DISEASE CONTROL PRIORITIES • THIRD EDITION

8

Child and Adolescent Health and Development

Optimizing Education Outcomes:

High-Return Investments in School Health for Increased Participation and Learning

EDITORS

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WITH A FOREWORD BY

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WITH A PREFACE BY

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WITH A PROLOGUE BY

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VOLUME 8

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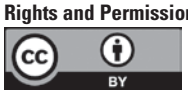

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Contents

The following chapters present *DCP3*'s messages for the education sector. They are numbered as they originally appeared in *DCP3* Volume 8, *Child and Adolescent Health and Development*. The complete table contents for volume 8 may be found at the end of this edition.

Foreword

HEALTH AND EDUCATION DURING THE 8,000 DAYS OF CHILD AND ADOLESCENT DEVELOPMENT: TWO SIDES OF THE SAME COIN

Today, there is comfort to be found in returning to the inspired words of others. Until H. G. Wells' time machine is made, words are our emotional anchor to the past and, one hopes, our window to a brighter future. Speaking before the 18th General Assembly of the United Nations in 1963, it was President John F. Kennedy who noted that the "effort to improve the conditions of man, however, is not a task for the few." Development is a shared, cross-cutting mission I know well. For the breakthroughs we witness—from Borlaug's wheat to a vaccine for polio—are the products of cooperation, a clean break from siloed thinking, and a courage to work at the sharp edges of disciplines.

Working as a lecturer for five years in the 1970s and early 1980s, I came to see—in a way I never had as a student—that education unlocks talent and unleashes potential. And as Chancellor, Prime Minister, and most importantly a parent, education has remained a centerpiece in my life because of the hope it delivers. For when we ask ourselves what breaks the weak, it is not the Mediterranean wave that submerges the life vest, nor the food convoy that does not make it to the besieged Syrian town. Rather, it is the absence of hope, the soul-crushing certainty that there is nothing ahead to plan or prepare for—not even a place in school.

Two years ago, the International Commission on Financing Global Education Opportunity, composed of two dozen global leaders and convened by the Prime Minister of Norway and the Presidents of Chile, Indonesia, and Malawi, as well as the Director-General of UNESCO, set out to make a new investment case for global education. What resulted was a credible yet ambitious plan capable of ensuring that the Sustainable Development Goal of an inclusive and quality education for all is met by the 2030 deadline. While we continue to work today to ensure our messages become action—from increased domestic spending on schooling to an International Finance Facility for Education—we sought to produce an authoritative, technically strong report that would spend more time being open on desks than collecting dust on a shelf.

The *Disease Control Priorities* (*DCP*) series established in 1993 shares this philosophy and acts as a key resource for Ministers of Health and Finance, guiding them toward informed decisions about investing in health. The third edition of *DCP* rightly recognizes that good health is but one facet of human development and that health and education outcomes are forever intertwined. The Commission report makes clear that more education equates with better health outcomes. And approaching this reality from the other direction, this year's volume of *DCP* shows that children who are in good health and appropriately nourished are more likely to participate in school and to learn while there. The Commission report raises the concept of progressive universalism or giving greatest priority to those children most at risk of being excluded from learning. Here, too, the alignment with *DCP* is clear as health strides are most apparent when directed to the poorest and sickest children, as well as girls.

It is fitting that one of the Commission's background papers appears as a chapter in this volume. The Commission showed that education spending,

particularly for adolescent girls, is a moral imperative and an economic necessity. Indeed, girls are the least likely to go to primary school, the least likely to enter or complete secondary school, highly unlikely to matriculate to college, and the most likely to be married at a young age, to be forced into domestic service or trafficked. And with uneducated girls bearing five children against two children for educated girls, the vicious cycle of illiterate girls, high birth rates, low national incomes per head, and migration in search of opportunity will only worsen so long as we fail to deliver that most fundamental right to an education.

Here is a projection to remember. If current education funding trends hold, by 2030, 800 million children—half a generation—will lack the basic secondary skills necessary to thrive in an unknowable future. In calling for more and better results-based education spending, the Commission estimated that current total annual education expenditure is US$1.3 trillion across low- and middle-income countries, an anemic sum that must steadily rise to US$3 trillion by 2030. A rising tide must lift all ships, and so as education spending at the domestic and international levels sees an uptick, the same must be witnessed for health. The numbers may seem large, but the reality is that this relatively inexpensive effort would do more than unlock better health and education outcomes; it would bring us closer to achieving all 17 Sustainable Development Goals and unlocking the next stage of global growth.

A key message of this volume is that human development is a slow process; it takes two decades—8,000 days—for a human to develop physically and mentally. We also know a proper education requires time. So the world needs to invest widely, deeply, and effectively—across education, health, and all development sectors—during childhood and adolescence. And while individuals may have 8,000 days to develop, we must mobilize our resources today to secure their tomorrow. Let us not forget that the current generation of young people will transition to adulthood in 2030, and it will be their contribution that will determine whether the world achieves the Sustainable Development Goals.

We have, to again draw on Kennedy's words, "the capacity to control [our] environment, to end thirst and hunger, to conquer poverty and disease, to banish illiteracy and massive human misery." We have this capacity, but only when we work together. Both the Commission report and this latest *Disease Control Priorities* volume seek to elevate cross-sector initiatives on the global agenda. In human development, health and education are two sides of the same coin: only when we speak as one will this call be heard.

Gordon Brown
United Nations Special Envoy for Global Education
Chair of the International Commission on
Financing Global Education Opportunity
Prime Minister of the United Kingdom, 2007–2010
Chancellor of the Exchequer, 1997–2007

Preface

There is much to be proud of the achievements in global education over the past 15 years. Good planning, funding, and collaborative efforts have contributed to a tremendous increase in access to primary school for many millions of girls and boys in developing countries. Today, there are more schools, more students, and more and better trained teachers than ever before.

And yet, an estimated 264 million children and youth find themselves unable to go to school; many millions more are in school but are not learning at the levels they should. The reasons are complex, but if you are poor, a girl, or living in a rural location—or, as is often the case, a combination of these—your chances of success in school are far less likely than others. Where you come from affects not only your education achievements but also your health status and your life chances and opportunities.

For the poorest students, enrolling in school, attending regularly, and learning are often made more difficult by illness, hunger, and malnutrition. In low- and middle-income countries, an estimated 500 million days off school that are due to sickness affect student attendance, concentration, growth, and learning.

Consider Sier Leap, for example. She lives in Cambodia, is in grade 9, and is doing well now. But not so long ago, Sier was struggling in class, her eyes hurt, and she found it difficult to concentrate. Through a school health program delivered by the Ministry of Education, funded by the Global Partnership for Education, and implemented by the World Bank and specialist eye health organizations, Sier was among many thousands of school-age children who had simple vision testing carried out by trained teachers at her school. After a follow-up exam at a nearby health clinic, she received glasses to correct her vision and transform her life. Sier is happier and more confident now, performing well in school and hoping to become a lawyer.

Schools can be effective places to support children's health, and some countries are implementing school health programs. The 2017 report of the International Commission on Financing Global Education Opportunity highlighted some of the best-proven health practices for increasing enrollment, attendance, participation, and learning for primary school–age girls and boys. It highlighted school-based malaria prevention, feeding, water and sanitation, and deworming. For girls, in particular, investments in comprehensive sexuality education, reproductive health knowledge and related services, and sanitary facilities are effective in supporting enrollment and retention.

Optimizing Education Outcomes draws on the latest evidence and analysis available in volume 8, *Child and Adolescent Health and Development* of *Disease Control Priorities,* third edition (*DCP3*). It makes clear the synergies between education and health investments and outcomes. It also confirms that our efforts and resources must focus on both health and education to achieve further gains in human development and progress toward the Sustainable Development Goals. Long-term goals in health are unattainable without an educated population, and children cannot learn if they suffer from the effects of poor health and nutrition.

DCP3 volume 8 proposes a package of school health investments that can effectively address the most pressing health problems and health knowledge needs of school-age children in low- and lower-middle-income countries. It contains evidence that policy makers, practitioners, and planners can use to make the case for high-return, affordable school health interventions to improve not only school-age children's health and development, but also their participation and learning.

For school-age children between ages 5 and 14, selected vaccinations, vision screening, insecticide-treated

mosquito net promotion and use to prevent malaria, deworming in high-load areas, and school meals are among the report's recommendations. It calls also for older children, ages 10 to 19 approximately, to have access to healthy lifestyle and comprehensive sexuality education, adolescent-friendly health services within schools, and mental health education and counseling.

School-age children—approximately 400 million worldwide—typically have the highest burden of worm infection of any age group. They struggle with fatigue, sickness, anemia, and malnutrition, which in turn keep them out of school or sap their ability to concentrate and learn. However, for a cost of less than US$0.50 a year, school-based deworming can reduce absenteeism by up to 25 percent, and the benefits of school health interventions can be dramatic and immediate.

Jyoti, age 12, took part in the Indian state of Bihar's school deworming day, along with 18 million other students, half of whom are estimated to be infected. "I felt like I couldn't live any longer," she said. "I had so much trouble, I had stomach pain, nausea. I used to feel like vomiting, it was terrible." She adds, "I took the pill at night, and immediately, in the morning I felt good. I suddenly felt lively and energetic."

To be successful, school health programs need to be designed and implemented and funded in collaboration with others. The Global Partnership for Education has supported teams from ministries of education and health—in almost one-third of the countries we support—to do the necessary planning work to ensure that teachers and health workers, local communities, and students work together to implement effective school-based health programs. Many also include programs that alleviate hunger and provide healthy school environments in their national education sector plans.

Optimizing Learning Outcomes sets out the latest evidence to support ministries of education, health, and finance to review existing programs for children's health in school and invest in what works. Their goal is to increase student health, well-being, participation, and learning. This makes sound economic sense, increasing the effectiveness of investments that are beneficial for students now and that build stronger societies and more successful economies in the future.

Implementing these essential packages for school-age children and adolescents will help secure a healthy, better-educated, successful, and more prosperous future for up to 870 million children and young people in the poorest countries. The clock is ticking toward 2030, the deadline the world has set to educate all the world's children. The time is right to work together, across sectors, in a collaborative effort to ensure all girls and boys are healthy and able to complete a free, equitable, and quality primary and secondary education.

Julia Gillard
Board Chair, Global Partnership for Education
and former Prime Minister of Australia

Prologue

Optimizing Education Outcomes: High-Return Investments in School Health for Increased Participation and Learning was developed by the Global Partnership for Education and Disease Control Priorities and published by the World Bank to increase access within the education sector to the latest child-centered evidence about how health affects education outcomes in poor countries—and what to do about it.

This book has its origins in a 30-year effort by the global health sector, initiated at the World Bank, to identify the highest return investments in health in low- and middle-income countries (LMICs), informing the publication of the *Disease Control Priorities* series. The third edition (*DCP3*), published in 2015–18 and supported by the Bill & Melinda Gates Foundation, notably includes volume 8, *Child and Adolescent Health and Development* (Bundy and others 2017). It provides for the first time an expanded analysis of how health status affects the development of school-age children, how ill health affects children's ability to benefit from education, and how this might manifest differently for girls and boys at different ages.

This new book brings together the key chapters of volume 8 that are of particular relevance to the global education sector, providing the latest evidence to inform financing decisions for better education results. The chapters show that health is important to optimize educational outcomes. While the prospects for synergy between health and education are great, they are currently undervalued and underexploited.

Approximately US$210 billion is spent annually on educating school-age children in low- and lower-middle-income countries. From the work of the International Commission on Financing Education Opportunity, it is apparent that this expenditure is woefully inadequate to enable every girl and boy to receive a quality education through a full cycle of schooling. Financing from all sources, including domestic resources and official development assistance, must increase. Of current spending, only about US$2 billion addresses the health needs of children ages 5 to 19 years, whereas some US$29 billion is invested in children under age 5. It is therefore clear that resourcing for the health of school-age children and adolescents must also increase substantially.

BUILDING ON THE SUCCESSES IN EDUCATION

The purpose of this education version of volume 8 is to help policy makers, planners, and practitioners build on the remarkable successes achieved in education during the 15 years of the Millennium Development Goals (MDG) era. It also aims to support rational and informed choices about high-return investments to optimize outcomes during the era of the Sustainable Development Goals (SDG) through 2030 and beyond.

Children entering school now will become adults by 2030. The investments made between now and then in education, health, and nutrition will do much to determine how well these young women and men are equipped and prepared to fulfill their potential in life, for the betterment of themselves, their families, their nations, and the world.

The benefits of a quality education are numerous, well researched, and well documented; they include a broad range of private and public returns to investments. Educating girls in particular has been shown to have a multiplier effect, not only on their own health and economic prospects, but also on the survival, health, education, and well-being of their children, with positive intergenerational impacts on poverty reduction. Educating girls and young women has contributed to

one-third of the reductions in adult mortality over the past five decades.

Chapter 30 in this volume specifically focuses on the health returns to education and draws some important conclusions. First, returns to education are substantially higher than generally understood, and it is important for donors and countries to reflect this in their investment decisions. Second, the results strongly indicate that female education matters more than male education in achieving health outcomes. Overall, investments targeted to girls' education yield a substantial return on health, and increased efforts are needed to close remaining gender gaps. It is vital to invest in what works at scale and what is affordable, to ensure that all girls and boys, young women and young men, everywhere, receive a quality education.

In 2000, at the World Education Forum in Dakar, Senegal, there was formal recognition that health was a key determinant of the ability of children to respond to education, and there was a commitment from many countries to improve school health programs (Barry 2000). The expanded commentary on the Dakar Framework for Action describes three ways that health relates to Education for All (EFA): as an input and condition required for learning, as an outcome of effective quality education, and as a sector that can and must collaborate with education to achieve EFA.

In 2015, at a World Education Forum (WEF) event in Incheon, the Republic of Korea, participants affirmed the growing understanding of the key interactions between education and health. They called for countries to ensure that school health is included in follow-up planning and action. They also called for the mainstreaming of school policies and school health needs in costed and budgeted national education sector plans (FRESH 2015).

HEALTHY, WELL-NOURISHED STUDENTS LEARN BETTER

In low-income countries (LICs) in particular, illness and malnutrition prevent children from getting into school, participating regularly, and reaching their learning potential. The report entitled "The Learning Generation: Investing in Education for a Changing World" (International Commission on Financing Global Education Opportunity 2016) estimates that students miss 500 million school days because of ill health in LICs, often from preventable conditions. Late enrollment and entry to school, patchy attendance, dropping out, repetition of grades, and poor performance all contribute to educational system inefficiencies and undermine education investments.

Educators are well aware that increased spending on education does not, in and of itself, lead to better learning outcomes. Child-centered analyses have shown repeatedly that marked differences exist in outcomes among individuals and different groups of children. The numerous reasons include the impact of student socioeconomic backgrounds on learning potential and achievement. In many countries, the gap in learning between poorer and wealthier students is significant; this gap worsens when the effects of gender, mother's education status, disability, and location are factored in. In LICs, the health of school-age children can be a key factor, and targeted approaches are essential to direct finances most strategically to deliver the strongest results; the current analysis provides evidence to guide decision making on these strategic investments.

OVERCOMING THE LEARNING CRISIS: A CROSS-SECTORAL AND COLLABORATIVE ENDEAVOR

Among the major challenges facing the education sector and education systems globally, broad consensus exists that improving learning achievement and overcoming marginalization and exclusion are top priorities. As the *World Development Report 2018: Learning to Realize Education's Promise* (World Bank 2018) states, schooling is not the same as learning, and schooling without learning is more than a wasted opportunity—it is an injustice. More than 240 million students in school in LICs are not expected to learn much. Just 8 percent will likely learn basic primary level skills and 23 percent basic secondary level skills. By 2030, more than 825 million young people are unlikely to have the basic secondary skills needed to get a job.

Clearly, new thinking and innovative approaches are urgently needed to overcome this learning crisis. Cross-sectoral collaboration, cooperation, and investments can support the achievement of the ambitious SDG goals for education, as well as contribute to the achievement of the health, gender equality, and wider SDG goals. Planning for education and health investments together can support the optimization of the full range of societal benefits of education (GPE 2016).

"The Learning Generation" report notes the positive effects of education on students' sexual and reproductive health, mental health, and physical health in terms of lowered risks of noncommunicable diseases in later life and fewer incidents of violence. The report also highlights some of the best-proven health practices for increasing enrollment, attendance, participation, and learning for girls and boys, and it recommends increasing investments in these areas.

School-based interventions have been proven to be effective and cost-effective in several areas, including malaria prevention, school feeding at primary level, nutrition supplementation, water and sanitation, and deworming in high-load areas (Bundy and Schultz 2016). For adolescent girls, in particular, investments in comprehensive sexuality education, reproductive health knowledge and related services, sanitary facilities, and iron supplementation are crucial to support enrollment and retention. Iron supplementation has been found to increase attention, concentration, and intelligence.

WHAT WORKS TO IMPROVE STUDENT PARTICIPATION AND LEARNING

This book sets out the best current evidence about what works in LMICs to increase student participation and learning. The analyses reaffirm the importance of health at school age, and identify key interventions for different age groups, relevant for the different needs of girls and boys, that are now proven to be worthwhile investments.

The key messages from the chapters in this volume include the following:

- Although investments in basic education for girls and boys ages 5 to 14 have been substantial, but still too low, investments in health interventions for children in this age range have been neglected.
- Three key phases of development have been identified: ages 5 to 9, when infection and malnutrition remain key constraints on development; ages 10 to 14, when significant physiological and behavioral changes are associated with puberty; and ages 15 to early 20s, when further brain restructuring and initiation of behaviors are life-long determinants of health.
- A package of essential interventions that is highly cost-effective and has high benefit-cost ratios can address the needs of ages 5 to 14, using a school-based approach.
- A similarly cost-effective package for ages 10 to 19 years is proposed for delivery through both nonschool mechanisms, such as the media and health services, as well as through secondary schools.
- Investments in education and schooling can be leveraged further by well-designed health interventions, and better design of educational programs can produce better health outcomes for students. The potential synergy between education and health is undervalued and returns on co-investments are rarely optimized.
- Age-appropriate and condition-specific health support, delivered though schools, is required for girls and boys to achieve their full potential as adults.

Although this may be the best available evidence, the picture remains unclear. Indeed, one important finding of volume 8 is that school-age children are the focus of less than 10 percent of the research effort on the health of children and that research on the links between health and education is particularly lacking. The global education sector needs to engage in the dialogue and decision making on research priorities and funding to ensure that these areas, and the impact on girls and boys at different ages, are the focus of future research efforts.

Schools as an Effective Platform for Health Interventions

The chapters in this volume confirm that schools are an effective platform for addressing the health needs of children and adolescents, particularly for students in primary and lower secondary grades (sometimes called *basic education*). Valuable, specific policy analyses on the range of interventions, packages, and policies relevant to school-age children and young people are provided. Essential cost-effective intervention packages that can be delivered with and through schools are described, assisting decision makers in allocating limited resources to achieve both education and health objectives. Importantly, the volume focuses on simple, safe, and well-tried interventions shown to be deliverable through schools, without becoming a burden on the primary role of schools as institutions of learning.

BOOSTING BOTH EDUCATION AND HEALTH OUTCOMES WITH MODEST INVESTMENTS

In many LMICs, the ambition to ensure a good quality education for all is tempered by both financial and resource constraints, requiring difficult choices to be made. The book sets out the economic case for leveraging domestic financing and development assistance funding, with practical and affordable health investments for girls and boys ages 5 to 14. It uses cost-effectiveness, extended cost-effectiveness, benefit-cost-analysis, and returns on investment to identify and prioritize investments at different ages. It also uses the school as a platform, to propose elements of an essential package that is costed, scalable, and particularly relevant in low-resource settings.

The chapters provide a detailed breakdown of the cost of components of the proposed essential package to promote the health of school-age children and adolescents. In summary, the aggregate cost in LICs per year is estimated at US$430 million plus US$43 million to include the human papillomavirus (HPV)

vaccine; in lower-middle-income countries, the estimate is US$2,700 plus US$74 million for the HPV vaccine. The total costs of the school-age package are about US$10 per child in the 5-to-14 age group and US$9 per adolescent in the 10-to-19 age group.

Analysis commissioned for "The Learning Generation" report found that for each US$1 invested in an additional year of schooling in LICs, particularly for girls, earnings increase by US$5 and earning and health benefits increase by US$10. In middle-income countries, the increases are US$3 and US$4, respectively, for the same investment. For every US$1 allocated to childhood immunizations, there is a $44 net return rate on investment.

LMICs have a high proportion of young people in the population. With the successes in education that are due to commitments made during the EFA and MDG eras, more young people are in school than ever before; accordingly, investing in proven and affordable interventions that use schools as the platform to reach a high percentage of the population makes good sense. Modest investments in school-based health interventions can establish firm foundations and set the direction for a healthier and better educated population and a more prosperous and peaceful future. Such investments can benefit all students, particularly girls, children with disabilities, and marginalized groups, and they can help students to expand their life and economic opportunities.

School-Based Health Programs: Affordable and Scalable

Many countries are already implementing school-based health programs that have impact and are sustainable and scalable. These include a range of essential interventions, such as water and sanitation, and health investments, such as deworming and school feeding (Drake and others 2016; Drake, Burbano, and Bundy 2016). For the past 15 years, the use of FRESH (Focusing Resources for Effective School Health) (UNESCO and others 2000), a comprehensive evidence-based framework that promotes better education results through health interventions delivered by schools, has effectively supported collaboration and cross-sectoral planning, financing, implementation, and monitoring (Sarr and others 2017) around a framework of four components for schools. These components for schools are health-related school polices, safe water and sanitation facilities, skills-based health education, and health and nutrition services.

The FRESH framework (UNESCO and others 2000) was first proposed and adopted at the World Education Forum meeting in Dakar in 2000. At that time, an estimated 10 percent of education ministries in Sub-Saharan Africa had policies and activities that recognized the importance of student health and nutrition for education outcomes. When this topic was reviewed at the ninth meeting of the High-Level Group for Education for All in Addis Ababa in 2010, school health programs had become nearly universal; however, programs varied considerably in terms of the quality and coverage of interventions. The need now is to go beyond the high-level policy implications of the FRESH framework and use available guidance, including the advice in this volume, to help the programs make a real contribution to education outcomes.

