conditional transfers (Behrman, Parker, and Todd 2011) and school feeding programs (Adelman, Gilligan, and Lehrer 2008). The latter category was reviewed by Glewwe and others (2013), who reported that there are few unambiguous results regarding investments and schooling outcomes. A more comprehensive review can be found in Glewwe and Muralidharan (2016). Although that literature goes far beyond the issues central to disease control priorities, a few salient points are worth discussing here.

- First, although ability affects both schooling attainment and what is learned in school, the latter is the stronger determinant of earnings (Hanushek and Woessmann 2008).
- Second, despite the regular pattern of increased earnings with increased schooling, the quality of education in many settings is discouraging. For example, 52.7 percent of standard 5 (grade 5) students in India could not read a standard 2– (grade 2–) level text (ASER Centre 2014). Similar patterns are found in many Demographic and Health Surveys across the globe. Although many reasons for this waste of resources call for reforms and improvements in school systems, it may be the case that students, or a subset of them, come to school with huge disadvantages that could be offset through interventions in early childhood.
- Third, the impact of specific investments depends, in part, on the ability of students. For example, Glewwe, Kremer, and Moulin (2009) found that an increased supply of books in Kenya benefited the stronger students but had no measurable impact on the others. A different view of complementarity of inputs comes from Grantham-McGregor, Chang, and Walker (1998). This study found that feeding schoolchildren improved attention, but the impact on learning depended on the classroom structure, with stronger results found where the classes were more effectively organized.
- Finally, education responds to health, not only with respect to early-life nutrition, but also with respect to health investments for school-age children. For example, Miguel and Kremer (2004) found deworming in Kenya to be more cost-effective at increasing school participation[3] than supply-side interventions such as the provision of textbooks. Bleakley (2007) noted that hookworm infections in the American South in the early 1900s reduced the income in adulthood of infected children by 43 percent and that this negative outcome was effectively eliminated by a concerted program of hookworm control. Bleakley (2010) estimated a similar impact of malaria-control campaigns on incomes in the United States (circa 1920) and in Brazil, Colombia, and Mexico (circa 1955).

The possibility that healthier children will respond more to schooling inputs is an example of dynamic complementarity and is a major component of the returns to nutrition (Glewwe, Jacoby, and King 2001). However, the interaction of health and schooling may show some dynamic substitution rather than complementarity; there may be educational interventions with higher impacts the lower the initial health conditions. For example, Bobonis, Miguel, and Sharma (2006) studied the provision of iron supplementation and deworming medicine to preschool children in India. Overall, children in the treatment group had less absenteeism, but children who were initially anemic at baseline had a larger response to the intervention. Similarly, iron supplementation costing less than US$5 per child in primary schools in China over a seven-month period led to an improvement in hemoglobin as well as a significant improvement in math test scores (Luo and others 2012), and the academic improvement was found only for children who were anemic before the program.

CONCLUSIONS

Interventions to improve nutrition as well as to enhance cognitive and socioemotional development in each of the early lifecycle stages—preschool ages, schooling ages, and later adolescence—can achieve returns in later stages that greatly exceed their costs. Yet an empirical question remains: at what lifecycle stage, and in what context, are the benefit-cost ratios high enough to warrant investments? The benefit-cost estimates from nutritional interventions in the first 1,000 days are based on extensive data and have been accumulated on a global basis, albeit mostly for small, special samples; there is less evidence on benefits and costs for stimulation and early child development for programs at appreciable scale. Moreover, a review of the cost of programs at scale in Latin America and the Caribbean indicates a wide—and not fully understood—heterogeneity of costs (Araujo and López-Boo 2013). This knowledge gap hinders any definitive generalizations.

Even if estimates of costs were confined to a narrow range over various environments, there is also a general dearth of results on the heterogeneity of impacts. A few studies show that programs may have greater impacts for children who enter these programs at an initial disadvantage (Engle and others 2011). Berlinski, Galiani, and Manacorda (2008) found that the impact of preschool attendance was largest for those children from households with parents who have less schooling, and Jung and Hasan (2014) found that block grants for preschool groups in Indonesia narrowed gaps in language and cognitive development. To the degree that such programs reduce gaps in children's development, they have an additional social value in reducing the intergenerational transmission of poverty with possible gains in efficiency if such programs partially offset capital market failures that result in underinvestments in children. Although a reduction in poverty is usually not translated into benefits that can be aggregated into benefit-cost ratios, the benefits are likely to be real and positive and could be incorporated by weighting outcomes for children from poorer families more heavily.

According to widespread evidence, gradients in cognitive ability by socioeconomic status appear early in life (Fernald and others 2012; Naudeau and others 2011; Schady and others 2015); therefore, the potential to prevent or reverse gaps suggests that nutrition programs, the promotion of early stimulation, and preschool education may have social returns that are appreciably larger than commonly reported.

Some perceive that an ounce of prevention is worth a pound of cure, so that the earlier such interventions can be delivered, the better. The evidence does suggest that, given the current distribution of investments over the lifecycle, in many contexts the rates of return to some additional investments are likely to be highest very early in life. However, there are likely to be diminishing marginal rates of return to such interventions; even if under present circumstances the rates of return were highest to interventions to improve nutrition in the womb or very early in a child's life, it does not follow that all resources should be moved from later to earlier in life. As more resources are moved from later to earlier life, most likely diminishing marginal rates of return will mean that the rates of return to the investments in early life will fall and those to investments in later life will increase. Indeed, it would be socially optimal in an economic sense to move resources directed to human development from older to younger ages until the social rates of return to the use of resources at all ages are equalized.

NOTES

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

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

1. Halfon and others (2014) propose four phases—generative, acquisition of capacity, maintenance of function, and managing decline—that differ from the stages discussed here, although they are related conceptually.
2. For example, compare the estimates of van der Sluis, van Praag, and Vijverberg (2005) on returns to schooling among the self-employed to the estimate of Psacharopoulos and Patrinos (2004) on the returns to schooling among wage earners.
3. School participation combines enrollment with attendance; among two children enrolled in school, the one with higher attendance in a given year has higher participation, and any child not enrolled has a participation rate of zero.

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