Proposed Packages of Interventions

This book provides education policy makers, planners, and practitioners with the latest evidence base and analysis on additional effective school-based health interventions that are both pro-poor and pro-girls. School health and nutrition programs can help level the playing field for the most vulnerable students: the poor, the sick, the disabled, and the malnourished. These are the children who require the greatest support throughout their schooling.

School-Age Girls and Boys

For ages 5 to 14, the essential package includes interventions such as tetanus toxoid and HPV vaccination, oral health promotion, vision screening and treatment, insecticide-treated mosquito net promotion and use, deworming, and school meals and school feeding fortified with micronutrients.

Adolescent Girls and Boys

For ages 10 to 19, the essential package includes interventions such as healthy lifestyle education, comprehensive sexuality education, adolescent-friendly health services within schools, nutrition education, and mental health education and counseling.

A Note on Water and Sanitation

Some education readers may wonder why volume 8 does not include the evidence for vital water and sanitation interventions. The rationale, according to health practitioners and the authors of this volume, is that water, sanitation, toilets, and hygiene services are key components of school construction efforts essential for the provision of quality education; these have, for the most part, been accepted and adopted by ministries of education for their education systems (World Bank 2011).

Menstrual hygiene management, also an important aspect of quality education, is a school health activity and can be coordinated with the necessary infrastructural improvements at schools, as needed. Although it is well established that adequate water and sanitation

facilities are necessary to ensure equitable access to education, systematic reviews of menstrual hygiene management interventions demonstrate that education and health research currently lacks the historical depth necessary to state with confidence which menstrual hygiene management interventions work best.

CONTRIBUTIONS FROM MINISTRIES OF EDUCATION AND THE EDUCATION SECTOR

In order for the planning and delivery of interventions to be effective, there needs to be engagement with, and partnership agreements among ministries of education and health, teachers and health workers, and schools and local communities. Student consultation, contribution, and participation are also vital.

Ministries of education and the education sector are asked to do the following to support efficient and effective implementation:

- Open their schools and provide the platform for health service delivery to support improved student health and increase student enrollment, regular attendance, participation, and learning.
- Provide the necessary foundation for effective delivery of school-based health interventions, including education personnel time and associated costs, for example; focal point training in the ministry of education centrally or at district level; and teacher training resources for focal points in schools.
- Ensure that the policy environment and sector plan includes and encourages the development and effective dissemination of education resources to train educators for health activities.
- Encourage and advocate for other line ministries and external partners, including civil society organizations and nongovernmental organization partners, to align with national education sector strategies and school health plans and offer training and personnel to deliver or support activities in schools; coordinate partner resources, expertise, financing, and inputs to boost coverage and streamline the delivery of health investments and interventions in schools.
- Provide the infrastructure necessary for a safe learning environment in schools, including access to water for drinking and washing, and provision of sanitation and hygiene facilities and services for pupils and staff at schools.

Funding These Investments

Given burgeoning populations, the expanding scale and scope of national education plans, and inevitable budget constraints, the question of who will fund these investments and how is clearly very important. Chapter 20 in this volume acknowledges that the funding, implementation, and oversight of school health and nutrition programs do not tend to fall squarely within either the education or the health sector. Rather, many approaches, stakeholders, and collaborations are required to deliver health services in schools. The combination of education and health sector funding, alongside all domestic funding and external financing contributions, will enable the proposed essential packages to be fully funded and implemented.

Ministries of education are encouraged to work closely with ministries of health to make the case to fund school health investments jointly to the ministries of finance. They must be willing and able to fully exploit the experience, commitment, and contributions of the many partners outside of government (for example, civil society organizations, international nongovernmental organizations, and the private sector) and external funders (for example, the United Nations, bilateral and multilateral aid agencies, philanthropists and foundations, and the private sector).

MOVING FORWARD TOGETHER

Taken as a whole, the information presented in this book represents a strong economic case for investment and a robust body of analysis that can inform joint and consultative national education sector analysis and planning exercises. It can also support the preparation of practical, costed, and comprehensive school health policies and plans, in pursuit of the achievement of a quality education for all, leaving no child behind.

Louise Banham, *Global Partnership for Education*
Lesley Drake, *Partnership for Child Development*
Bradford Strickland, *School Health Expert and Independent Consultant*

NOTE

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.

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Abbreviations

AIDS	acquired immune deficiency syndrome
AQ	amodiaquine
AS	artesunate
BCR	benefit-cost ratio
BMI	body mass index
CCT	conditional cash transfer
CHERG	Child Health Epidemiology Reference Group
CME	Child Mortality Estimation
CT	cash transfer
DALY	disability-adjusted life year
DCP1	*Disease Control Priorities in Developing Countries,* first edition
DCP2	*Disease Control Priorities in Developing Countries,* second edition
DCP3	*Disease Control Priorities*, third edition
DHS	Demographic and Health Surveys
DMFT	decayed, missing, and filled teeth
DOHaD	Developmental Origins of Health and Disease
DP	dihydroartemisinin-piperaquine
ECD	early child development
ECE	early childhood education
EFA	Education for All
EGRA	Early Grade Reading Assessment
ESP	education sector plan
FA	fractional anisotropy
FRESH	Focusing Resources on Effective School Health
FRP	financial risk protection
GBD	Global Burden of Disease
GDP	gross domestic product
GHE	Global Health Estimates
GIZ	German Development Cooperation
GNI	gross national income
GYTS	Global Youth Tobacco Survey

HAZ	height-for-age z-scores
Hb	hemoglobin
HBSC	Health Behaviour in School-Aged Children
HEADSS	home, education, activities/employment, drugs, suicidality, sex
HICs	high-income countries
HIV	human immunodeficiency virus
HIV/AIDS	human immunodeficiency virus/acquired immune deficiency syndrome
HLM	hierarchical linear model
HPV	human papillomavirus
HSV-2	herpes simplex virus-2
ICF	International Classification of Functioning, Disability and Health
IEA	International Association for the Evaluation of Educational Achievement
IEC	information, education, and communication
IHME	Institute for Health Metrics and Evaluation
INCAP	Institute of Nutrition for Central America and Panama
IPCs	intermittent parasite clearance in schools
IPT	intermittent preventive treatment
IQ	intelligence quotient
IRS	indoor residual spraying
IST	intermittent screening and treatment
ITN	insecticide-treated bednet
KMC	kangaroo mother care
LBW	low birth weight
LICs	low-income countries
LMICs	low- and middle-income countries
MDA	mass drug administration
MDGs	Millennium Development Goals
m-health	mobile health
MICs	middle-income countries
MICS	Multiple Indicator Cluster Survey
NCDs	noncommunicable diseases
NTD	neglected tropical diseases
OECD	Organisation for Economic Co-operation and Development
OOP	out of pocket
OTL	opportunity to learn
PDV	present discounted value
PIAAC	Programme for the International Assessment of Adult Competencies
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
PFC	prefrontal cortex
PRIMR	Primary Mathematics and Reading
PT	planum temporale
QALY	quality-adjusted life year
RCT	randomized controlled trial
RDT	rapid diagnostic test
RMNCH	reproductive, maternal, newborn, and child health
RoR	rate of return
RSC	Rockefeller Sanitary Commission
RTI	road traffic injury

SABER	Systems Approach for Better Education Results
SSBs	sugar-sweetened beverages
SBM	school-based management
SDGs	Sustainable Development Goals
SES	socioeconomic status
SHN	school health and nutrition
SMC	seasonal malaria chemoprevention
SP	sulphadoxine-pyrimethamine
SR	self-regulation
STHs	soil-transmitted helminths
STI	sexually transmitted infection
TFR	total fertility rate
TIMSS	Trends in International Mathematics and Science Study
TT	tetanus toxoid
U5MR	under-5 mortality rate
UCT	unconditional cash transfer
UMICs	upper-middle-income countries
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
VLY	value of a life year
VSL	value of a statistical life
VWFA	visual word form area
WASH	water, sanitation, and hygiene
WAZ	weight-for-age
WG	Washington Group
WHO	World Health Organization
WHZ	weight-for-height
WPP	World Population Prospects
WRA	women of reproductive age
YLD	years lost to disability
YOURS	Youth for Road Safety

Chapter 1

Child and Adolescent Health and Development: Realizing Neglected Potential

Donald A. P. Bundy, Nilanthi de Silva, Susan Horton,
George C. Patton, Linda Schultz, and Dean T. Jamison

INTRODUCTION

It seems that society and the common legal definition have got it about right: it takes some 21 years for a human being to reach adulthood. The evidence shows a particular need to invest in the crucial development period from conception to age two (the first 1,000 days) and also during critical phases over the next 7,000 days. Just as babies are not merely small people—they need special and different types of care from the rest of us—so growing children and adolescents are not merely short adults; they, too, have critical phases of development that need specific interventions. Ensuring that life's journey begins right is essential, but it is now clear that we also need support to guide our development up to our 21st birthday if everyone is to have the opportunity to realize their potential. Our thesis is that research and action on child health and development should evolve from a narrow emphasis on the first 1,000 days to holistic concern over the first 8,000 days; from an age-siloed approach to an approach that embraces the needs across the life cycle.

To begin researching and encouraging action, this volume, *Child and Adolescent Health and Development,* explores the health and development needs of the 5 to 21 year age group and presents evidence for a package of investments to address priority health needs, expanding on other recent work in this area, such as the *Lancet* Commission on Adolescent Health and Wellbeing (Patton, Sawyer, and others 2016). Given new evidence on the strong connection between a child's education and health, we argue that modest investments in the health of this age group are essential to attain the maximum benefit from investments in schooling for this age group, such as those proposed by the recent International Commission on Financing Global Education Opportunity (2016). This volume shares contributors to both commissions and complements an earlier volume, *Reproductive, Maternal, Newborn, and Child Health,* which focuses on health in the group of children under age 5 years.

There is a surprising lack of consistency in the language used to describe the phases of childhood, perhaps reflecting the historically narrow focus on the early years. The neglect of children ages 5 to 9 years in particular is reflected in the absence of a commonly reflected name for this age group. Figure 1.1 illustrates the nomenclature used in this volume, which we have sought to align with the definitions and use outlined in the 2016 *Lancet* Commission on Adolescent Health and Wellbeing. The editors of this volume built upon the commission's definitions to include additional terms that are relevant to the broader age range considered here, including *middle childhood* to reflect the age range between 5 and 9 years. The editors also refer to children and adolescents between ages 5 and 14 years as "school-age," since in low- and lower-middle-income countries these are the majority of children in

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Box 1.1

Key Messages from Volume 8

1. It takes 21 years (or 8,000 days) for a child to develop into an adult. Throughout this period, there are sensitive phases that shape development. Age-appropriate and condition-specific support is required throughout the 8,000 days if a child is to achieve full potential as an adult.
2. Investment in health during the first 1,000 days is widely recognized as a high priority, but there is historical neglect of investments in the next 7,000 days of middle childhood and adolescence. This neglect is also reflected in investment in research into these older age-groups.
3. At least three phases are critical to health and development during the next 7,000 days, each requiring a condition-specific and age-specific response:
   - Middle Childhood Growth and Consolidation Phase (ages 5–9), when infection and malnutrition remain key constraints on development, and mortality rates are higher than previously realized
   - Adolescent Growth Spurt (ages 10–14), when there is a major increase in body mass, and significant physiological and behavioral changes associated with puberty
   - Adolescent Growth and Consolidation Phase (ages 15 to early 20s), bring further brain restructuring, linked with exploration and experimentation, and initiation of behaviors that are life-long determinants of health.
4. Broadening investment in human development to include scalable interventions during the next 7,000 days can be achieved cost-effectively at modest cost. Two essential packages were identified: the first addresses needs in middle childhood and early adolescence through a school-based approach; the second focuses on older adolescents through a mixed community and media and health systems approach. Both offer high cost-effectiveness and benefit-cost ratios.
5. Well-designed health interventions in middle childhood and adolescence can leverage the already substantial investment in education, and better design of educational programs can bring better health. The potential synergy between health and education is currently undervalued, and the returns on co-investment are rarely optimized.

Box 1.2

Evolution of *Disease Control Priorities* and Focus of the Third Edition

Budgets constrain choices. Policy analysis helps decision makers achieve the greatest value from limited resources. In 1993, the World Bank published *Disease Control Priorities in Developing Countries* (*DCP1*), which sought to assess systematically the cost-effectiveness (value for money) of interventions addressing the major sources of disease burden in low- and middle-income countries (Jamison and others 1993). The World Bank's *World Development Report 1993* drew heavily on *DCP1*'s findings to conclude that specific interventions to combat noncommunicable diseases were cost-effective, even in environments with substantial burdens of infection and undernutrition (World Bank 1993).

DCP2, published in 2006, updated and extended *DCP1* in several respects, giving explicit consideration to the implications for health systems of expanded intervention coverage (Jamison and others 2006). One way to expand coverage of health interventions is through platforms for interventions that require similar logistics but that address heterogeneous health problems. Platforms often provide a more natural unit for investment than do individual interventions, but conventional health economics

box continues next page

Box 1.2 (continued)

has offered little understanding of how to make choices across platforms. Analysis of the costs of packages and platforms—and of the health improvements they can generate in given epidemiological environments—can help guide health system investments and development.

DCP3 introduces the notion of packages of interventions. Whereas platforms contain logistically related sets of interventions, packages contain conceptually related ones. The 21 packages developed in the nine volumes of *DCP3* include surgery and cardiovascular disease, for example. In addition, *DCP3* explicitly considers the financial risk–protection objective of health systems. In populations lacking access to health insurance or prepaid care, medical expenses that are high relative to income can be impoverishing. Where incomes are low, seemingly inexpensive medical procedures can have catastrophic financial effects. *DCP3* considers financial protection and the distribution across income groups as outcomes resulting from policies (for example, public finance) to increase intervention uptake and improve delivery quality. All of the volumes seek to combine the available science about interventions implemented in specific locales and conditions with informed judgment to reach reasonable conclusions about the effect of intervention mixes in diverse environments.

DCP3's broad aim is to delineate essential intervention packages—such as those for school-age children and adolescents, as outlined in this volume—and their related delivery platforms. This information is intended to assist decision makers in allocating often tightly constrained budgets and achieving health system objectives.

Four of *DCP3*'s nine volumes were published in 2015 and 2016, and the remaining five will appear in 2017 or early 2018. The volumes appear in an environment in which serious discussion about quantifying and achieving the Sustainable Development Goals (SDGs) for health continues (United Nations 2015). *DCP3*'s analyses are well-placed to assist in choosing the means to attain the health SDGs and assessing the related costs. These volumes, and the analytic efforts on which they are based, will enable researchers to explore SDG-related and other broad policy conclusions and generalizations. The final volume will report those conclusions. Each individual volume will provide specific policy analyses on the full range of interventions, packages, and policies relevant to its health topic.

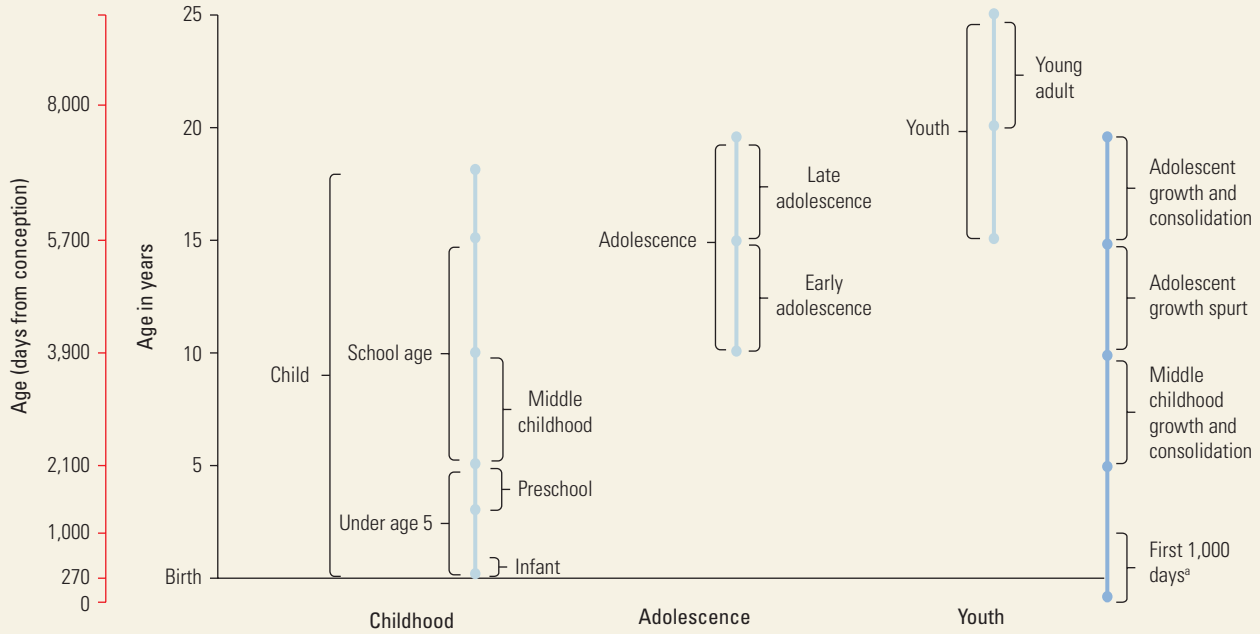
Source: Dean T. Jamison, Rachel Nugent, Hellen Gelband, Susan Horton, Prabhat Jha, Ramanan Laxminarayan, and Charles N. Mock.

primary school, owing to high levels of grade repetition, late entry to school, and drop outs. As income levels rise and secondary schooling enrollment increases, children attending school will be older than age 14 years. Figure 1.1 also demonstrates the overlap between many of these terms. For example, the Convention on the Rights of the Child defines *child* as every human being younger than age 18 years, whereas this volume defines *adolescence* as beginning at age 10 years and continuing through age 19 years (United Nations General Assembly 1989). Figure 1.1 also shows the alignment between age groups and four key phases critical to development. These key phases are used as an organizing principle for intervention throughout this volume. Where possible, the editors have extended the analyses to include children through age 21 years; but standard reporting of age data is in quintiles, so for convenience the editors have accepted the upper age range as 15-19 years.

Some issues of potential importance to child development are examined in other volumes of *DCP3.* For example, environmental issues are examined in some depth in volume 7 (Mock and others 2017), which examines the impact of pollution on health and human development—especially the exceptional prevalence of lead poisoning, which affects the intellectual development of children.

A premise of this volume is that human development occurs intensively throughout the first two decades of life (figure 1.1), and that for a person to achieve his or her full potential, age- and condition-specific interventions are needed throughout this 8,000 days (box 1.3). We use four key tools—cost-effectiveness, extended cost-effectiveness, benefit-cost, and returns on investment—to identify and prioritize investments at different ages and to propose delivery platforms and essential packages that are costed, scalable, and relevant to low-resource settings. These analyses suggest that public investment in health and development after age 5 years has been insufficient.

Figure 1.1 Nomenclature Concerning Age and Four Key Phases of Child and Adolescent Development



Note: a. The first 1000 days is typically measured from the time of conception, as is the 8,000 days that we discuss as the overall child and adolescent development period; other age-ranges presented here are measured from birth.

Box 1.3

Early Childhood Development

This volume takes a broad approach by examining child and adolescent health and development more generally, rather than focusing only on health. Therefore, although it focuses primarily on the 5–19 years age group, it also includes a discussion of early childhood development (ECD), which complements the discussion on early health in volume 2.

The existence of key synergies justifies the inclusion of ECD in a series focused on health. These include synergies in the outcomes of different investments in children and synergies in the delivery of both sets of interventions.

Synergies in investments in children. Elsewhere in this chapter, we discuss the synergies between health and education for those ages 5–19 years. These same synergies are also important for young children. A pathbreaking study in Jamaica (Grantham-McGregor and others 1991) demonstrated that health and nutrition interventions alone are insufficient to address developmental deficits in young children facing multiple deprivations. Combining health and nutrition interventions with responsive stimulation was found to have short-term developmental benefits for growth and cognitive development not only in childhood but also into adulthood (Gertler and others 2014), with long-term effects on adult earnings and social outcomes.

Violence against children (child abuse) is an extreme negative example of the same synergy.

A systematic review (Norman and others 2012) documented how this extreme form of poor nurturing adversely affects physical and mental health. Child maltreatment and neglect are associated with substantial medical costs in childhood and adulthood

box continues next page

Box 1.3 (continued)

(Brown, Fang, and Florence 2011; Fang and others 2015) and have negative impacts on adult economic well-being (CDC 2015; Currie and Widom 2010; Zielinski 2009). Although most of these studies are from high-income countries, similar results have been found in low- and middle-income countries.

Delivery platforms for early interventions at different ages. In the first 1,000 days, children's main contact with public sector institutions is with the health system, and it makes sense to use the health system to deliver education to parents about responsive stimulation. This education can be delivered through group sessions for parents at the local health facility or through home visits incorporating messages on responsive stimulation, as discussed in chapter 19 in this volume (Black, Gove, and Merseth 2017). Once children have received the required immunizations, they have fewer interactions with the health system; there are synergies then in using preschools and the school system to deliver health and nutrition interventions to children after age three years.

To date, the few published studies that have estimated the marginal additional cost of integrating programs for responsive stimulation into existing health services have found these costs to be modest (Horton and Black 2017, chapter 24 in this volume). However, these additional tasks cannot simply be loaded onto existing health workers without recognition of the need for additional training and supervision and for some increase in the ratio of health workers to population. Given the limited number of studies, it is not possible to estimate the economic returns to integrated programs.

An essential package for ECD. Chapter 24 in this volume (Horton and Black 2017) develops a basic ECD package relevant for low-income countries; the package focuses on parenting programs and encourages "responsive stimulation" (the positive interaction between a young child and his or her caregiver, with mutual benefit). These programs are estimated to cost US$6 per child and are delivered in the first 1,000 days. As per capita incomes rise, preschool programs for children ages three to five years might be added.

Investment lags far behind the potential for return and is far below investments in health in the first five years and in primary education after age 5 years. Table 1.1 compares our recommendations for additional spending with current spending on education and with spending on health for children under age 5 years.

This bias in investment is paralleled by a similar bias in research. Approximately 99 percent of publications in Google Scholar and 95 percent in PubMed on the first 20 years of life focus on children under age 5 (annex 1A shows the number of publications since 2004 that our search found that include the terms *health*, *mortality*, or *cause of death*). The availability of age-specific publications reflects a lack of research funding for and attention to middle childhood and adolescence, resulting in a lack of data. The analysis for the Global Burden of Disease 2013 came to a similar conclusion, pointing out that most of the unique data sources for risk factors for adolescents ages 15–19 years were from school-based surveys, that children younger than age 5 had the most data available of any age group, and that adolescents ages 10–14 years had the fewest data sources (Mokdad and others 2016). The *World Development Report 2007: Development and the Next Generation* similarly found severe data shortcomings for these older age groups (World Bank 2006), whereas Hill and others found no empirical studies of mortality rates for the age group 5–14 years in countries without vital statistics, which include the majority of low- and middle-income countries (LIMCs) (Hill, Zimmerman, and Jamison 2017). The estimates, based on Demographic and Health Surveys Program data, reported here result in sharp upward adjustments in estimated numbers of deaths in that age range (Hill, Zimmerman, and Jamison 2017). This strong bias toward early childhood in the health literature may have been helpful in the successful United Nations Millennium Development Goals (MDG) drive to reduce under-five mortality. But it seems to have caused us to lose sight of the fact that the subsequent decades of growth and development in the transition to adulthood involve complex processes and critical periods that are sensitive to intervention.

This volume focuses on the scientific evidence, but local contexts, including culture, beliefs, lifestyles, and health systems, as well as other key determinants such as gender, race, ethnicity, sexuality, geography, socioeconomic status, and disability, are important for developing practical policies (Chandra-Mouli, Lane, and Wong 2015).

Table 1.1 Estimates of Public Sector Investment in Human Development in Low- and Lower-Middle-Income Countries

US$, billions per year

	Low-income countries	Lower-middle-income countries	Total for both low- and lower-middle-income countries
Current spending			
Basic education[a]	19	190	210
First 1,000 days[b]	4.4	24	29
Proposed new package			
School-age children package (excluding school feeding)	0.13	0.38	0.51
School-age children package (including school feeding)[c]	0.47	2.8	3.3
Adolescent package[c]	0.88	2.7	3.6
Total proposed spending on new packages in middle childhood and adolescence (including school feeding)[c]	1.4	5.5	6.9

a. These estimates are from *The Learning Generation* (International Commission on Financing Global Education Opportunity 2016, 37). They estimate current public sector spending on basic (primary-level) education in low- and lower-middle-income countries. The report calls for increases to US$50 billion and US$712 billion, respectively, by 2030.
b. These estimates are from *DCP3,* volume 2 and are for the cost of two packages: (1) maternal and newborn and (2) under-five child health. The editors of volume 2 estimate current spending in low- and lower-middle-income countries. Estimated incremental annual investments of US$7 billion and US$14 billion, respectively, are needed to achieve full coverage.
c. These estimates are summarized in table 1.4. They are the estimated total cost of implementing the school-age and adolescent packages in low- and lower-middle-income countries. There are no formal estimates of current coverage, but it is likely in the range of 20 percent to 50 percent of these figures.

Some groups that tend to be marginalized and overlooked when planning intervention strategies, such as ethnic minorities, LGBT (lesbian, gay, bisexual, or transgender) youth, persons with disabilities, youth in conflict areas, and refugees, are also likely to have the greatest need for health and development support.

A CONCEPTUAL FRAMEWORK FOR UNDERSTANDING CHILD AND ADOLESCENT HEALTH AND DEVELOPMENT

In this volume, we develop a conceptual framework for exploring the processes and inputs that determine physical and cognitive growth from birth to adulthood (Bundy and Horton 2017, chapter 6 in this volume). The framework recognizes the importance of the first 1,000 days. It further notes that during the first two decades of life, there are at least three other critically important development phases: middle childhood (ages 5 to 9 years), the early adolescent growth spurt (ages 10 to 14 years), and the later adolescent phase of growth and consolidation (ages 15 to 19 years) when age-specific interventions are necessary. See figure 1.2.

Rates of physical growth are indeed at their highest at ages below age two, emphasizing the importance of the first 1,000 days. However, at the peak of the adolescent growth spurt, the growth rate for girls is similar to—and for boys exceeds—the rate at age two years and growth begins to occur in quite different ways (Tanner 1990). Furthermore, a review in chapter 8 in this volume (Watkins, Bundy, and others 2017) suggests that human growth remains relatively plastic throughout much of childhood, with potentially important amounts of catch-up growth. We need to be more careful about claiming that early insults are irreversible and recognize that more can be done to help older children catch up, especially in middle childhood. The data signal how unintended research bias and the scarcity of studies of ages 5–19 have had perverse policy consequences.

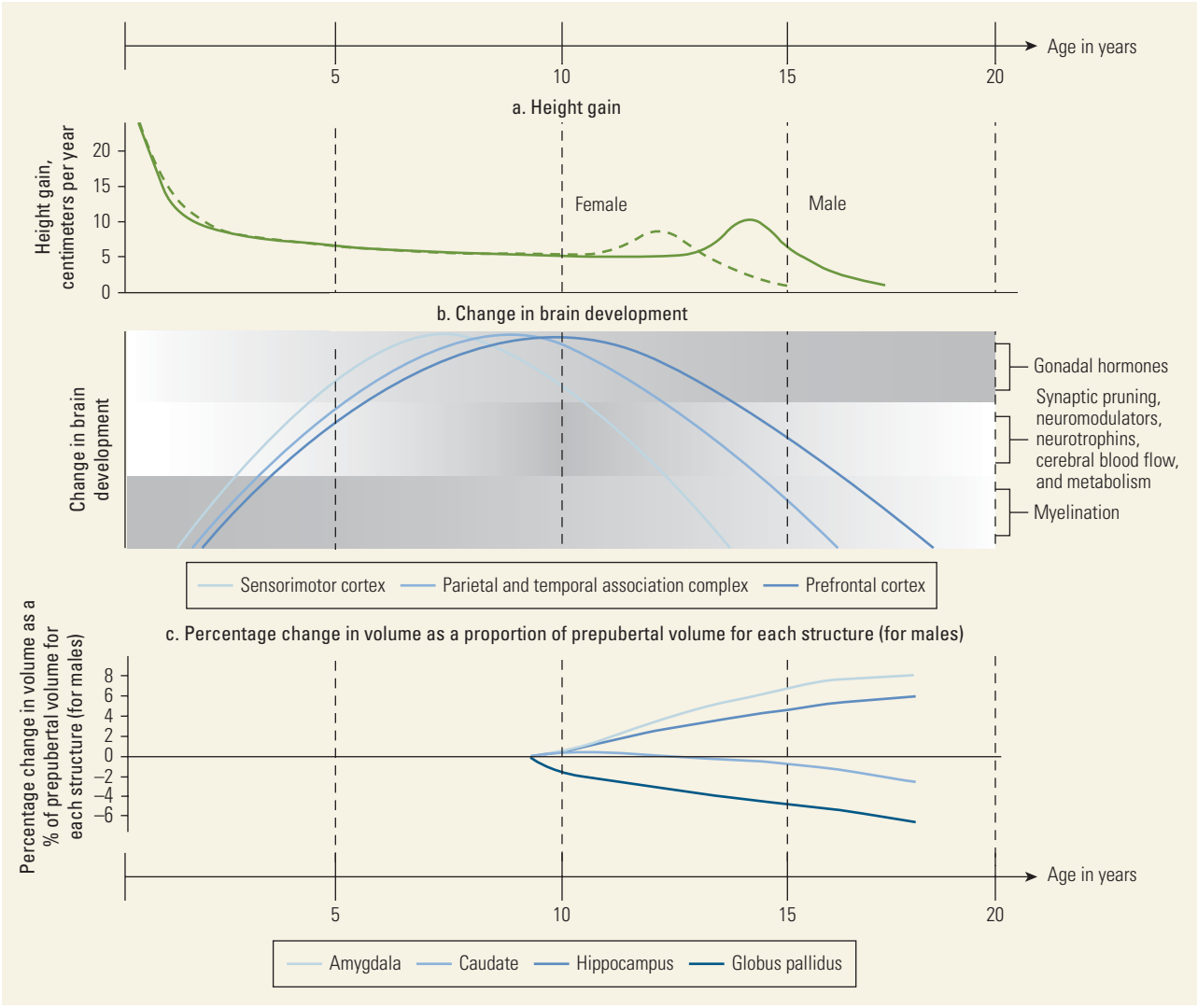
Evidence from neuroscience over the past 15 years suggests that critical phases of brain development occur beyond the first 1,000 days and in some cases long after. By age six years, the brain has reached approximately 95 percent of its adult volume, but size is not everything; rather, the connections within the brain are of growing importance through middle childhood and adolescence (Grigorenko 2017, chapter 10 in this volume). Different areas of the brain have different functions and develop at different rates. Peak development of the sensorimotor cortex—which is associated with vision, hearing, and motor control—occurs relatively early, and development is limited after puberty. The parietal and temporal association complex, responsible for language skills and numeracy, develops

the fastest a little later; thus by about age 14 years, although it is possible to learn new languages, it is more difficult to speak a new language in the same way as a native speaker (Dahl 2004). The prefrontal cortex develops later still; this area is associated with higher brain functions, such as executive control (figure 1.2, panel b).

There is a sequence of brain development, and the kind of growth in middle childhood and adolescence differs from the kind of growth in early life. It is possible to see some of these differential growth rates in brain capabilities by studying the size of the subcortial regions as shown in figure 1.2, panel c (Goddings and others 2014). The panel shows the pattern for adolescent boys. The patterns are similar for girls but occur at earlier ages because of different patterns of puberty. The panel shows that the regions associated with movement (such as the caudate and globus pallidus) are shrinking in size during early adolescence because these structures become more efficient as the functions become more mature. In contrast, regions associated with memory, decision making, and emotional reactions (amygdala and hippocampus) are still developing and growing in size during adolescence.

Brain development during infancy and early childhood is marked by the development of primary

Figure 1.2 Human Development to Age 20 Years



Sources: Adapted from Tanner 1990; Goddings and others 2014; Grigorenko 2017.
Note: Behavioral attributes are paralleled by hormonal and neurobiological changes that target specific brain regions and cell populations (shown in shaded gray to capture the dynamic influences of hormones, various brain processes, and myelination). The vertical axis in panel b shows relative rate of growth of three brain areas from 0 to highest. The progressive shading indicates when the indicated activity is at its most intense (darkest shading).

cognitive and emotional abilities. With the onset of the hormonal changes of puberty in middle childhood, a new phase of brain development commences in which the individual's interactions with the social, cultural, and educational environment shapes the processes of myelination and synaptic pruning of centers involved in emotional processing and higher executive functioning (Viner, Allen, and Patton 2017). Although primary cognitive abilities in stunted children may improve during middle childhood (Crookston and others 2013), brain development during these years and during adolescence is primarily focused on acquiring the higher-level cognitive, emotional, and social skills essential for functioning in complex social systems. As in earlier childhood, nutritional as well as social environments shape brain development (Andersen and Teicher 2008; Blakemore and Mills 2014).

Early intervention is critical for setting human development on an effective trajectory. However, the emphasis on the proposition that harm experienced in early life is irreversible is not only weakly supported by the evidence but also has led to an unfortunate lack of emphasis on exploring interventions later in childhood (Prentice and others 2013). Similarly, the widely cited conceptual framework of continuously declining rates of return with age (Heckmann 2011) is at variance with what is now known about the plasticity of brain development (Black, Gove, and Merseth 2017, chapter 19 in this volume) and of physical growth during much of middle childhood (Watkins, Bundy, and others 2017, chapter 8 in this volume), and it also fails to take into account the intergenerational benefits of actions in later childhood and adolescence. Some interventions make sense only at specific points in development; for example, some famous tennis players attribute their success to learning to play at age eight years, but they recognize that no amount of tennis lessons at age three would have achieved the same outcome. Current evidence suggests that there are substantial returns on investments made throughout the first two decades of life.

THE UNFINISHED AGENDA OF MORTALITY REDUCTION

During middle childhood and adolescence, the major consequences of ill health are related to morbidity rather than mortality. This fact does not mean that mortality is unimportant in older children. A new analysis of mortality was specifically conducted for this volume using Demographic and Health Surveys to estimate death rates for ages 5 to 19 years in the same way that data have been used to estimate rates for children under age 5 (Hill, Zimmerman, and Jamison 2017, chapter 2).

The estimates for 2010 suggest that the total annual mortality in LMICs in the 5 to 19 age group is around 2.3 million. The number of deaths estimated for children ages 5 to 9 years are 935,000, which is higher than the estimates of the United Nations Population Division and the Institute for Health Metrics and Evaluation (IHME) for this age group. Congruence of the new estimates with the UN and IHME data is closer for the 10 to 14 age group and closer yet for the 15 to 19 age group.

These results suggest that we need to do more to understand mortality in older children. A natural conclusion for policy would be to extend major national and international programmatic efforts that assess levels and causes of mortality in children under age 5 years to include the entire age range from birth through age 19 years. The United Nations Inter-agency Group for Child Mortality Estimation (IGME), which provides child mortality estimates through the Child Mortality Estimation (CME) database, and the Child Health Epidemiology Reference have historically focused on children under age 5 years, which helps explain why the data are so poor, and so poorly known, for children in middle childhood and adolescence. At least in part because of the focus in this volume on mortality levels in older children, IGME is expanding its work to cover this age range (Masquelin 2017). Although empirical estimates are still evolving, it is to be expected that IGME's effort will soon provide stable and up-to-date estimates that are country specific.

Morbidity is even more poorly documented than mortality for children over age five years. The volume explores the evidence for geographical and social differences in four key outcome measures—education, anthropometric status, micronutrient deficiency, and adolescent health— and describes major geographic variation in all four development outcomes (Galloway 2017; Wu 2017; Patton and others 2017, chapters 3–5, respectively, in this volume), but there is no systematic collection of morbidity data for this age-group, especially in LMICs. In exploring morbidity, we have begun to see that health and education are strongly linked in this age group; the education analysis shows that individual differences in health between students contribute to differences between educational outcomes and that differences in health are amenable to intervention in the short term.

ESSENTIAL PACKAGES OF INTERVENTIONS FOR SCHOOL-AGE CHILDREN AND ADOLESCENTS

Appropriate health interventions for the first 1,000 days are addressed in detail in volume 2, which describes

Table 1.2 Essential Package of Interventions for School-Age Children (Ages 5–14 Years)

Health area	Population	Community	Primary health center	School	Benefit of delivering interventions in schools
Physical health	—	Deworming	Deworming	Deworming	In endemic areas, regular deworming (following WHO guidelines) can be done inexpensively in schools now that the majority of deworming drugs are donated; there are reported benefits in school attendance as a result.
		Insecticide-treated net promotion	Insecticide-treated net promotion	Insecticide-treated net promotion	Education concerning the use of insecticide-treated nets in endemic areas is important because schoolchildren tend to use nets less often than do mothers and small children.
		Tetanus toxoid and HPV vaccination	Tetanus toxoid and HPV vaccination	Tetanus toxoid and HPV vaccination	Schools can be a good venue for administering tetanus boosters, which benefit not only young people themselves but also babies born to those young women.
		Oral health promotion	Oral health promotion and treatment	Oral health promotion	Education on oral health is important; poor households generally cannot afford dental treatment.
			Vision screening and provision of glasses	Vision screening and treatment	Vision screening and provision of inexpensive ready-made glasses boost school performance.
Nutrition	—	Micronutrient supplementation	—	Micronutrient supplementation	—
		Multifortified foods	—	Multifortified foods	—
				School feeding	School meals promote attendance and education outcomes.

Source: Fernandes and Aurino 2017 (chapter 25 in this volume).
Note: — = not available; HPV = human papillomavirus; WHO = World Health Organization. School-age children do not regularly come in contact with the health system unless they seek treatment. With the remarkable success of the Millennium Development Goals in increasing school enrollment and participation and the continuing focus on universal education with the Sustainable Development Goals, it makes sense to use schools to promote health in this age group and to deliver preventive and curative health interventions. These interventions are affordable and also the highest priority, given their health and educational benefits. Table 1.4 presents the cost of components of the essential package of investments for school-age children.

two essential packages of interventions targeted at young children: one on maternal and newborn health and the other on child health. In volume 8, we complement these packages with an analysis of early childhood development (Alderman and others 2017; Black, Gove, and Merseth 2017; Horton and Black 2017; Horton and others 2017, chapters 7, 19, 24, and 26, respectively, in this volume). Our analysis suggests that there is significant value in adding "responsive stimulation" to these health packages (box 1.3). More detailed analysis of the cost and relative effectiveness of the early child development package is presented in chapter 2 of volume 9 (Watkins, Nugent, and others 2018).

This volume focuses on the three phases of development for those older than age five years: middle childhood growth and consolidation, the adolescent growth spurt, and adolescent growth and consolidation (figure 1.1). We argue that intervention during each of these stages is essential to enhanced survival and to effective development; in addition, each stage provides an opportunity to remedy earlier failures in development, at least to some extent.

First we discuss a package of interventions aimed at school-age children (see table 1.2); this package addresses both middle childhood growth and consolidation (ages 5–9 years) and the adolescent growth spurt (ages 10–14 years). We then discuss a package aimed at later adolescence, which addresses adolescent growth and consolidation (ages 15–19 years) (table 1.3). In practice, there is considerable overlap between the age groups able to benefit from these two packages, and both packages are required to cover the needs of adolescents from ages 10 to 19 years.

As illustrated in maps 1.1 and 1.2, school-age children and adolescents (that is, the age group of 5–19 years) together constitute a substantial proportion of the overall population of all countries, with the proportion greatest in the poorest countries: 17.2 percent of high-income countries and rising to 37.2 percent of low-income countries. The essential health and development

Table 1.3 Essential Package of Investments for Adolescents (Ages 10–19 Years, Approximately)

Health area	Population	Community	Primary health center	School	Benefit of targeting interventions to adolescents
Physical health	Healthy lifestyle messages: tobacco, alcohol, injury, accident avoidance, and safety	Adolescent-friendly health services	Adolescent-friendly health services: provision of condoms to prevent STIs, provision of reversible contraception, treatment of injury in general and abuse in particular, screening and treatment for STIs	Healthy lifestyle education, including accident avoidance and safety	National media messages on healthy life choices in formats designed to appeal to adolescents, combined with national policy efforts to support healthy choices (limiting access of adolescents to products most harmful to their health)
	Sexual health messages	—	—	Sexual health education	Additional health education in schools aimed at issues relevant to older ages, intended to supplement messages for younger children in the school-age package
				Adolescent-friendly health services	Provision of adolescent-friendly health services within schools or within health care facilities in ways that respect adolescent needs
Nutrition	Nutrition education messages	—	—	Nutrition education	—
Mental health	Mental health messages	—	Mental health treatment	Mental health education and counseling	—

Source: Horton and others 2017 (chapter 26 in this volume).
Note: — = not available; STI = sexually transmitted infection. Adolescents are the hardest group to reach because many are no longer in school and feel uncomfortable accessing health services predominantly designed for adults. They may fear lack of confidentiality, and in some cases (such as teen pregnancy) may be stigmatized by health care workers. The total costs of the school-age package are about US$10 per child in the 5–14 years age group and US$9 per adolescent in the 10–19 years age group. Table 1.4 presents the cost of components of the essential package of investments for adolescents.

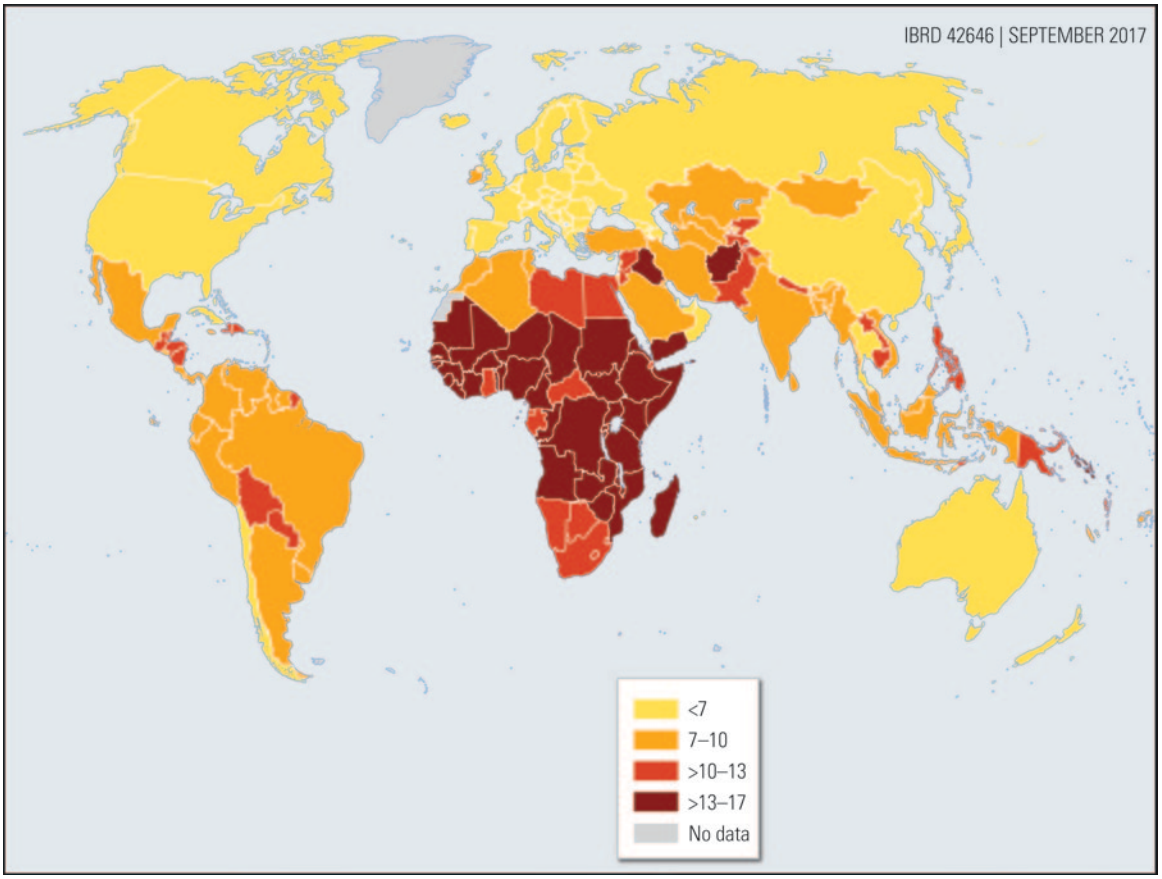
packages for school-age children and adolescents have particular relevance in low- and lower-middle-income countries where the population that can benefit from these developmental interventions constitutes approximately one-third of the total population.

Essential Package of Interventions for School-Age Children

Health and nutrition programs targeted through schools are among the most ubiquitous for school-age children in LMICs. Since the inclusion of school health programs in the launch of Education for All in 2000, it is difficult to find a country that is not attempting to provide school health services at some level, although the coverage is often limited (Sarr and others 2017). The World Food Programme estimates that more than 360 million schoolchildren receive school meals every day (Drake and others 2017, chapter 12 in this volume), many of whom live in LMICs, and the World Health Organization (WHO) estimates that more than 450 million schoolchildren—more than half of the target population—are dewormed annually (Bundy, Appleby, and others 2017, chapter 13 in this volume) in nearly all LMICs. These largely public efforts are variable in quality and coverage, but the large scale of existing programs indicates a willingness by governments to invest in health as well as education for this age group.

The school system represents an exceptionally cost-effective platform through which to deliver an essential package of health and nutrition services to this age group, as has been well documented in high-income countries (HICs) (Shackleton and others 2016). It is also increasingly equitable, especially because increases in primary enrollment and attendance rates, and narrowing of gender gaps, are among the greatest achievements of the Millennium Development Goals (Bundy, Schultz, and others 2017, chapter 20 in this volume). In LMICs with weak health systems, the education system is particularly well-situated to promote health among school-going children and adolescents who may not be reached by health services. There are typically more schools than health facilities in all income settings,

Map 1.1 Proportion of Country Population That Comprises Children in Middle Childhood (between Ages 5–9)
Percent



Source: United Nations, *World Population Prospects: The 2015 Revision,* July 2015.

and rural and poor areas are significantly more likely to have schools than health centers.

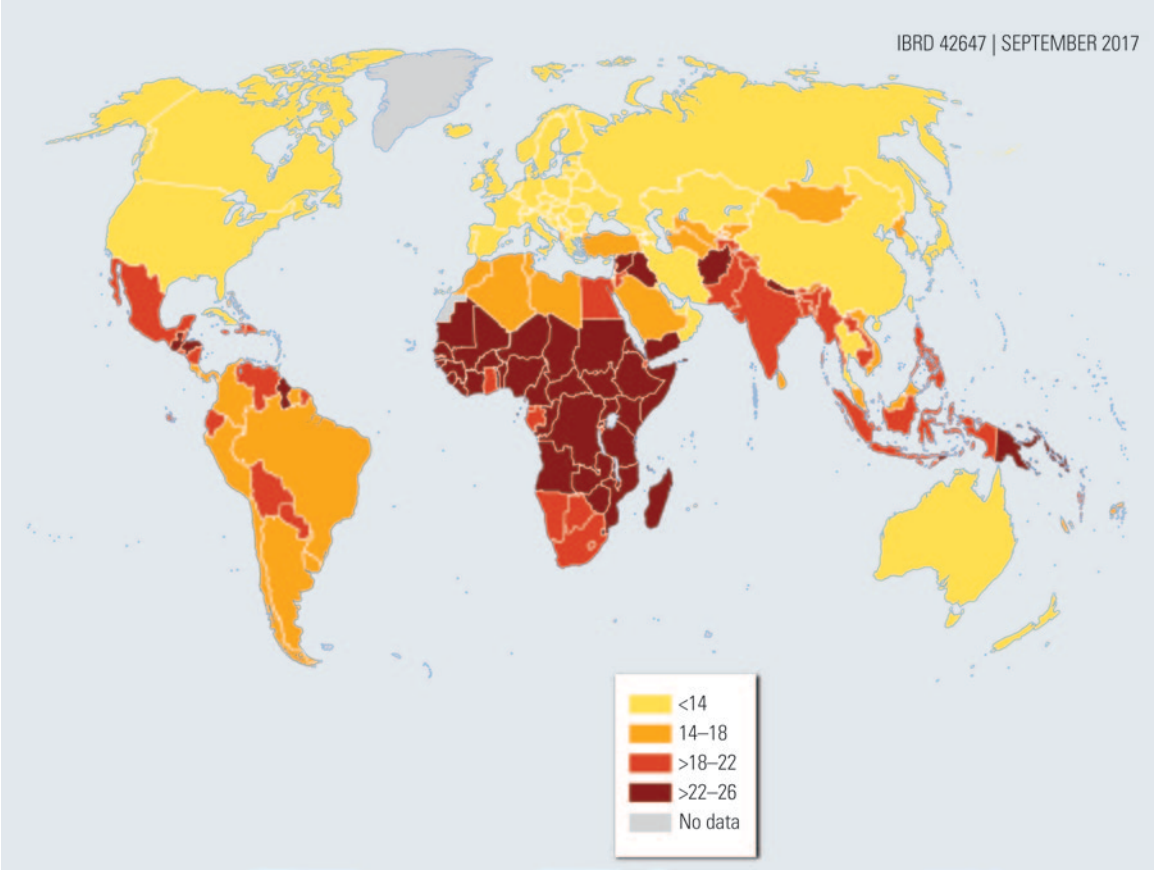
In this section, we examine the investment case for providing an integrated package of essential health services for children attending school in low- and lower-middle-income countries (see table 1.2). "School-age" includes both middle childhood and younger adolescence.

Middle Childhood Growth and Consolidation Phase

An important economic rationale for targeting the health and development of school-age children is to promote learning at an age when they have what may be their only opportunity to attend school. Ill health can be a catalyst for extended absence from or dropping out of school; for example, malaria and worm infections can reduce enrollment, and anemia resulting from malaria or worm infections can affect cognition, attention span, and learning (Benzian and others 2017; Brooker and others 2017; Bundy, Appleby, and others 2017; Drake and others 2017; LaMontagne and others 2017; Lassi, Moin, and Bhutta 2017 [chapters 11–16 in this volume]). Estimates suggest that in areas where malaria and worm infections are prevalent, poor students could gain the equivalent of 0.5 to 2.5 extra years of schooling if given appropriate health interventions, while sustaining benefits across multiple years of schooling could improve cognitive abilities by 0.25 standard deviation, on average. Extrapolating the benefits of improved accumulation of human capital could translate to roughly a 5 percent increase in earning capacity over the life course (Ahuja and others 2017, chapter 29 in this volume).

Chapter 8 in this volume (Watkins, Bundy, and others 2017) shows that some of these interventions also have important roles to play in maintaining and sustaining the gains of earlier investments, and children who slip through the early safety net can still achieve some catch-up growth with interventions in middle childhood. Furthermore, the new mortality analyses presented in chapter 2 (Hill, Zimmerman, and Jamison 2017) show that, for those ages five to nine years, survival continues to be a significant challenge, largely

Map 1.2 Proportion of Country Population That Comprises Adolescents (between Ages 10–19)
Percent



Source: United Nations, *World Population Prospects: The 2015 Revision*, July 2015.

because of the persistently high prevalence of infectious diseases, including pneumonia, diarrhea, and malaria. The control of infectious diseases therefore remains a critical element of intervention in this age group.

In many malaria-endemic areas, successful control programs have reduced the level of transmission substantially (Noor and others 2014; O'Meara and others 2008; WHO 2015). However, since the age pattern of clinical malaria is determined by the level of transmission and the consequent level of acquired immunity (Carnerio and others 2010; Snow and others 1997), clinical attacks of malaria are becoming more common in older children. In The Gambia, the peak age of hospital admission for severe malaria increased from 3.9 years in 1999–2003 to 5.6 years in 2005–2007 (Ceesay and others 2008); similar changes have been seen in Kenya (O'Meara and others 2008). This has created a new challenge for intervention, because none of the population-based presumptive treatment approaches are recommended for the school-age group and the current policy of testing and treating with Artemisinin-based combination therapy does not appear cost-effective in this age-group (Brooker and others 2017, chapter 14 in this volume; see also Babigumira, Gelband, and Garrison 2017, chapter 15 in volume 6). Analyses in this volume (Bundy, Appleby, and others 2017, chapter 13) and in volume 6 (Fitzpatrick and others 2017, chapter 16) also show that intestinal worm burdens are often greatest in school-age children, and whereas there is broad consensus on the benefits of treating infected children, there is controversy regarding the most cost-effective approach to school-based delivery. In practice, most countries use school-based mass treatment—that is, treatment of all children at risk, without prior screening. In 2015, more than 450 million children were treated, and India alone claims to have treated 340 million children in 2016.

Adolescent Growth Spurt Phase

The pubertal growth spurt is a watershed feature in the transition from childhood to adolescence, a process that occurs earlier for girls and that can be modified by external factors, including diet. The phase may provide the best opportunity for catch-up growth, with growth velocities reaching equivalence to those of children at age two years.

The growth spurt is a time of rapidly increasing muscle, bone, and organ mass, and of high dietary demand. One way of responding to this—providing meals in schools—is arguably the most prevalent publicly funded resource transfer program worldwide, with some 360 million children being fed every school day. A narrow focus on health outcomes underestimates the benefits of multiple cross-sectoral outcomes, including promoting school participation, especially for girls; providing a productive social safety net in hard-to-reach communities; and stimulating rural economies through the procurement of local produce (Drake and others 2017, chapter 12 in this volume). School feeding should be viewed as an option among other transfer programs with multiple outcomes. From a social perspective—often taken in economic evaluation—the net cost of a transfer is often close to zero, or the 10 percent to 15 percent of the total cost that is required for delivery (see discussion of the costs of cash and other transfer programs from multiple perspectives in chapter 23 in this volume, de Walque and others 2017). School feeding can thus be viewed as conditional (because school attendance triggers the transfer) non-cash transfer programs, and evaluations suggest that offering school meals typically increases attendance rates by 8 percent (Drake and others 2017). From this effect alone, benefit-cost ratios of 2 or more can be inferred.

School-based delivery of vaccination is particularly effective at this age, especially for girls. Tetanus toxoid vaccination lowers the risk of contracting tetanus both for recipients and for the children of adolescent girls, thus providing an intergenerational benefit. In addition, 70 percent coverage of human papillomavirus vaccine that is effective over a lifetime could avert more than 670,000 cases of cervical cancer in Sub-Saharan Africa over consecutive birth cohorts of girls vaccinated as young adolescents (LaMontagne and others 2017, chapter 15 in this volume). There is evidence that school-based vaccination programs can achieve effective coverage.

Early adolescence is the age when the most common vision problems—refractive errors—first emerge, and school-based screening of children in select grades is a cost-effective way to detect and correct refractive errors of vision that could otherwise increase the probability of dropping out of school, perhaps leading to lifelong visual impairment (Graham and others 2017, chapter 17 in this volume). Early adolescence is also a key phase for promoting lifelong healthy behaviors (World Bank 2006), including oral hygiene and good dietary practices. This phase may be particularly sensitive to diet, as it is associated with the emergence of micronutrient deficiency diseases, such as anemia and iodine deficiency.

Essential Package of Interventions for Later Adolescence

A phase of adolescent growth and consolidation begins around 15 years of age, continues into the 20s, and requires a package of age-specific interventions (table 1.3). This period has traditionally been viewed as socially important but has lacked concerted attention as a critical period for health and development. This is an age when self-agency becomes increasingly important, and although the concept of adolescent-friendly health services has been widely adopted, in reality the quality and coverage rarely respond to the need, in particular, ensuring that adolescents are able to make their own decisions about their health. School-based interventions that go beyond the teaching of health education in classrooms and encompass changes to the curriculum and the wider social environment, as well as engagement with families and the community, are more likely to improve sexual health, reduce violence, and decrease substance abuse (Reavley and others 2017, chapter 18 in this volume; Shackelton and others 2016). In the broader population, intersectoral action has been central to public health gains in many countries, including transport sector actions to reduce road traffic injuries and taxes to achieve tobacco control (Elvik and others 2009; Farrelly and others 2013).

With the exception of sexual and reproductive health, available evidence on preventive interventions derives largely from high-income countries and the United States in particular. The social and environmental determinants of adolescent health and well-being act at different levels and across different sectors. The most effective responses are likely to operate at multiple levels of particular settings (Viner and others 2012). The lives of young people are affected by community behavior and norms as well as by the values of adults and other adolescents. Community interventions have commonly involved local government, families, youth-focused and religious organizations, and schools.

Universal health coverage for adolescents requires training health care providers not only to respond to specific health problems beyond a focus on sexual and

reproductive health but also to adopt nonjudgmental attitudes, to maintain confidentiality, and to engage with adolescents—while maintaining lines of communication with families. There needs to be a focus on addressing the financial barriers that are especially important for adolescents to overcome, such as making out-of-pocket payments and finding accessible platforms for health delivery that work for this age group. There is growing recognition of the importance of agency for this age group and of the importance of identifying approaches to health that enhance decision making and engagement of adolescents around their health and health care. Lack of adolescent agency is particularly common in LMICs.

Particularly for girls, the expansion of secondary education, which is one of the Sustainable Development Goals (SDGs) targeted for 2030, offers remarkable opportunities to improve health and well-being. Secondary education is effective in increasing the age at marriage and first pregnancy (Verguet and others 2017, chapter 28 in this volume). Participation in quality secondary education enhances cognitive abilities; improves mental, sexual, and reproductive health; lowers risks for later-life noncommunicable diseases; and offers significant intergenerational benefits (Blank and others 2010). Secondary schools also provide a platform for health promotion that can strengthen self-agency around health; provide essential health knowledge, including comprehensive sexuality education; and help to maintain lifestyles that minimize health risks. Equally, achieving the educational and economic benefits that secondary schools offer requires the avoidance of early pregnancy, infectious diseases, mental disorders, injury-related disabilities, and undernutrition.

Media messages have particular salience during the adolescent years and provide an essential platform for health action and have proven effective in HICs. Adolescents are biologically, emotionally, and developmentally primed for engagement beyond their families, and the media, particularly social media, offer that opportunity. Social media may also bring hazards, among the most conspicuous being online grooming, cyberbullying, and a growing preoccupation with body image, and so any intervention has to take these negatives into account (Durlak, Weissberg, and Dymnicki 2011; Farahmand and others 2011; Murray and others 2007).

Economic Analysis of the Essential Packages

Table 1.1 summarizes current levels of public investment in three important areas for child and adolescent health and development in LMICs: basic education (pre-primary, primary, and secondary), health in the first 1,000 days, and the two intervention packages for ages 5–19 years in low- and lower-middle-income countries. Table 1.4 summarizes the costs of the essential packages to promote health of school-age children and adolescents.

Of the three areas, education attracts the largest investment at US$206 billion per year in 2015, much of which is from the public sector and is intended to provide pre-primary, primary, and secondary education free at the point of delivery. The International Commission on Financing Global Education Opportunity (2016) calls for governments to increase domestic public expenditures to support universal provision of primary education in low- and lower-middle-income countries by 2030, requiring an increase from 4.0 to 5.8 percent of gross domestic product (GDP), which is equivalent to an annual rate of growth in public education spending of 7 percent over a 15-year period. In addition to education interventions, the commission identifies 13 nonteaching interventions as "highly effective practices to increase access and learning outcomes," including three health interventions: school feeding, malaria prevention, and micronutrient intervention. The achievement of universal secondary education by 2030 is a specific Sustainable Development Goal and is also cited in the report of the *Lancet* Commission on Adolescent Health and Wellbeing as key to adolescent growth and development.

In contrast to these very large public expenditures for education, the current annual investment for children younger than age five years is an estimated US$28.6 billion, which includes investments in maternal and newborn health, as well as child health for children under age five years. It is estimated, based on current prices, that the cost of increasing coverage to 80 percent would be an additional US$27.3 billion annually (table 1.1). This is based on estimates in volume 2 (Black, Walker, and others 2015) of the cost of the two packages: maternal and newborn health, and health of children under five.

For interventions in the health and development of children in the age range of 5–19 years in low- and lower-middle-income countries, we have no direct estimate of current expenditure. We present here the estimated total and incremental costs of providing a school-age package and an adolescent package to this age group (table 1.1). We estimate the total cost as US$6.9 billion, comprising US$1.4 billion and US$5.5 billion in low- and lower-middle-income countries, respectively (not including HPV vaccination). Assuming that current provision is on the order of 20 percent to 50 percent of need, this implies an incremental need of between US$3.4 billion and US$5.4 billion annually, representing between 0.03 percent and 0.07 percent of GDP, dramatically less

Table 1.4 Cost of Components of Essential Packages to Promote Health of School-Age Children and Adolescents in Low- and Lower-Middle-Income Countries

Intervention	Mode of delivery	Approximate cost per child who benefits (US$) in low- and lower-middle-income countries	Approximate cost per child (US$) in relevant age group	Aggregate cost in low-income countries (US$, millions, per year)	Aggregate cost in lower-middle-income countries (US$, millions, per year)
School-age children					
School feeding programs	Meals (fortified with micronutrients) provided at school	41 (targeted to 20% of population in most food-insecure or poor areas)	8.2 per child ages 6–12 years	340	2,400
Health education (oral health, ITN use)	ITN education delivered only in endemic areas	0.50 per educational message (ITN message delivered only in endemic areas; assumed 50% of children in low- and lower-middle-income countries)	0.75 per child ages 6–12 years	31	110
Vision screening	Prescreening by teachers; vision tests and provision of ready-made glasses on site by eye specialists	3.6 per child to screen and provide glasses to the fraction of the age group needing glasses	0.60 per child ages 6–12 years	25	90
Deworming	Medication for soil-transmitted helminths or schistosomiasis delivered by teachers once a year in endemic areas	0.70 per child; 50% of endemic areas	0.35 per child ages 6–12 years	14	52
Tetanus toxoid booster	Single-dose booster administered to all children in one grade by nurse or similar health care worker	2.4 per child	0.40 per child ages 6–12 years	16	59
HPV vaccine	Part of the cancer essential package	10 per fully vaccinated girl (Gavi-eligible countries)	0.83 per child ages 6–12 years	43	74
Aggregate costs without HPV vaccine		48	10	430	2,700
Aggregate costs without school feeding programs but with HPV vaccine		17	2	130	390
Adolescents					
Media messages on national policy regarding health	Messages concerning use of tobacco, alcohol, and illicit drugs; sexual and reproductive health; mental health; healthy eating or physical activity	1 per adolescent	1 per adolescent ages 10–19 years	—	—
Health education in schools	Education for targeted age group	9 per year per adolescent ages 14–16 years	3 per adolescent ages 10–19 years	90	450
Adolescent-friendly health services	Health services offering respectful and confidential access for adolescents	5 per adolescent	5 per adolescent ages 10–19 years	790	2,300
Aggregate costs		15 per adolescent ages 10–19 years	9 per adolescent ages 10–19 years	880	2,700

Source: Fernandes and Aurino 2017 (chapter 25 in this volume); Horton and others 2017 (chapter 26 in this volume).
Note: — = not available; Gavi = Gavi, the Vaccine Alliance; HPV = human papillomavirus; ITN = insecticide-treated bednet. The total cost of the school-age package is about US$10 per child in the 5–14 years age group and about US$9 per adolescent in the 10–19 years age group. Compared with per capita public expenditures on health in 2013 of about US$31, this does not seem unreasonable, but it is high for low-income countries, which spent only US$14 per capita on health in 2013.

than the increments sought for education or for the health programs for children under five years of age.

The single most costly component is school meals, which account for almost half of the additional investment required. We have argued earlier that this is a special case and is neither paid for by the ministry of health nor primarily aimed at improving health. It is standard in *DCP3* to distinguish between interventions within the health sector and those delivered and financed outside the health sector. School meals, although part of the health package, are intersectoral in origin. For this reason, table 1.1 shows the costs with and without school meals. See also volume 9 for further discussion of this issue (chapter 2 [Watkins, Nugent, and others 2018]).

Taken together, these analyses suggest two important conclusions for investing in health in the 5 to 19 age group. It is apparent that education investments dominate all other public investments in human development during the first two decades of life. Using our estimates of current expenditure, the current costs of providing access in low- and lower-middle-income countries to basic education and a health care services package for under-fives (including maternal and newborn health) are US$206 billion and US$28.6 billion, respectively. The cost of the additional essential health and development packages for those ages 5–19 years are between US$1.4 billion and US$3.4 billion, respectively. Given that the latter two health and development investments underpin those in education, it seems difficult to justify investing in education without making the complementary investments in health and human development for this age group, especially given the comparatively low cost of the health and development packages. The modest cost of the two packages suggests that scaling up the health packages for those ages 5–19 is therefore a high return and low-cost investment that addresses the most pressing development needs throughout the first two decades of life.

HEALTH AND EDUCATION: TWO SIDES OF THE SAME COIN

This volume makes a strong case for providing both education and health services during middle childhood and adolescence. The view that education and health are separate silos in human development reflects an administrative and bureaucratic reality but does not best serve the needs of the growing child and adolescent. The common sense view that growing children need both health and education—*mens sana in corpore sano*—is supported by the evidence for strong links between health outcomes and educational attainment (Bundy, Schultz, and others 2017, chapter 20 in this volume; Plaut and others 2017, chapter 22 in this volume), and between educational attainment and health outcomes (Pradhan and others 2017). Years of schooling and quality of schooling (as measured by standardized test scores) reduce mortality rates in adults and children. Chapter 30 of this volume (Pradhan and others 2017) reports research that has recently incorporated both adult mortality outcomes and education quality into the literature. If rates of return to educational investments are recalculated to take into account reasonable estimates of the value of reducing mortality, the returns to education increase by about one-third. For example, in lower-middle-income countries, the estimated internal rate of return to one additional year of education increases from 7.0 percent to 9.3 percent if the effect of education on mortality is included. In this volume we explore both of these directions of influence.

Health, Education, and Social Outcomes

Exposing young children to drought and social shocks in Zimbabwe was shown to adversely affect height in adolescence, which, in turn, adversely affected schooling (Alderman, Hoddinott, and Kinsey 2006). Effect sizes were large: if individuals had reached median height for age, they would have been 3.4 centimeters taller, started school six months earlier, and have achieved an additional 0.85 years of schooling. There are also some trials in low- and middle-income countries that indicate impact: for example, young children with better diets in the Philippines did better in school than their less-advantaged siblings (Glewwe, Jacoby, and King 2001). Micronutrient deficiencies (particularly of iodine and iron, both known to affect cognition) have adverse effects on grade repetition and scores on cognitive tests (surveyed by Alderman and Bleakley 2013). In contrast, a recent systematic review, largely in LMICs, provides a more ambiguous picture of the impact of school-based interventions (Snilstveit and others 2015). We now recognize that development outcomes are crucially dependent upon the age-specific timing of intervention and upon the duration of follow-up. This is an area where longitudinal studies are particularly important but are currently rare. Chapter 7 of this volume (Alderman and others 2017) uses the lifecycle approach to assess the benefit-cost ratios of interventions in nutrition and child development in LMICs where nutrition is a risk factor, with a focus on the first five years of life. Chapter 12 (Drake and others 2017) summarizes the effects of school feeding programs (which alleviate hunger) on improved school attendance and test scores.

Chapter 27 (Nandi and others 2017) discusses the long-term human capital and economic benefits of early-life interventions.

Chapter 14 in this volume (Brooker and others 2017) reviews the effect of malaria on education. Randomized controlled trials found that treatment of malaria reduced absenteeism and that treatment provided in childhood improved schooling attainment in adolescence; in two countries, schoolchildren receiving malaria prophylaxis had better attention spans. Chapter 13 (Bundy, Appleby, and others 2017) and chapter 29 (Ahuja and others 2017) emphasize the importance of deworming for education.

Uncertainty about the appropriate metrics is one reason the scale of the contribution of ill health to unrealized cognitive attainment, and hence learning, is poorly understood. Both the WHO and IHME estimate the effect of ill health on cognition using a threshold approach, typically the proportion of the affected population that scores below some threshold—for example, an intelligence quotient (IQ) of 75, indicative of severe cognitive disability. A more informative metric would be some population level metric of the extent to which individuals reach their cognitive potential, analogous to the assessment of anthropometric status. There is also a need for an impact model that takes into account the overlapping benefits of multiple interventions. Given the secular trend for IQ scores to drift upward (Flynn 2007), it might be helpful to estimate the extent to which improved health will contribute to the achievement of cognitive potential.

Education and Health Outcomes

An extensive literature documents the correlation between higher levels of education and lower levels of mortality, illness, and health risk. The earliest data showed no association: in the late nineteenth century, mortality levels of individuals with high education were no lower than those of individuals with little education. However, by the early twentieth century, U.S. census data revealed a strong association between health and education. This transition has been attributed to the scientific revolution launched by Koch and Pasteur with the germ theory of disease, which gave households and states practicable means of interrupting the transmission of infectious disease (Preston and Haines 1991). Without such knowledge, an educated person could do little more than could an illiterate compatriot, but the more educated person learned about and adopted the newly available science from Europe much more quickly. This conclusion has close parallels with research on the value of education to economic productivity: in the presence of access to new markets, new seeds, or new crops, educated farmers quickly surpass illiterate farmers, but in closed, stagnant economies, formal education confers no advantage (Schultz 1993).

Rapidly changing knowledge and greater access to powerful drugs and vaccines should have led education to play an important role in halving the mortality rate for adolescents and adults 15–60 years of age around the world in the half century since 1970. But rates of decline varied markedly from country to country. Why such variation? For child mortality, variation in income growth explained a modest amount of cross-country differences (Jamison, Murphy, and Sandbu 2016). The number of available medical professionals explained more, and the pace at which some countries were able to adopt powerful and low-cost child survival technologies explained even more. About 9 percent of the reduction in child mortality from 1970 to 2000 in LMICs resulted from increased levels of education, as discussed in chapter 30 (Pradhan and others 2017).

Similarly, strong controls for country-specific effects in both the level and the rate of change of child and adult mortality resulted in education effects that were quantitatively and statistically highly significant (Pradhan and others 2017, chapter 30 in this volume). This study suggests that education's effects on adult mortality rates are about the same as the effects on child mortality (around 2–3 percent reduction per additional year of education and per one standard deviation improvement in test scores). If rates of return to educational investments are recalculated to take into account reasonable estimates of the value of mortality reduction, the returns to education increase by about one-third. For example, in lower-middle-income countries, the estimated internal rate of return to one additional year of education increases from 7.0 to 9.3 percent if the effect of education on mortality is included.

RESEARCH AND DEVELOPMENT PRIORITIES

The analyses presented here suggest some priorities for future research, with a focus on longer-term periods of observation that will capture developmental outcomes, assessment of multiple and complementary interventions, and, most important, a greater focus on children in middle childhood and adolescents. Specifically, future research should take into account the following issues.

1. *Collect better data on health and development needs in the 5 to 21 age range.* As shown in annex 1A, there has been a strong research focus on the health and development of children under five and a concomitant

relative absence of research on the needs of children in middle childhood and adolescence. There is a particular lack of information on children five to nine years of age.

2. *Pilot and evaluate packages of interventions for middle childhood and adolescence.* The packages proposed in this volume are based on the published literature for the individual interventions. In many cases, the evidence is partial and overly reliant on experiences in high-income countries. This suggests a need to carefully pilot and evaluate the packages under local circumstances before going to scale.
3. *Conduct more long-term longitudinal studies.* Most of the available analyses are too short term (typically less than a year) to provide useful guidance on development, which is inherently a long-term issue. To be useful, studies need to track outcomes over multiple years. A key question concerns the relative importance to development outcomes of intervention at different phases.
4. *Measure multiple outcomes of interventions.* Studies generally assess a single or a few outcomes, whereas the focus of development is inherently multisectoral and multifactorial. In particular, more studies are needed that simultaneously assess physical growth and cognitive development to assess the mutual benefits for health and education outcomes.
5. *Track mortality beyond age 5.* The new evidence that mortality is higher than recognized in those ages 5–14 indicates a need for more clarity about appropriate survival interventions for this age group. A starting point in middle childhood would be to assess the applicability of interventions that have proved successful in reducing the mortality of children under five; however, the causes of death are likely to be quite different for older adolescents, in particular.
6. *Examine the social dimensions of intervention in childhood and adolescence.* The social ecology of children's lives is poorly understood, especially in low- and lower-middle-income countries. There is a specific need for locally relevant research on the importance of families and teachers and of the gender context.
7. *Understand biological differences as a development issue.* There are sex differences in growth and development. For example, pubertal development differs by sex, so the timing of the growth spurt and the accompanying physiological changes also happen on a different timeline and scale. We now know that large differences are also apparent in brain development, yet we know little of the implications for behavioral intervention.
8. *Estimate the scale of the contribution of disability to development.* Children with disabilities are less able to benefit from prosperity, and disability remains a largely hidden topic. This is particularly true of mental health challenges in low-income countries and LMICs, and even more so of behavioral and social challenges, including autism. IHME estimates suggest that one in six children ages 5–19 years is severely or very severely disabled.

In reviewing these research issues, two short-term responses could be quickly implemented if there is to be a serious effort to understand the health and development needs of middle childhood and adolescence: (1) support existing longitudinal studies to define returns on interventions in middle childhood and adolescence, and (2) extend current mortality surveillance tools to include those ages 5–19 years.

In this volume, we propose intervening during ages that have not traditionally been given policy priority, especially in low-income countries. Developing an appropriate response will require stronger investment in implementation research that addresses the specific needs of middle childhood and adolescence. A potential way to move forward efficiently would be to expand the age range and interventions explored in current research models designed to assess developmental outcomes longitudinally. Examples include the 20-year-old Matlab Health and Socioeconomic Survey in Bangladesh; the 40-year-old Medical Research Council Keneba study in The Gambia; and the 15-year-old Young Lives studies in Ethiopia, India, Peru, and Vietnam, all of which are still ongoing. One of the key questions might be, what intervention is necessary to achieve remediation for children who slipped through the early safety net?

The burden of mortality and serious disease in the 5–19 age group is substantially higher than had been realized. During the Millennium Development Goals era, there was notable success in reducing under-5 mortality, and a key contributor was the creation of two new mechanisms for tracking mortality in children in this age group: the United Nations Interagency Group for Child Mortality Estimation, which provides current child mortality estimates through the Child Mortality Estimation database; and the Child Health Epidemiology Reference Group, which develops improved evidence on the causes of child mortality. If the world is to be similarly successful in addressing mortality in older children, there will need to be a similarly strong evidence-based approach to mortality in ages beyond five. This could be

achieved if both of these groups extended the age range up to 21 and engaged with the research and public health communities working with these older age groups.

CONCLUSIONS

Although the current investment focus on the first 1,000 days of human development is necessary, it is not enough. The narrow focus on investing in health in the earliest childhood years underserves our children and adolescents by failing to support their development at other critical phases during the first two decades of life and by failing to secure the early gains. This unbalanced approach has not only resulted in a neglect of health service provision after the first 1,000 days but has also deflected research away from middle childhood and adolescence.

The issue is not that the first 1,000 days are less important than previously thought, but rather that the subsequent 7,000 days before the child reaches age 21 have much greater importance than has been recognized. Based largely on cost-effectiveness and benefit-cost analyses, we have identified two essential packages of interventions that together can help address these health and development demands in middle childhood and adolescence. A school-age package, largely built around school-based delivery, can address many of the needs during middle childhood and the adolescent growth spurt. An adolescence package, built both around the school and around access to non-stigmatizing, affordable, and confidential health care, can help further address the needs during the adolescent growth spurt and the very particular needs of later adolescence. The purposes of the two packages overlap, as do the age ranges of the target populations, and so both packages are required to support development through middle childhood and adolescence. It is important to recognize that the school and the education sector are key participants in these processes, both by providing an infrastructure for delivery and, just as important, by providing the learning, understanding, and life skills that have contributed, for example, about 30 percent of the observed decline in maternal mortality since 1990.

There are powerful opportunities for synergy between health and education that are currently underexploited. The school and the education sector should be recognized as key participants in promoting health, both by providing an infrastructure for delivery and, just as important, by providing the learning, understanding, and life skills that, for example, have contributed about 30 percent of the observed decline in maternal mortality since 1990. However, the health of school-age children and adolescents, especially in low- and lower-middle-income countries, is an important determinant of education outcomes, having consequences for both education access and learning. The analyses presented here for the first 8,000 days indicate that investments in health leverage education outcomes, and investments in education leverage health.

The current world view is that education is a high priority and that the MDGs have helped ensure near-universal access to free primary education that is free at the point of delivery. One of the new Sustainable Development Goals is to achieve the same for secondary education. There is also increasing recognition that the RMNCH (reproductive, maternal, newborn and child health) demands of the 1,000 days should also be viewed as a high priority. Here we argue that, for similar reasons, the incremental costs of addressing health and development needs during middle childhood and adolescence should be viewed in the same way. Our calculations suggest that the proposed essential packages are a practical and affordable investment, even for LMICs. Based on current expenditures world-wide in LMICs, the annual cost of providing access to health care for children under five is US$28.6 billion, and the cost of providing primary education is US$206 billion. For the same countries, the estimated incremental cost of the essential health and development packages for ages 5 to 19 would add between US$1.4 billion and US$3.4 billion. This is a small increment to leverage the existing investments in early childhood and education and to secure the health and development of the next generation. Given the current levels of development assistance and domestic investment in both the first 1,000 days and in education, there would seem to be a strong economic case for leveraging these investments with critical, but more modest, health investments during the next 7,000 days, with benefits for equity, for realizing individual potential, and for maximizing the opportunities for the next generation.

The implication is that public policy needs to align with parental commitments and to the commitment to addressing health, development, and education through the first two decades of life. More countries already emphasize the social and legal importance of the 21st birthday, and our analyses suggest that it is necessary and affordable for all countries to translate that commitment into practical investments in middle childhood and adolescence.

ANNEX

The annex to this chapter is as follows. It is available at http://www.dcp-3.org/CAHD.

- Annex 1A. Analysis of Published Literature Describing Health and Mortality, Ages 0–19 Years

NOTE

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.

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Chapter 4

Global Variation in Education Outcomes at Ages 5 to 19

Kin Bing Wu

INTRODUCTION

Education produces far-reaching benefits to populations by improving health, increasing individual productivity and earnings, enhancing civic engagement, and facilitating economic and social intergenerational mobility (Hannum and Xie 2016; Montenegro and Patrinos 2014; OECD 2013c; Schultz 1961). In the aggregate, it enhances economic growth by contributing to technological change and innovation (Becker 1964; Mankiw, Romer, and Weil 1992; Mincer 1974; Solow 1956; Pradham and others 2016, chapter 30 of this volume).

Education outcomes are affected by a number of factors. At the child or student level, nutrition, health, and interactions with parents and other adults affect brain development, emotional and psychological well-being, and the capacity to learn (Crookston and others 2013). At the school level, education quality is enhanced by school leadership, an orderly and safe environment, high expectations, positive reinforcement, regular assessment, constructive school-home relations, and opportunity to learn (OTL) (Sammons, Hillman, and Mortimore 1995). Education, health, and social policies can create an enabling environment and equalize opportunities for all students through resource allocation, monitoring and supervision, curriculum improvement, teacher management, policy toward the language of instruction, and interventions targeted to disadvantaged groups. Chudgar and Luschei's (2009) study of 25 participating systems in international studies found that although family background affects outcomes more, schools are an important source of variation in student achievement in poor countries and can bridge the achievement gap. Definitions of age groupings and age-specific terminology used in the volume can be found in chapter 1 (Bundy and others 2017).

INTERNATIONAL ASSESSMENT OF STUDENT ACHIEVEMENT

Cross-national studies confirm the positive relationship between educational attainment, as measured by average years of schooling, and economic growth (Barro 1991, 1997). However, student achievement can vary widely across countries, even across countries with the same average years of schooling. Education quality is the most critical component because the capability to use technology and to innovate is contingent on the improvement of cognitive skills. Hanushek and Woessmann (2015) found a strong positive relationship between student achievement and gross domestic product (GDP) per capita growth between 1964 and 2003; they also found that cognitive skills explained differences in growth rates between regions. For example, 10 East Asia and Pacific countries in their sample experienced growth that was at least 2.5 percentage points per year faster than the typical country in the world, attributable to their knowledge capital. Although other qualities, such as resilience, collaboration, and entrepreneurship, are very important, cognitive skills lend themselves more easily to international comparison.

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The International Association for the Evaluation of Educational Achievement (IEA) and the Organisation for Economic Co-operation and Development's (OECD's) Programme for International Student Assessment (PISA) conducted 21 cross-country studies of student achievement in mathematics, science, and reading between 1964 and 2015 (see annex 4A and table 4.1 for the history of international student assessments).

The IEA organized the first, second, and third mathematics, science, and reading tests from the 1960s to the 1990s, about once every decade, to study the differences between education systems and outcomes. The IEA subsequently conducted the Trends in International Mathematics and Science Study (TIMSS) once every four years and the Progress in International Reading Literacy Study (PIRLS) once every five years. Participating

Table 4.1 History of International Assessments of Student Achievement and Adult Skills

Studies conducted by the International Association for the Evaluation of Educational Achievement	Year	Age (years) and grade	Participating education systems
FIMS	1964	13 and final year	11
FISS	1970–71	10, 14, and final year	14, 16, 16
FIRS	1970–72	13	12
SIMS	1980–82	13 and final year	17, 12
SISS	1983–84	10, 13, and final year	15, 17, 13
SIRS	1990–91	9, 13	26, 30
TIMSS	1994–95	9 (grade 3 or 4), 13 (grade 7 or 8), final year	29, 46, 21
TIMSS-R	1999	13 (grade 8)	38
PIRLS	2001	9 (grade 4)	36
TIMSS	2003	9 (grade 4), 13 (grade 8)	26, 47
PIRLS	2006	9.5 (grade 4)	45
TIMSS	2007	9.5 (grade 4), 13.5 (grade 8)	37, 50
PIRLS	2011	9 (grade 4)	57
TIMSS	2011	9 (grade 4), 13 (grade 8)	50, 42
TIMSS	2015	9 (grade 4), 13 (grade 8)	48, 40
PISA, conducted by the OECD	**Year**	**Age (years)**	**Participating education systems**
PISA	2000, 2002	15	31, 10
PISA	2003	15	40
PISA	2006	15	57
PISA	2009	15	65
PISA	2012	15	65
PISA (to be published in late 2016)	2015	15	74
PIAAC, conducted by the OECD	**Year**	**Age (years)**	**Countries**
PIAAC	2011	16–65	24
PIAAC	2014	16–65	33

Sources: Hanushek and Woessmann 2015; NCES (National Center for Education Statistics) Trends in International Mathematics and Science Study (TIMSS), http://www.nces.ed.gov/TIMSS//countries.asp; NCES Progress in International Reading Literacy Study (PIRLS), http://www.nces.ed.gov/surveys/pirls/countries.asp; NCES Programme for International Student Assessment (PISA), http://www.nces.ed.gov/surveys/pisa/countries.asp.

Note: FIMS = First International Mathematics Study; FIRS = First International Reading Study; FISS = First International Science Study; OECD = Organisation for Economic Co-operation and Development; PIAAC = Programme for the International Assessment of Adult Competencies; PIRLS = Progress in International Reading Literacy Study; PISA = Programme for International Student Assessment; SIMS = Second International Mathematics Study; SIRS = Second International Reading Study; SISS = Second International Science Study; TIMSS = Trends in International Mathematics and Science Study; TIMMS-R = Trends in International Mathematics and Science Study-Repeat.

educational systems increased from the original 11 in 1964 to more than 50 in recent years; they include systems from Europe, East Asia, the Middle East and North Africa, Latin America and the Caribbean, South Asia, and Sub-Saharan Africa.

The IEA has historically assessed three student populations: upper primary (third or fourth grade), lower secondary (seventh or eighth grade), and the final year of upper secondary school. Participating educational systems agree on the content to ensure that the test covers topics in their curricula. The IEA enforces strict sampling rules and protocols to ensure that an educational system under study is representative, whether of a country or of a region of a country. A properly drawn sample of several hundred schools and several thousand students could yield results representative of an education system.

In 2000, PISA began testing the mathematics, science, and reading competency of 15-year-olds every three years, irrespective of the grade of enrollment. PISA assesses students' acquisition of the knowledge and skills that are essential for full participation in modern societies, with the goal of identifying ways in which students can learn better, teachers can teach better, and schools can operate more effectively (OECD 2010).

Both IEA and PISA provide training to participating education systems in sampling, test administration, and data cleaning and analysis. They also validate the results to ensure comparability across countries. The IEA and PISA scores are highly correlated at the national level (Hanushek and Woessmann 2015). Over 100 countries or regions of a country have participated in at least one of the IEA or OECD tests (annex 4A).[1] Financial constraints and consideration of the results' political impact often are the main deterrents to participation.

LESSONS FROM INTERNATIONAL ASSESSMENTS

Education system performance varies tremendously, and country rankings in the international league table often generate headlines. However, in addition to the previously mentioned student-level and school-level factors, student achievement at the system level is affected by size of the rural population, diversity of terrain, adult literacy rates, income distribution, ethnicity and languages, attitudes toward gender equality, and history of conflict. It is important to put the results in a broader context when interpreting them.

Changes in Student Performance and Adult Skills

Education system performance can improve or decline over time. For example, in TIMSS 1995, six education systems scored at the top of the international league table in eighth-grade mathematics: Singapore; Japan; the Republic of Korea; Hong Kong SAR, China; Belgium (Flemish); and the Czech Republic. In TIMSS 2011, the Republic of Korea's score increased by 32 points, rising to the top spot; Hong Kong SAR, China, increased by 17 points; and Singapore increased by 2 points. Over this period, Japan's score decreased by 11 points, Belgium's (Flemish) by 13 points, and the Czech Republic's by 42 points (Loveless 2013). Between PISA 2000 and PISA 2012, Peru made the greatest gains among all participating systems (increasing by 76 points in mathematics), albeit from a very low base, while Brazil and Chile were among the top 10 countries with the greatest gains during this period (Patrinos 2013). In PISA 2009 and 2012, Shanghai, China, overtook Finland as the top performer (annex 4B). Vietnam, a lower-middle-income economy, scored higher than the OECD average (OECD 2013a). These changes in performance demonstrate that cognitive skills are not fixed but can be developed. The relationship between education quality and economic development is not linear; relatively low income countries can make great strides, thereby changing the trajectory of their development.

The reasons for changes in student achievement are complex and country specific, and they may be attributable to a combination of interventions at the student, school, and policy levels and broader social trends. Where girls' performance in mathematics and science lagged behind boys', programs to improve girls' proficiency in these subjects increased the overall national average, as in the Republic of Korea (Chiu, personal communication 2016).[2] Countries that had previously divided their educational systems into general and vocational education saw improved academic achievement by postponing tracking and exposing more students to general education, as in Poland (OECD 2011). Germany increased its scores and ranking from 2003 to 2012 after it adopted a national educational standard in all federal states and put significant effort into teacher training and assessment (Chiu, personal communication 2016). Teaching math through strong visual presentation and improving student engagement improved test scores, as in Singapore (Cavendish 2015). Curriculum change that unintentionally reduced coherence led to a decline in test scores, as in Taiwan, China (Chiu, personal communication 2016). Linking strong schools with weak schools raised teachers' competency in weaker schools, as in Shanghai (Liang, Kidwai, and Zhang 2016). Using international assessment to guide educational interventions has substantially improved student outcomes, as in Germany and Peru (Anderson, Chiu, and Yore 2010; Patrinos 2013). The opening up, particularly to women, of more nonteaching professions with better

remuneration and expanded migration opportunities with open borders made it harder for the education sector to retain capable teachers and recruit new talent, thereby affecting education quality (Chui, personal communication, 2016).

Findings from the OECD's first survey of adult skills, the Programme for the International Assessment of Adult Competencies (PIAAC), launched in 2011, confirmed that educational systems could shape people's skill profiles (OECD 2013b). The Republic of Korea was among the three lowest-performing countries when comparing the performance of adults ages 55–65 years with other countries, but it followed Japan in skill proficiency among the younger generation of workers ages 16–24 years. The United Kingdom was among the three highest-performing countries in literacy proficiency among adults ages 55–65 years, but it was among the bottom three in literacy proficiency among those ages 16–24 years. High school–educated adults ages 25–34 years in Japan and the Netherlands outperformed Italian and Spanish university graduates of the same age (annex 4C).

The PIAAC found that skills have a major impact on each person's life chances. The median hourly wage of workers scoring at the highest two levels in literacy (levels 4 and 5) is more than 60 percent higher than that for workers scoring at or below level 1. Those with lower skills also tend to report poorer health and lower civic engagement, and they are less likely to be employed (OECD 2013b). Countries would benefit from using mixed-method case studies to examine how decadal changes in education policy affect generational changes in skill profiles.

Characteristics of High-Performing Systems

Examining the distribution of student achievement at different levels of proficiency is important for assessing the depth of skills. For example, PISA has five levels of proficiency in ascending order, from level 1 to level 5. In PISA 2012, 55 percent of students in Shanghai, 40 percent in Singapore, and 37 percent in Taiwan, China, scored at level 5 in mathematics, compared with 13 percent of OECD students. Only 4 percent of students in Shanghai, 8 percent in Singapore, and 13 percent in Taiwan, China, performed below level 2, compared with 23 percent in OECD countries (annex 4B; OECD 2013a).

High-performing education systems tend to have standards-based external examinations and allocate resources more equitably across all types of schools. Systems that create more competitive environments in which schools vie for students do not systematically perform better. High teacher salaries relative to national income are associated with better student performance. School autonomy has a positive relationship with student performance when public accountability measures are in place, when school principals and teachers collaborate in school management, or when both occur. Schools with better disciplinary climates, more collaboration among teachers, and more positive teacher-student relationships tend to perform better. Stratification in school systems into general and vocational streams and grade repetition are negatively related to equity and student achievement. School systems with higher percentages of students having attended preprimary education tend to produce better results (OECD 2010, 2013b).

Variance in Achievement between Schools and between Students

International comparisons of the percentage of variance in achievement attributable to between-school differences and between-student (within-school) differences can provide direction for policy intervention. Variance in achievement attributable to between-school differences results from education policies, school resources, teacher characteristics, and instructional strategies. The smaller the between-school variance, the more equitable the school system. In Finland, less than 10 percent of the variance in PISA 2009 was attributable to between-school differences, suggesting that student achievement was less likely to be affected by which school they attended. In Hong Kong SAR, China; the Republic of Korea; Shanghai; and Taiwan, China, the variance in between-school achievement ranged from 30 percent to 35 percent, indicating relatively inequitable schools. In low-performing countries, such as Argentina and Trinidad and Tobago, the variance in student achievement between schools in PISA 2009 was 90 percent and more (OECD 2010). Where between-school variance is large, policy interventions could be directed to improving school-related factors to equalize the OTL.

Variance in achievement attributable to differences between students (within-school) results from students' family characteristics, innate ability, nutrition and health status, early childhood education, and learning strategies. PISA found that students whose parents read to them in their early years and who had attended preprimary school performed better than those without these types of support. Policy interventions directed at students and families could improve achievement. However, international student assessments focus on collecting the characteristics of education systems, schools, teachers, and students; they do not collect data on nutrition and health, which could be very important determinants of education outcomes, particularly in low-income countries and disadvantaged communities.

STUDENT ACHIEVEMENT IN POOR REGIONS OF INDIA AND CHINA

The high-performing education systems in TIMSS, PIRLS, PISA, and PIAAC are relatively small in size and population. Managing an educational system well is much more challenging in countries with more than a billion people and with highly variable geography and income. For example, top-performing Shanghai is a municipality of 23 million people and has the highest per capita income in China. The key question is how students in the poor regions of populous countries fare, relative to the more advanced regions of the same country and to international averages. This section addresses this question by reporting the findings of two surveys conducted in poor regions of India and China, using selected TIMSS mathematics items.

The India survey was part of the World Bank's study on secondary education in India. It was conducted in 2005, involving 3,418 students in 114 schools in Rajasthan (in the west) and 2,856 students in 109 schools in Orissa (in the east) (Wu, Sankar, and Azam 2006). These states have a significantly lower per capita GDP than the national average. The eighth grade was part of elementary education in Rajasthan but was part of secondary education in Orissa. The differences in the education structure in these two states led to selection of the ninth grade for testing because it was part of secondary education in both states. Thirty-six test items designed for the eighth grade internationally were selected from published items from the TIMSS 1999 (TIMSS-R) and administered to the sampled ninth-graders in both states (annex 4D). The survey also administered questionnaires to the sampled students, teachers, and schools to assess factors affecting student performance (annex 4E).

The China survey was part of a 2006 World Bank study on compulsory education (Wu, Boscardin, and Goldschmidt 2011). The same test items from TIMSS-R used in India were used to test a sample of 4,103 eighth-graders in 138 schools in Gansu province in China. Located in arid northwest China, Gansu is the second poorest province in the country. As in India, the survey administered questionnaires to the sampled students, teachers, and schools to assess factors affecting student performance, but a question on breakfast and measurement of weight and height were added to the student questionnaire (annex 4F).

Major differences existed between the two countries. India's per capita GDP was less than one-fourth of China's. Infrastrastructure and the telecommunication systems were relatively well developed, even in China's poor western regions, but much less so in India in 2006. India lagged far behind China in health indicators (WHO 2010). India did not have a national curriculum; each state determined its own education structure, curriculum, and language of instruction. China has a national curriculum that applies to all public schools irrespective of location. Chinese schools were far better resourced than Indian schools. In both countries, local educational authorities were consulted on the appropriateness of applying the test to their students. Stratified random sampling was used in both countries, but the sampling frames were different (and they were different from that of TIMSS-R). As such, the findings are only suggestive, not representative or definitive, of student achievement in the hinterland of these two large countries and its potential link with TIMSS performance. The results should be treated as a test case for further investigation.

Gansu's eighth-graders' average of 72 percent correct of the 36 items was above the international average of 52 percent; Rajasthan's and Orissa's ninth-graders scored 34 percent and 37 percent correct on average, respectively. Item by item, the Gansu students scored above the international average on 34 of 36 items, while Orissa students had lower scores on 35 of 36 items, and Rajasthan students performed below on all items. Given that students in Rajasthan and Orissa had the benefit of an additional year of education, their low scores should be a concern for policy makers. Figure 4.1 illustrates the differences in percentage correct for each item. These results to some extent foreshadow the relatively weak performance of two of the better-performing Indian states (Tamil Nadu and Himachal Pradesh) on PISA 2009 and the stellar performance of Shanghai, China, on the same test. Yet, a significant achievement gap between Gansu and Shanghai could be inferred given the latter's top position in PISA 2009 and 2012.

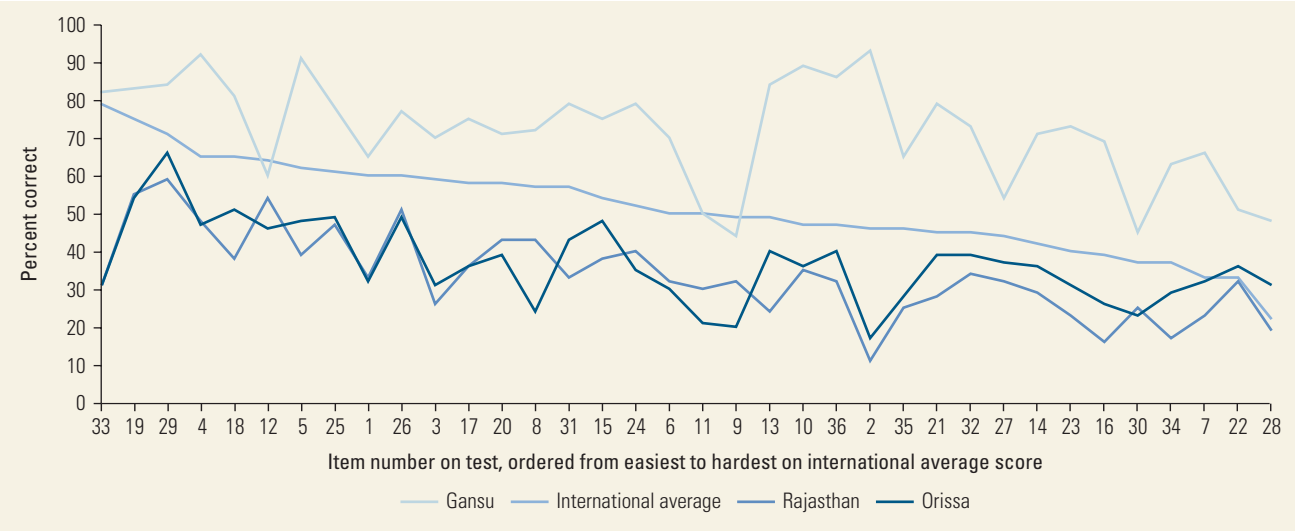
A multilevel analysis was performed to explore the determinants of achievement in Rajasthan, Orissa, and Gansu (Wu, Boscardin, and Goldschmidt 2011; Wu, Sankar, and Azam 2006). The unconditional analytical models found that school quality was highly variable in the poor regions of both large countries—46 percent of the variance in achievement in Rajasthan and 50 percent of the variance in Orissa was attributable to differences between schools; in Gansu, 55 percent of the variance was attributable to between-school differences (annex 4E). The paragraphs that follow and annexes 4F and 4G report only those variables with statistical significance and could inform policy.

India

Student Level

At the student level in Rajasthan and Orissa, the analysis found a statistically significant association between good

Figure 4.1 Average Percentage Correct by Item in Gansu, China, and Rajasthan and Orissa, India, Compared with International Average



Source: Wu, Boscardin, and Goldschmidt 2011.

performance on the one hand, and being male, higher education levels of mothers, higher parental expectations, advanced resources at home, and OTL on the other hand. Boys outperformed girls, on average, in both states. In Rajasthan, students who belonged to Scheduled Tribes[3] performed below nontribal students. In Orissa, Scheduled Caste students performed lower than the general students, on average. The OTL through homework and examination had positive effects on student achievement (annex 4F).

School Level

When students' family resources were aggregated at the school level, a significant effect on student achievement in both states was found. School types made a difference in Rajasthan: students enrolled in government-aided schools and unaided (private) schools performed better than government schools (annex 4F).

In the full model, student-level variables explained only 8 percent of the variance in achievement and school-level variables explained 33 percent in Rajasthan. Student-level variables explained only 4 percent of the variance in achievement between students, and school-level variables explained 19 percent in Orissa (annex 4E).

China

Student Level

In Gansu, significant factors at the student level were as follows: gender, age, students' prior achievement, parental expectations, and having had breakfast. On average, girls performed lower than boys. Increase in age and grade repetition were associated with lower performance. Students with parents who expected them to complete tertiary education performed better. Students who rarely had breakfast before school performed lower than students who had breakfast. The last variable is particularly important because 43 percent of students rarely had breakfast. However, there was insufficient variation in weight and height at the ninth-grade level to link those measures with student performance (annex 4G).

School Level

At the school level, teacher qualification, teacher preparation, and teaching strategy were positively associated with student achievement. Students with teachers who had higher levels of education performed much higher. An increase of an additional hour of lesson preparation by the teacher was associated with a small but significant increase in student performance. Additional teacher time spent during class time discussing questioning strategies was positively associated with student performance. Schools with more resources and facilities, ranging from drinking water and electricity to computers, student dormitories, and televisions, were positively associated with student performance. Schools with a high percentage of minority students were negatively associated with student performance, although at the individual student level, minority status was not associated with student outcome (annex 4G).

In the full model, the student-level variables only explained 7 percent of the variance in achievement between students, and the school-level variables only explained 12 percent of variance between schools (annex 4E).

Discussion

In both the India and China studies, the collected data explained a much smaller portion of the variance in achievement between students than the variance between schools. This outcome suggests that a singular focus on education policy without simultaneous interventions at the student level is unlikely to improve achievement on a large and sustained scale. Although it is difficult to change family characteristics, socioeconomic backgrounds, and innate abilities, it is entirely possible to improve students' nutrition and health, and to provide opportunity for early child development.

Longitudinal studies in a number of countries have found significant long-term impacts of nutrition and health on educational outcome (Crookston and others 2013; Hannum, Liu, and Frongillo 2014; Lundeen and others 2014). Several randomized controlled trials in elementary schools in western China that took blood samples from elementary students to use as independent variables to predict their test scores confirmed that giving the treatment group multivitamins, including iron, raised hemoglobin and increased mathematics test scores by 0.2–0.4 standard deviation compared with those of a control group (Kleiman-Weiner and others 2013; Luo and others 2012). These studies suggest that directly measuring nutrition and health through blood tests can help target interventions at the student level to increase their educational outcomes.

CONCLUSIONS

The evidence from international student assessments supports the overall relationship between knowledge capital and economic growth, although it is not linear. The PIAAC findings on adult skills suggest that countries with low skill levels are at a competitive disadvantage in the global knowledge economy. Yet TIMSS and PISA have shown that education systems can improve student achievement on a large scale. Future international assessments could consider including a more detailed questionnaire on nutrition and health and collection of biomarkers through blood tests, at least in a subsample. Availability of such integrated information on education, nutrition, and health on an international scale could explain in greater depth the differences in achievement across countries and between students, help countries prioritize their interventions, and enable international donors to target their resources more effectively.

ANNEXES

The annexes to this chapter are as follows. They are available at http://www.dcp-3.org/CAHD.

- Annex 4A. Participating Educational Systems in International Assessment of Student Achievement, 1995–2015
- Annex 4B. Performance of 15-Year-Old Students in 10 Top-Performing Educational Systems in PISA, 2012
- Annex 4C. Comparison of Skill Proficiency among Adults, 2011
- Annex 4D. Average Percentage Correct, by Item, in Gansu, China, and Rajasthan and Orissa, India, Compared with International Average
- Annex 4E. Percentage of Variance in Achievement Explained by Differences between Schools and between Students in Rajasthan, Orissa, and Gansu
- Annex 4F. Factors Associated with Student Achievement in Grade 9 in Rajasthan and Orissa, India
- Annex 4G. Factors Associated with Student Achievement in Grade 8 in Gansu

NOTES

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. Other regional student assessment programs focus on Latin America and the Caribbean, as well as on English-speaking and French-speaking countries in Sub-Saharan Africa. However, this chapter only focuses on the IEA and PISA assessments because of their international scope and long history.
2. M. H. Chiu was interviewed by the author in Taiwan, China, on June 23, 2016. Dr. Chiu is Professor at the Graduate Institute of Science Education, National Taiwan Normal University and President, National Association for Research in Science Teaching (NARST), United States.
3. Scheduled Tribes are indigenous peoples and Scheduled Castes are the most disadvantaged social groups in India. They are recognized in India's constitution as eligible for support.

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Chapter 6

Impact of Interventions on Health and Development during Childhood and Adolescence: A Conceptual Framework

Donald A. P. Bundy and Susan Horton

This chapter provides a conceptual framework for exploring the processes and inputs that determine the physical, cognitive, and intellectual growth of human beings from birth to adulthood. This task is made particularly difficult by the absence of a holistic academic discipline that provides an overview of this critical phase in the human life course. It is also complicated by the curiously partial approach to studies in this area; much of the literature on child health ends when a child reaches age two years, while much of the literature on child education does not begin until a child reaches age five years. This significant mismatch in the literature reflects a similar lack of connection between the scale of public investment in primary education—one of the few public goods that attracts near-universal support—and the scale of investments in health and nutrition during middle childhood and adolescence.

Development during adolescence (ages 10–19 years) has received greater attention than the middle childhood years (ages 5–9 years; see, for example, Patton and others 2016). The unfortunate tendency to treat adolescence as separate from childhood has impeded efforts to enhance the understanding of the interrelationships between adolescence and earlier development and of the contribution of health and nutrition to the development of the next generation. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017).

The focus on the first 1,000 days—from the first day of pregnancy until age two years—has caused us to lose sight of the fact that child and adolescent growth and development are complex processes with multiple periods of sensitivity to intervention. Early intervention is undoubtedly critical to human development. However, the emphasis on the proposition that harm experienced in early life is irreversible not only is weakly supported by the evidence, but also has led to an unfortunate lack of emphasis on exploring important and relevant interventions later in childhood. Similarly, the declining rate of return on educational investments posited by Heckmann (2011) may need to be reconsidered following recent neurobiological research on brain development and a broader recognition of the complexity of intellectual skills, which extend well beyond numeracy and literacy.

INTERVENTIONS DURING MIDDLE CHILDHOOD AND ADOLESCENCE

Volume 2 of the third edition of *Disease Control Priorities, Reproductive, Maternal, Newborn, and Child Health* (Black and others 2016), explores evidence of the importance of maternal and young child health for subsequent child development. This chapter complements those findings by exploring evidence of the consequences of intervention at later points throughout the life course. This chapter places

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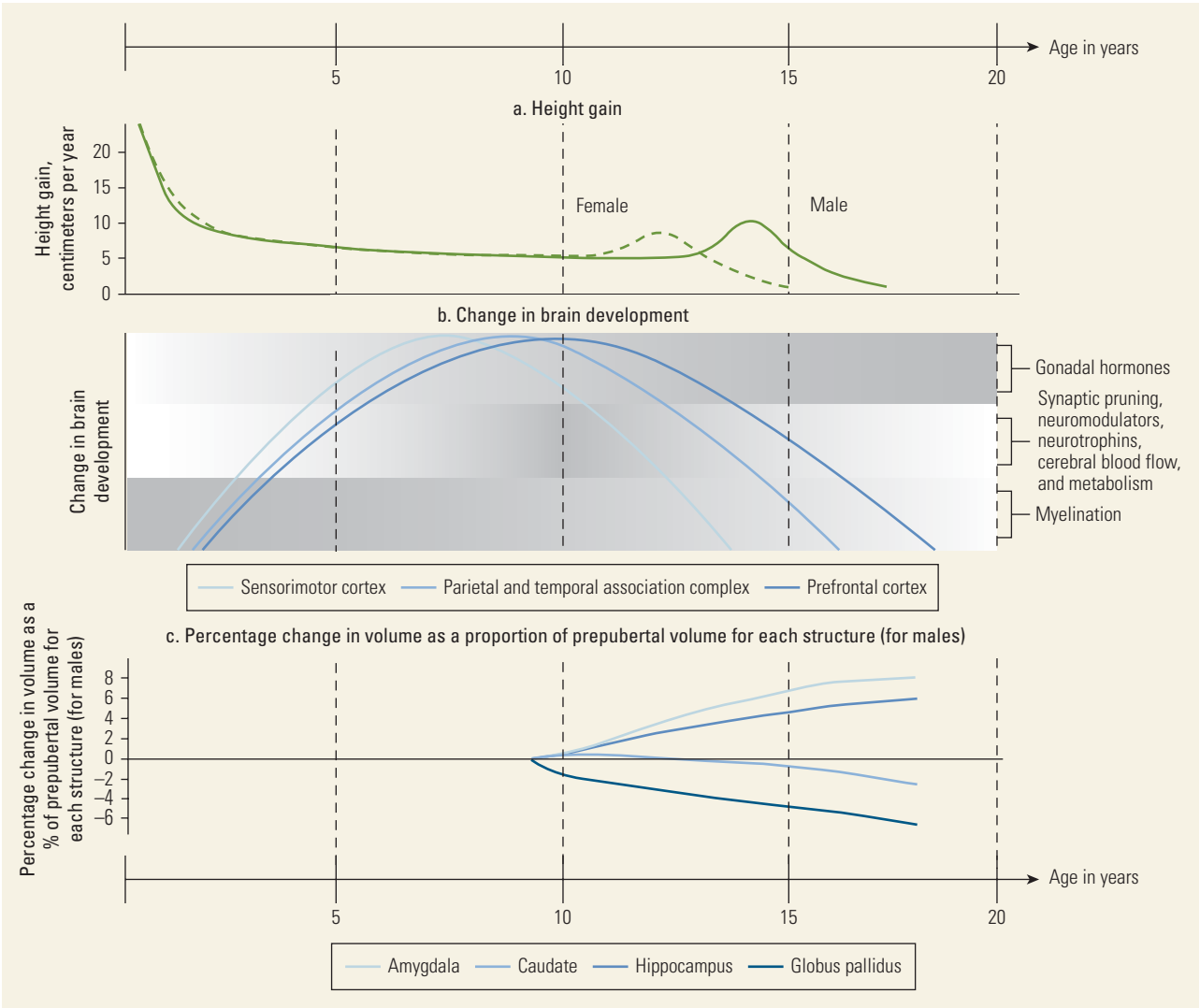
particular emphasis on giving equivalent weight to the understanding of the role of interventions at all stages, from early childhood through middle years and adolescence. To provide a conceptual scaffolding, we developed figure 6.1 to assemble evidence of effects along the same age-specified life course.

Figure 6.1 illustrates the value of a perspective that extends beyond the first 1,000 days. Rates of physical growth are indeed the highest at younger than age two years, when nutrition is critical. However, the rates at the peak of the adolescent growth spurt for girls are similar to—and for boys exceed—the rates at age two years (figure 6.1, panel a). It has long been recognized that stunting before age three years can be partially reversed by delayed maturation and a longer period of catch-up (Martorell, Khan, and Schroeder 1994), given the right circumstances. A review in chapter 8 in this volume (Watkins and others 2017) presents evidence for smaller, but potentially important, amounts of catch-up growth in older children before the onset of puberty. These data may mean that we need to be more careful about assuming that early insults are irreversible and pay more attention to what can be done for children in middle childhood. The scarcity of studies in this age group also may show the influence of unintended research bias on policy.

Figure 6.1 Human Development to Age 20 Years



Sources: Panel a adapted from Tanner 1990; panel b adapted from Grigorenko 2017; panel c adapted from Goddings and others 2014.
Note: The vertical axis in panel b shows relative rate of growth of three brain areas from 0 to highest. The progressive shading indicates when the indicated activity is at its most intense (darkest shading). Behavioral attributes are paralleled by hormonal and neurobiological changes that target specific brain regions and cell populations (shown in shaded gray to capture the dynamic influences of hormones, various brain processes, and myelination).

Although the first 1,000 days are clearly a key period for brain development, evidence from neuroscience from the past 15 years has given us greater insight into the complexities of brain development. By age 6 years, the brain has reached approximately 95 percent of its adult volume; the volume of gray matter peaks about age 12 years in boys (figure 6.1, panel c) (Goddings and others 2014). For the brain, however, size is not everything. Connections within the brain are of greater importance to functioning than size. The process of myelination speeds up the processing of signals, and the process of synaptic pruning leads to strengthening of particular pathways. White matter in the brain, which reflects increased myelin, peaks in early adulthood. These processes of brain development also depend on individuals' interactions with their environments, which in turn stimulate their learning.

Different areas of the brain have different functions and develop at different rates. Peak development of the sensorimotor cortex, which is associated with vision, hearing, and motor control, occurs relatively early, and development is limited after puberty. The parietal and temporal association complex, responsible for language skills and numeracy, develops the fastest a little later; hence, the observation that by about age 14 years, although it is possible to learn new languages, it is more difficult to speak a new language in the same way as a native speaker (Dahl 2004). The prefrontal cortex develops later still; this is the area associated with higher brain functions, such as executive control (figure 6.1, panel b) (Grigorenko 2017).

It is possible to see some of these differential growth rates in brain capabilities in the relationship between the size of subcortical regions in figure 6.1, panel c. The figure plots size as a function of stage of puberty using Tanner's well-known five stages, which can be categorized as pre-, early, mid-, late, and postpuberty. The panel shows the pattern for adolescent boys; the patterns are similar for girls but occur at earlier ages because of different patterns of puberty. The panel shows that the size of those regions associated with movement (such as the caudate and globus pallidus) is shrinking during early adolescence because these functions are more mature. In contrast, regions associated with memory, decision making, and emotional reactions (amygdala and hippocampus) are still growing in adolescence.

The development of behaviors and social skills has long been recognized as age dependent, and it is now recognized that this development is closely related to neurological development. The subcortical regions are not fully developed at the point at which they reach maximum size; they require additional time to establish rapid processing and transmission of signals to other parts of the brain. The prefrontal cortex develops later still with maturation continuing into the third decade. This prolonged process helps explain why adolescence is a time of strong passions (Dahl 2004), impulsiveness (Casey, Jones, and Hare 2008), and risk taking (Casey, Jones, and Hare 2008; Steinberg 2007). The earlier development of brain regions associated with these behaviors outstrips the slower development of brain areas associated with control of impulses, delay of gratification, and regulation of emotions (Steinberg 2007). Accordingly, a focus on readily measurable cognitive function, as in much of the educational literature, ignores the more complex and later-developing brain functions that have important consequences for creativity, social functioning, and strategic thinking.

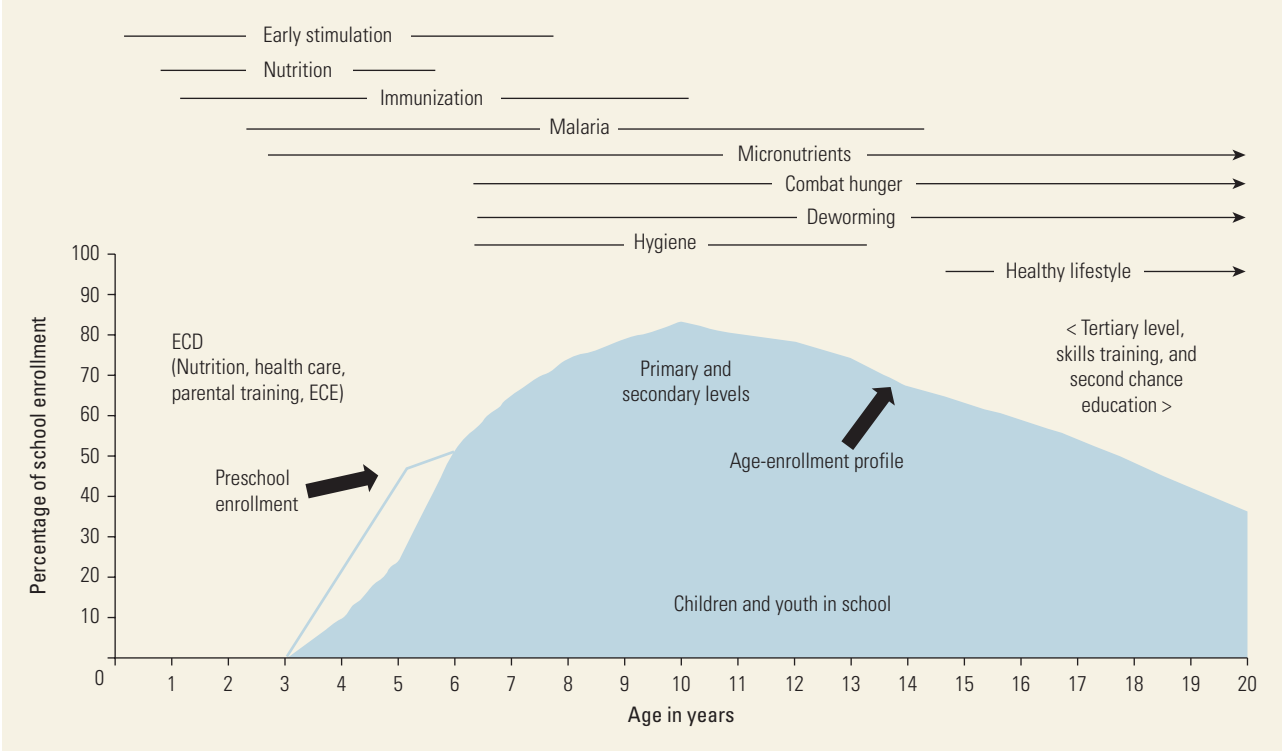
Figure 6.2 was developed to guide human development strategic policy and suggests how key health, nutritional, and educational interventions might be timed according to the different sensitivities at different ages. The figure also indicates the likely levels of school participation at different ages for low- and middle-income populations, showing how important the education sector can be for reaching children in middle childhood and adolescence, and presaging the discussion of delivery platforms in section 4 of this volume, which in turn underpins the discussion of various age- and stage-specific intervention packages discussed in section 5 of this volume.

IMPLICATIONS FOR PHASES OF DEVELOPMENT

Our current understanding of human development during the first two decades of life suggests that there is a series of phases, each of which is critical to development and each of which requires a different set of interventions to support development and sustain the gains of the previous phases. Table 6.1 attempts to represent this process by dividing the first 20 years of life into five phases of physical, behavioral, and emotional development.

The age ranges selected are indicative and simplified; at the population level the phases will each cover a broader range and they will overlap. Middle childhood arguably begins before age five years, but beginning at age five years helps alignment with formal education practice. Middle childhood is also not entirely separable from adolescence, and for many children incorporates an initial period of juvenility followed by the early beginnings of pubertal processes. Similarly, many of the health risks of middle childhood—especially around infectious disease—persist into early adolescence, so that during the adolescent growth spurt phase the school age and the adolescent packages are both relevant. Finally, the end point at age 20 years is a widely accepted marker of the transition from adolescence to adulthood, hence the social and legal importance of the

Figure 6.2 Indicative Rate of School Enrollment in Low- and Middle-Income Countries



Source: Adapted from World Bank 2011.
Note: ECD = early childhood development; ECE = early childhood education.

Table 6.1 Key Phases of Child and Adolescent Health and Development

Phase	Period	Developmental importance	Examples of interventions	Packages
The First 1,000 Days	Ages 9 months to 2 years	The most rapid growth of body and brain; underpins all subsequent development; highest risk of mortality	Maternal, reproductive, newborn, child health (see volume 2); responsive stimulation	RMNCH (volume 2): Packages on maternal and newborn health and on child health
Middle Childhood Growth and Consolidation	Ages 5 to 9 years	Steady physical growth of body while sensorimotor brain function develops; nontrivial risk of death; some catch-up growth possible	Infection control, diet quality, and promotion of healthy behaviors and well-being	The school-age package
Adolescent Growth Spurt	Ages 10 to 14 years	Rapid physical growth, attaining growth velocities not seen since age 2 years, and rapid growth of centers for emotional development; main phase for remedial catch-up growth	Age-appropriate variants on above, plus vaccination, structured physical exercise, and promotion of healthy emotional development	The school-age and adolescent packages
Adolescent Growth and Consolidation	Ages 15 to 19 years	Consolidation of physical growth and especially of links in the brain; risk-taking behavior associated with socioemotional development; last chance for remedial growth in height	More focus on reproductive health, incentives to stay in school, protection from excessive risk taking, and early identification of mental health issues	The adolescent package

Note: RMNCH = Reproductive, Maternal, Newborn, and Child Health.

twenty-first birthday, but it is now recognized that significant late-stage adolescent changes continue through to the mid-twenties.

Table 6.1 also indicates the packages of interventions that can be developed to respond to the specific needs of each phase of development.

OVERVIEW OF SECTION 2 OF THIS VOLUME

The following chapters in this section expand on the this discussion of intervention and the life course and are based on the conceptual framework illustrated in figure 6.1.

- Chapter 7 in this volume (Alderman and others 2017) examines in more detail the timing of investments and provides equity arguments for investment in those children who were disadvantaged in the investments received before age five years.
- Chapter 8 in this volume (Watkins and others 2017) explores the issue of the irreversibility of early insult by asking whether catch-up is possible for children whose physical or cognitive growth has been limited in the first 1,000 days.
- Chapter 9 in this volume (Viner, Allen, and Patton 2017) explores age-specific adolescent development.
- Chapter 10 in this volume (Grigorenko 2017) provides a more detailed explication regarding brain development.

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Chapter 8

Evidence of Impact of Interventions on Health and Development during Middle Childhood and School Age

Kristie L. Watkins, Donald A. P. Bundy, Dean T. Jamison, Günther Fink, and Andreas Georgiadis

INTRODUCTION

A large literature has highlighted the multifaceted and negative long-term consequences of poor health in early life. The large body of evidence linking adversity in the first 1,000 days of life to later life outcomes has created a major policy shift toward the early years, and it has promoted the idea that the consequences of early insults are irreversible. A longitudinal supplementation study in Guatemala of children ages 0–7 years is frequently cited in support of this argument (Martorell, Khan, and Schroeder 1994). The authors concluded that stunting is a condition that results from events in early childhood and that, once present, remains for life. This view was echoed in *The Lancet* series on maternal and child undernutrition: "Poor fetal growth or stunting in the first two years of life leads to irreversible damage, including shorter adult height, lower attained schooling, reduced adult income, and decreased offspring birthweight" (Victora and others 2008, 340).

The available evidence does indeed support the contention that children with a poor start in life are likely to remain on that low trajectory if nothing else changes: indeed, early investment clearly is important. However, this does not mean that children's experiences in later childhood are not important. From a biological perspective, early programming is plausible, but the same obviously also holds for later life gene-environment interactions. Is it possible for children with positive later childhood experiences to catch up with their peers? If yes, to what extent?

This chapter explores evidence regarding whether interventions in school-age children can affect their later development. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017). The main objective of this chapter is to review the evidence for and against irreversibility: Can interventions after the early years of life help children regain or approach their innate capacity for development? Given that the evidence base for older children is more limited, we do not pursue a systematic review strategy in this chapter, but rather look for specific empirical examples supporting or refuting the idea of lifelong irreversibility; a search for black swans.

CHANGES IN ENVIRONMENT

Changes in environment provide an ideal setting for investigating the irreversibility hypothesis: many children who grow up in poor early life environments move to better environments as a result of migration, adoption, or transfer to different institutional settings. These transitions provide a natural starting point for assessing the potential for catch-up.

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Immigration Studies

One study on immigration found that school-age children who were born in Turkey and then migrated to Sweden were short at first measurement upon immigration but then caught up to achieve heights similar to those of ethnically Turkish children born in Sweden (Mjönes 1987). Similarly, a semilongitudinal study assessed children ages 5–12 years of Chinese, Filipino, Hispanic, and Southeast Asian origins who had migrated to San Francisco (Schumacher, Pawson, and Kretchmer 1987). Upon their arrival, most of the children from the four ethnic groups had mean height and weight between the 5th and 25th percentiles of those of the U.S. population. At follow-up one year later, the median growth rate of most cohorts exceeded that of the U.S. reference, with no differences noted between younger and older children.

Adoption Studies

As Golden (1994) highlighted, immigration studies examine the effect of far-reaching changes to the physical environment of a child, whereas adoption studies examine the effect of a change in the quality of the local or home environment on growth later in life. In general, most adoption studies report anthropometric gains for school-age children—for example, Korean orphans adopted by American families (Lien, Meyer, and Winick 1977; Winick, Meyer, and Harris 1975), Indian girls adopted by Swedish families (Proos, Hofvander, and Tuvemo 1991a, 1991b), and previously abused children taken into foster care or adopted in England (King and Taitz 1985).

Adoption studies offer some of the clearest evidence that improving conditions can reverse the consequences of early childhood deprivation. They also offer evidence that, even if early intervention has been successful, intervention later in life may be necessary to sustain the gains of early intervention. A study in Peru found that children who were treated for severe malnutrition early in life and later adopted were significantly taller at age nine years than were similar children who remained in their original home environments (Graham and Adrianzen 1972). Also in Peru, a unique study (Graham and Adrianzen 1971) admitted children from very poor families to a convalescent unit after birth and maintained them on an optimal diet until an average age of 17.6 months. These children showed initial gains relative to their siblings who did not receive this treatment, but within one year of returning home and through the last measurements at age eight years, there was no significant difference in the heights of the two groups (Adrianzen, Baertl, and Graham 1973; Baertl, Adrianzen, and Graham 1976). These findings suggest that environments promoting growth later in life may be needed to consolidate early gains.

Historical Migration Evidence

Steckel (1987) examined historical data on children brought to the United States as slaves and found that they were initially stunted but grew rapidly through the centiles during adolescence. Similarly, Komlos (1986) examined historical data on students at Hapsburg military schools following the Napoleonic Wars and found that boys who were the sons of poor families and stunted at admission showed sizable catch-up growth, presumably attributable to improved diet and living conditions, once they were admitted to military schools.

SECONDARY STUNTING AND UNDERWEIGHT

Clinical and physiological conditions, such as frequent exposure to diarrhea or worm infections, can be associated with stunting and underweight that are secondary to disease. If the initial effects were irreversible, removing the primary risk factors later in life should not have an impact on growth. However, successful treatment of several conditions has been shown to result in partial or complete catch-up growth for school-age children: celiac disease (Barr, Schmerling, and Prader 1972; Bodé and others 1991; Cacciari and others 1991; Damen and others 1994), growth hormone deficiency (Burns and others 1981; Kemp and others 2005), hypothyroidism (Boersma and others 1996; Pantsiotou and others 1991; Rivkees, Bode, and Crawford 1988), and corticosteroid excess (Davies and others 2005; Prader, Tanner, and von Harnack 1963).

FOOD SUPPLEMENTATION

Studies of food supplementation in school-age children have reported small but significant gains in growth. Kristjansson and others (2007), in a meta-analysis of three randomized controlled trials (RCTs) in low-income countries and lower-middle-income countries (Du and others 2004; Grillenberger and others 2003; Powell and others 1998), reported a small, significant effect of school meals on weight gain (0.39 kilogram), approximately 0.25 kilogram per year factoring in study duration. The review also found a small, nonsignificant effect on height gain (0.38 centimeter).

More recently, the World Food Programme and the World Bank assessed the impact of school feeding programs on anthropometric outcomes in three independent studies in Burkina Faso, the Lao People's Democratic Republic, and Uganda. In Uganda, no significant effects were found on body-mass-index-for-age z-scores or height-for-age z-scores (HAZ) in children

ages 6–13 years (Adelman and others 2008). In Burkina Faso, significant gains were reported in weight-for-age (0.21 standard deviation) for children ages 6–10 years, especially boys (Kazianga, de Walque, and Alderman 2014). In Lao PDR, significant improvements were reported in both height-for-age (0.29 standard deviation) and weight-for-age (0.22 standard deviation) among children ages 3–10 years, although the authors suggested that the nutritional findings were inconclusive because of the complications that arise in stratified analyses (Buttenheim, Alderman, and Friedman 2011).

Kristjansson and others (2007) conducted a meta-analysis of three controlled before-and-after studies of school meals in low-income countries and lower-middle-income countries (Agarwal, Agarwal, and Upadhyay 1989; Bailey 1962; Devadas and others 1979). They found greater weight gains of approximately 0.75 kilogram per year, slightly larger than the impacts found in RCTs (0.71 kilogram). In contrast to the RCT evidence, meta-analysis of the three controlled before-and-after studies found a significant effect on height gain (1.43 centimeters), approximately one-third more than in control groups.

MICRONUTRIENT SUPPLEMENTATION

Micronutrient supplementation and fortification have been found to increase growth at school age. A meta-analysis of 33 zinc supplementation studies in prepubertal children conducted by Brown and others (2002) found significant effects for both weight (0.31 kilogram) and height (0.35 centimeter). In seven of the studies, the mean initial age of the children was greater than five years. Ramakrishnan and others (2004), in a meta-analysis of the effects of vitamin A, iron, and multiple-micronutrient interventions on the growth of children younger than age 18 years, found significant improvements in height and weight with multiple-micronutrient interventions, but not with vitamin A or iron alone. Five multiple-micronutrient interventions were included, two of which were in school-age children and reported significant effects on height and weight (Abrams and others 2003; Ash and others 2003). A systematic review focusing on multiple-micronutrient fortification in school-age children reported mixed effects for height and weight gain (Best and others 2011).

DEWORMING

The ability to detect improved growth as a result of anthelmintic treatment of children is controversial. Much of this controversy is about the interpretation of studies of interventions that treat all children in a community irrespective of their infection status, as discussed in chapters 13 and 29 in this volume (Bundy, Appleby, and others 2017; Ahuja and others 2017, respectively). Here we focus on the observation that effects are generally seen in studies of children who are known to be infected, especially when infection rates are high. For example, deworming of children with intense trichuriasis—which is associated with *Trichuris* dysentery syndrome and severe stunting—results in dramatic catch-up growth (Cooper and others 1995). Similarly, a Cochrane review of the effect of soil-transmitted helminths on growth in children younger than age 16 years found that the three studies that followed up with only those children who had been screened and found to be infected showed a significant mean increase in weight (0.58 kilogram), with no significant difference in height following treatment (Taylor-Robinson and others 2012).

A meta-analysis of 19 RCTs by Hall and others (2008) found that children ages 1–19 years who are treated for intestinal worm infections experience significant improvements in height (9 studies, 0.11 centimeter), weight (11 studies, 0.21 kilogram), HAZ (6 studies, 0.09 standard deviation), weight-for-age z-score (5 studies, 0.06 standard deviation), and weight-for-height z-score (4 studies, 0.38 standard deviation). According to Taylor-Robinson and others (2012), differences in the findings of the two reviews could be due to differences in their protocols.

IMPACT OF INTERVENTIONS AND CATCH-UP GROWTH ON COGNITIVE ACHIEVEMENT AMONG SCHOOL-AGE CHILDREN

Growth- and nutrition-promoting interventions in school-age children have been found to improve learning and cognitive functioning. Although not true for all studies (Gertler and others 2014), several studies on the impact of food supplementation (Cueto, Jacoby, and Pollitt 1998; Muthayya and others 2007), micronutrient supplementation (Soewondo, Husaini, and Pollitt 1989; Zimmermann and others 2006), deworming (Nokes and others 1992), and treatment of growth-hormone deficiencies (Van Pareren and others 2004) on school-age children found that these interventions led to significant improvements in learning and cognitive outcomes.

Evidence from studies using observational data indicates that reversing stunting or achieving catch-up growth among school-age children leads to gains in learning and cognition. Some of these studies used data from the Young Lives child cohort study in Ethiopia, India, Peru, and Vietnam, which follows children from infancy through childhood and adolescence. In particular, the studies by Crookston and others (2013), Crookston and others (2014), Fink and Rockers (2014), and Georgiadis and

others (2016) found evidence that children who experienced higher growth, as measured by the change in HAZ, in early primary school years and in adolescence performed better in reading comprehension, vocabulary, and mathematics tests and were less likely to be over-age for their grade than were children with slower growth across the four countries.

Although this evidence is suggestive, it is not conclusive regarding whether catch-up growth among school-age children leads to improvements in learning and cognitive outcomes.

Two studies used observational data to address this issue and to identify the causal effect on cognitive development of growth during school-age years. The first study is by Glewwe and King (2001), who investigated the impact of growth at different periods (from conception to age two years and from ages two to eight years) on the intelligence quotient (IQ) test score of children from the Philippines. The key finding of this study was that only growth in the second year after birth had a significant and positive effect on IQ test scores. The second study is by Georgiadis (2016), who investigated the impact of higher growth during early primary school years, compared with the period from conception to infancy and from infancy through just before starting primary school, on children's achievement in mathematics and vocabulary tests using data from the Young Lives study. In particular, Georgiadis (2016) compared the test scores of children who experienced different growth in these periods as a result of local weather conditions that, in turn, led to differential exposure to pathogens related to parasitic infection. The methodological approach of this study is based on instrumental variables that produce valid results as long as local weather conditions affect cognitive achievement only by influencing child growth. Georgiadis (2016) presents a range of tests that support this key assumption and thereby the validity of his conclusions. His findings suggest that growth in utero and in infancy and its impact on cognitive development can be reversed through parental promotion of nutrition and cognitive development in school-age years.

CONCLUSIONS

The evidence reviewed in this chapter suggests that the effects of early deprivation do not necessarily persist throughout life, especially if environmental circumstances change. Consistent with Golden's (1994) claim that substantial catch-up growth is possible at school age, we find that trajectories of child growth and cognitive development respond rather strongly to growth-promoting interventions after age two years, as summarized by the evidence in table 8.1. Of course, this does not mean that catch-up growth and improvements in cognitive functioning in school-age children always happen; it just means that there is very little evidence to support the notion that early deficits are irreversible, as concluded in the original work by Golden (1994).

Table 8.1 Findings of Studies on the Possibility of Catch-Up Growth

Study	Source of changed conditions	Description	Quantitative findings
Schumacher, Pawson, and Kretchmer 1987	Immigration	Immigrant children ages 5–12 years with low HAZ were studied upon their arrival in the United States and after one year.	On average, 0.1 standard deviation improvement in HAZ occurred after about one year.
Mjönes 1987	Immigration	The growth of school-age children who were born in Turkey and immigrated to Sweden was compared with the growth of Turkish children born in Sweden.	Immigrant children were short on arrival but caught up to heights of ethnically similar children born in Sweden.
Steckel 1987	Improved diet and lower exposure to infection (inference)	Anthropometric data were analyzed from logs of tens of thousands of American slaves between 1820 and 1860.	As children, slaves were about the first or second centile for height; as late adolescents, they exceeded the 25th centile.
Komlos 1986	Move to boarding school	Anthropometric data were analyzed from students who were born between 1775 and 1815 and who attended Hapsburg military schools.	The boys, who were stunted at admission, exhibited sizable catch-up, potentially attributable to improved diet and living conditions.
King and Taitz 1985	Foster care and adoption	Growth of previously abused children was tracked following (1) long-term placement in foster care or adoption or (2) short-term placement in foster care.	The children experienced significant improvements in both HAZ and WAZ, with the long-term foster care group showing the greatest improvement.

table continues next page

Table 8.1 Findings of Studies on the Possibility of Catch-Up Growth (continued)

Study	Source of changed conditions	Description	Quantitative findings
Abrams and others 2003	Micronutrient supplementation	Children ages 6–11 years were administered a beverage fortified with 12 micronutrients for eight weeks.	The treatment group on average gained 0.17 standard deviation in WAZ, significantly different from the 0.08 standard deviation gain in the control group.
Ash and others 2003	Micronutrient supplementation	Children ages 6–11 years were administered a beverage fortified with 10 micronutrients for six months.	The treatment group on average gained 3.2 centimeters in height, significantly different from the 2.6 centimeter gain in the control group.
Cooper and others 1995	Deworming	Children with intense trichuriasis associated with *Trichuris* dysentery syndrome and severe stunting were dewormed.	Six months after deworming, the children exhibited growth in mean height and weight that was two standard deviations greater than the growth of British children their age.
Stephenson and others 1993	Deworming	Primary school boys in a high-prevalence area were given a single dose of deworming treatment and followed up with four months later.	The treatment group exhibited rapid gain in weight, 1.0 kilogram more than the control group, across the four months of the study.

Note: HAZ = height-for-age z-score; WAZ = weight-for-age z-score.

The significant remaining task is to develop and evaluate a range of interventions, including intensive interventions that can be introduced over time into a policy broader than now exists for reaching disadvantaged children throughout their lifecycle. That many of the studies most relevant to understanding catch-up growth and its implication for cognitive development are now decades old points to the need for revitalizing the research and development agenda.

NOTE

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.

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Chapter 12

School Feeding Programs in Middle Childhood and Adolescence

Lesley Drake, Meena Fernandes, Elisabetta Aurino, Josephine Kiamba, Boitshepo Giyose, Carmen Burbano, Harold Alderman, Lu Mai, Arlene Mitchell, and Aulo Gelli

INTRODUCTION

Almost every country in the world has a national school feeding program to provide daily snacks or meals to school-attending children and adolescents. The interventions reach an estimated 368 million children and adolescents globally. The total investment in the intervention is projected to be as much as US$75 billion annually (WFP 2013), largely from government budgets.

School feeding may contribute to multiple objectives, including social safety nets, education, nutrition, health, and local agriculture. Its contribution to education objectives is well recognized and documented, while its role as a social safety net was underscored following the food and fuel crises of 2007 and 2008 (Bundy and others 2009). In terms of health and nutrition, school feeding contributes to the continuum of development by building on investments made earlier in the life course, including maternal and infant health interventions and early child development interventions (see chapter 7 in this volume, Alderman and others 2017). School feeding may also help leverage global efforts to enhance the inclusiveness of education for out-of-school children, adolescent girls, and disabled persons, as called for in the Sustainable Development Goals (see chapter 17 in this volume, Graham and others 2017).

Although the *Disease Control Priorities* series focuses on low- and middle-income countries (LMICs), evidence from high-income countries (HICs) is included because of the near universality of school feeding and the insights that inclusion can provide as economies develop. For example, the design of school feeding in countries undergoing the nutrition transition[1] may provide some lessons on how to shift from providing access to sufficient calories to promoting healthful diets and dietary behaviors for children and adolescents (WFP 2013).

Agricultural development has increasingly gained attention. It is clear that to enable the transition to sustainable, scalable government-run programs, the inclusion of the agricultural sector is essential (Bundy and others 2009; Drake and others 2016). Accounting for the full benefits of school feeding through cost-effectiveness and benefit-cost analysis is challenging, similar to other complex interventions, but undertaking this accounting is critical for assessing the tradeoffs with competing investments.

This chapter reviews the evidence about how school feeding meets these objectives and provides some indication of costs in relation to benefits. The costs of the intervention are well established; estimates that encompass all the benefits of school feeding are more challenging. The benefits must be quantified and translated to the same unit to allow for aggregation. Moreover, how school feeding interventions are designed and implemented varies significantly across

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countries. Given that delivery of school feeding often involves multiple sectors, common policy frameworks and cross-sectoral coordination are required to achieve maximum benefit (Bundy and others 2009).

Several other chapters in the volume highlight school feeding. These include chapter 11 (Lassi, Moin, and Bhutta 2017), chapter 20 (Bundy and others 2017), chapter 22 (Plaut and others 2017), and chapter 25 (Fernandes and Aurino 2017).

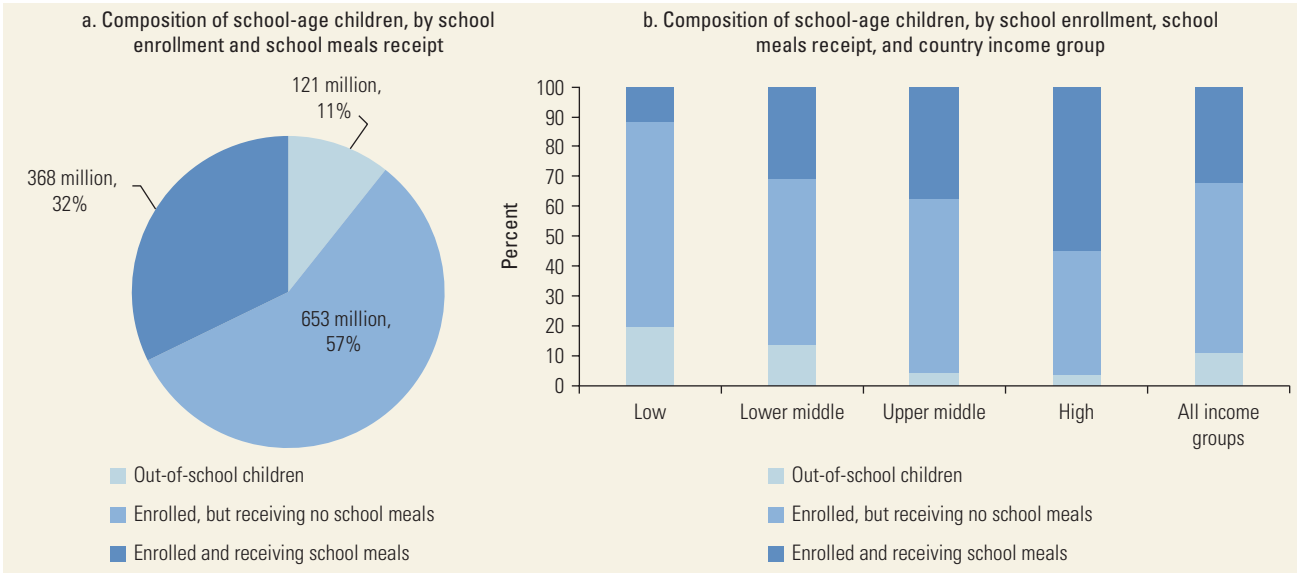
THE GLOBAL PICTURE

Almost all countries practice school feeding (Bundy and others 2009); about one of three primary and lower-secondary schoolchildren benefit, although the number of children varies markedly across countries (figure 12.1). Approximately 18 percent of schoolchildren in low-income countries (LICs) received school meals in 2012, compared with 49 percent in upper-middle-income countries (WFP 2013). On the basis of global estimates of coverage and investment, the authors estimate that an additional investment of US$1.7 billion is needed to support the increase in program coverage in 23 LICs to the levels of upper-middle-income countries—the equivalent of 2 percent to 3 percent of total global investment in school feeding and a 10 percent increase in total beneficiaries.[2] India's Mid-Day Meal Scheme is the largest national school feeding program in the world, serving an estimated 113.8 million children each day (Drake and others 2016). Brazil's national program, the next largest, provides daily meals to more than 43 million children (Drake and others 2016). China's National Nutrition Improvement Plan provided school meals to 33.5 million children ages 7–15 years across China in 2015 (Liu 2016).

School feeding interventions, most notably implementation modalities of delivery, vary across countries. School feeding may include hot meals, biscuits, or snacks provided in school or as take-home rations, where the households of schoolchildren receive a regular commodity ration on meeting conditions, such as regular attendance. School feeding programs vary in targeting. School meals may be provided free and at reduced, subsidized, or full price. Countries that follow a rights-based approach, such as Brazil and India, provide free school meals to all children in certain age groups. In most LMICs, however, free school meals are targeted geographically to areas with high prevalence of food insecurity and poverty, or individually, based on conditions of vulnerability, such as those in orphanages or disadvantaged households (WFP 2013).

School feeding programs have evolved with levels of development. Many HICs, such as the United States, introduced school feeding programs in the first half of the twentieth century as welfare interventions and to support agricultural markets. More recently, countries such as Brazil have systematically incorporated school feeding procurement with agriculture development interventions. In contrast, national school feeding programs in many LMICs were introduced more recently,

Figure 12.1 School Feeding Participation Worldwide



Sources: UNESCO 2014; World Bank 2016.
Note: Primary and lower-secondary schoolchildren only.

with education as the primary objective (Bundy and others 2009) or as a means of social protection in face of crises, given that experience has shown they are relatively easy to scale up during emergencies (Alderman and Bundy 2011). From 2000 to 2012, at least eight LICs launched school feeding programs—six in Sub-Saharan Africa—within the broader framework of the Education for All agenda (WFP 2013). Some of this growth may be due to the inclusion of homegrown school feeding, an approach that sources foods for school meals from local producers or markets, under the food security pillar of the Comprehensive Africa Agriculture Development Programme of 2003 (NEPAD 2003). The number of homegrown school feeding programs has grown steadily in Sub-Saharan Africa since that time (GCNF 2014).

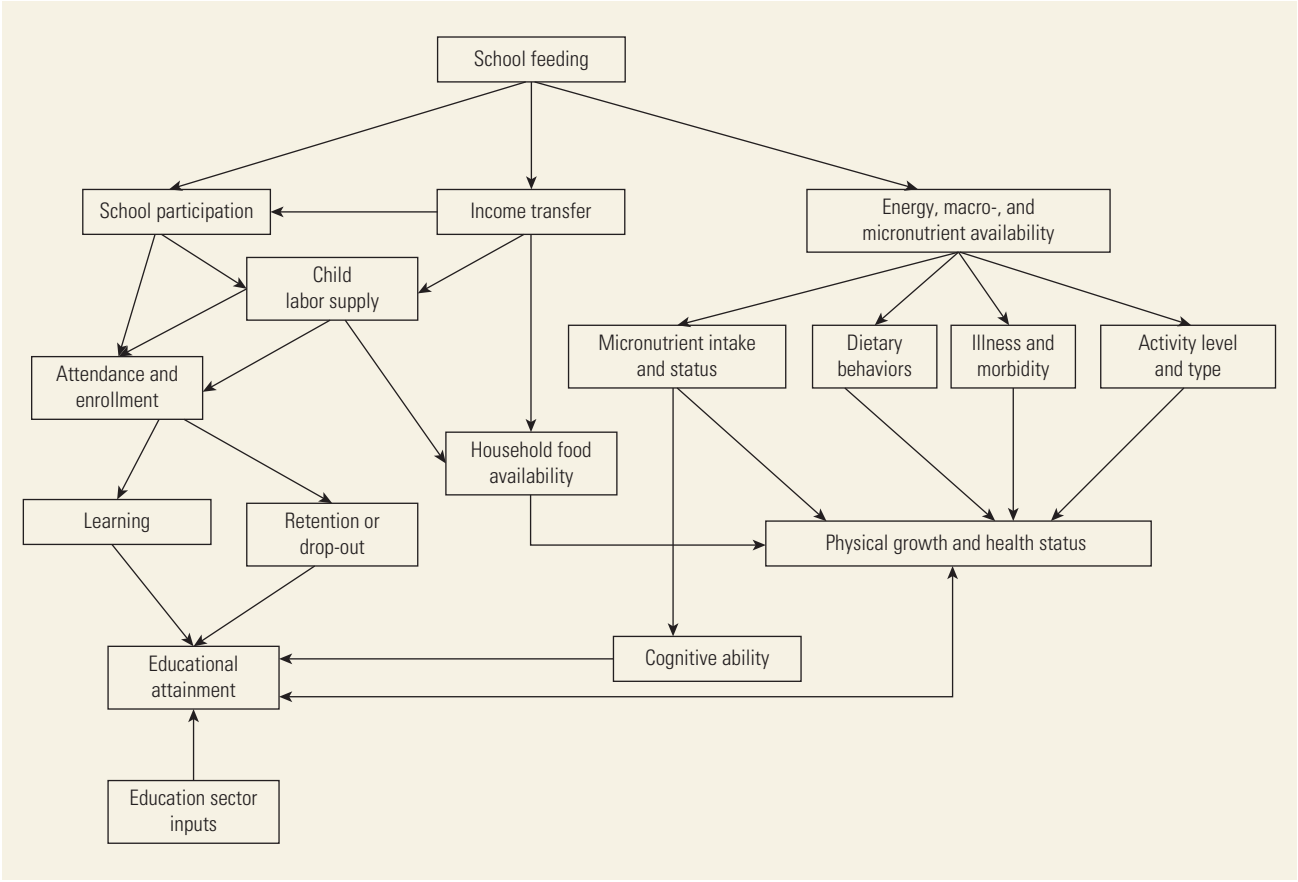
THE EVIDENCE FOR EFFECTIVENESS

This section reviews the large evidence base highlighting the effectiveness of school feeding for multiple outcomes. The evidence suggests that school feeding is a social protection tool that can contribute to education, nutrition, health, and agricultural objectives supporting child and adolescent development (Bundy and others 2009; Jomaa, McDonnell, and Probart 2011). Figure 12.2 presents ways school feeding can affect these outcomes. Homegrown school feeding may also contribute to agricultural development, but not enough evidence exists yet to be incorporated in this review, although box 12.1 presents specific examples.

Design and Implementation Issues

Characteristics such as age, gender, and level of disadvantage may modify the strength of some of these pathways (Kristjansson and others 2009). Moreover, external factors, such as the quality of school inputs, may confound the overall impact of school feeding (Adelman, Gilligan, and Lehrer 2008; Greenhalgh, Kristjansson, and Robinson 2007; Kristjansson and others 2009; chapter 22 in this volume, Plaut and others 2017; Watkins and others 2015). Intervention implementation and study design may also

Figure 12.2 School Feeding Pathways to Shaping Child and Adolescent Development



Source: Adapted from Adelman, Gilligan, and Lehrer 2008.

Box 12.1

Homegrown School Feeding: Supporting Local Agriculture

The O'Meals program in Nigeria (Osun State Elementary School Feeding and Health Programme) is viewed as a means to combat hunger, increase primary school enrollment, and encourage local and statewide economic growth. The program provides hot, nutritionally balanced school meals daily to more than 252,000 primary schoolchildren. At the same time, it provides employment and income to thousands of local caterers, farmers, and traders, which may indirectly improve their health. Recently, the menu replaced yam with the more-nutritious cocoyam, and organizers are investigating the introduction of orange-fleshed sweet potato (Drake and others 2016).

In Ghana, preliminary evidence from an impact evaluation of homegrown school feeding suggests sizable gains with regard to income from sales of produce and increases in farming households' agricultural incomes (Aurino and others 2016).

School Meal Planner, Ghana

Monday	Yam + fish stew + orange
Tuesday	Rice + beans + stew + chicken + orange
Wednesday	Bean porridge + bread + whole egg + banana
Thursday	Rice + egusi garnished with vegetable + chicken + banana
Friday	Cocoyam porridge + vegetable + beef + slice of paw paw

Source: Drake and others 2016.

affect the results. The key issues that can be reflected in the process indicators include consistency of implementation of the intervention over the entire study period, compliance of beneficiaries with the intervention, adequacy of energy transferred, duration of the study, and palatability (Greenhalgh, Kristjansson, and Robinson 2007).

To illustrate this point, table 12.1 presents a selection of parameters for nationally led school feeding programs in 15 countries (Drake and others 2016). Ration design is key, particularly for assessing the quality of the meals and the potential link to local agriculture. The number of school days may enhance the nutritional impact of school feeding, as well as the educational impact, while also influencing the implementation costs.

It is important to understand not only whether school feeding is effective but also the causal chain according to which impact is achieved, which is context specific. This is an important area for further research (Greenhalgh, Kristjansson, and Robinson 2007). More rigorous design evaluations are also needed on government-led school feeding programs, given that the bulk of such evidence is based on school feeding implemented by the World Food Programme (WFP), which may be considerably different. For example, WFP school feeding rations typically include a basic set of foods, such as multifortified corn-soy blend, sugar, and salt, which are internationally procured, in contrast with the rations presented in table 12.1.

Benchmarking School Feeding Programs across Countries

School feeding programs across countries can be benchmarked using the Systems Assessment for Better Education Results (SABER) tool, which is structured around five pillars (Bundy and others 2009; Drake and others 2016):

- Policy frameworks
- Institutional capacity and coordination
- Budget and financing
- Design and implementation
- Community participation.

A national school feeding policy can contribute to sustainability and integration with other policy priorities. Capacity and coordination among relevant institutions

Table 12.1 Government-Led School Feeding Interventions in 15 Countries, Selected Parameters

Country	Income level[a]	Timing	Ration contents	Ration calories	Number of school days	Net enrollment rate, overall (%)	Gender parity index
Botswana	Upper middle	Daily mid-morning hot meal; second meal provided in some districts	Sorghum porridge, stewed canned beef, maize, beans, vegetable oil, bread, milk	572	185	90	0.97
Brazil	Upper middle	Modality varies across states and municipalities	At least 20 percent of daily nutritional needs provided, including three portions of fruits and vegetables	335	200	—	—
Cabo Verde	Lower middle	Hot in-school meal; a glass of milk provided in some schools	Cereals (rice or pasta), beans, oil (vegetable or soya), carrot, fish, Portuguese cabbage	300	—	98	0.92
Chile	Upper middle	Modality varies by age group	Food items vary by vendor but should include meat and fresh fruit and vegetables	850	180	94	0.97
China	Upper middle	Hot meal; mid-morning snacks	Hot dishes include meat and vegetables; snacks include biscuits and bread	810 for meals; 300 for snacks	200	100	0.87
Côte d'Ivoire	Lower middle	Hot meal	Cereals, flours, and legumes	1,141	52	77	0.87
Ecuador	Upper middle	Breakfast meal; milk snack also provided in some schools	Fortified drink composed of wheat flour and soy, granola in flakes, cereal bar, and four types of biscuits	396	—	95	1.00
Ghana	Lower middle	Hot midday meal	Maize, legumes, rice, fish, yams, eggs, groundnuts, vegetables	800	195	76	1.00
India	Lower middle	Hot midday meal	Cereals, pulses, eggs, and fruits	575	200	94	1.03
Kenya[b]	Lower middle	Hot midday meal	Cereals, pulses, vegetable oil, and salt	700	—	82	1.00
Mali	Lower middle	Cooked lunch	Staple foods (millet, sorghum, maize, and rice) with legumes, oil, pulses (such as cowpeas), and meat, fish, or both	735	180	70	0.88
Mexico	Upper middle	Cold or warm breakfast	Skim or partially skim milk, wholemeal cereals, and fresh or dried fruit	395	—	95	1.00
Namibia	Upper middle	Mid-morning meal	Fortified maize meal blend porridge	475	200	86	0.97
Nigeria[c]	Lower middle	Hot midday meal	Includes eggs, fish, and meat	536	—	64	0.92
South Africa	Upper middle	Mid-morning meal	Protein, starch, and a vegetable or fruit	—	182	90	0.95

Sources: Drake and others 2016; World Bank 2016, latest year available for each country.
Note: — = not available. The net enrollment rate is the ratio of children of official school age who are enrolled in school to the population of the corresponding official school age. The gender parity index for gross enrollment ratio in primary education is the ratio of girls to boys enrolled at the primary level in public and private schools.
a. World Bank income level in 2012.
b. School feeding details specific to homegrown school feeding program.
c. Osun State. See box 12.1 for more information about this program.

at the national, regional, and local levels are needed, particularly across different ministries. Channels for financing the program and the implementers, for example, payments to caterers, need to be defined. Communities must be engaged in the program; their contributions, such as firewood, condiments, and meal preparation, may be needed.

Social Protection

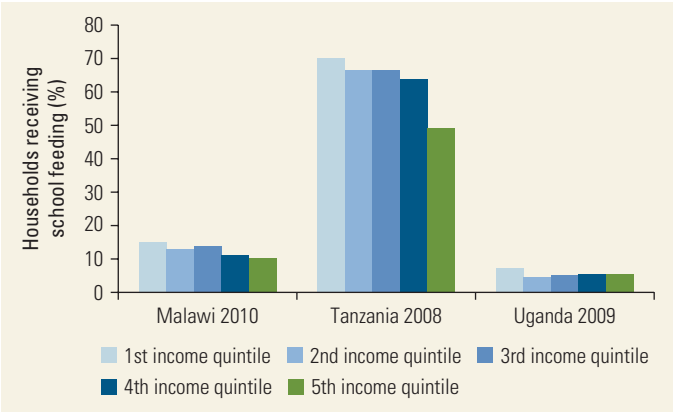
School feeding provides a transfer to households in the value of food distributed (Alderman and Bundy 2011). This transfer can reduce a household's food needs; when provided regularly over the school year, it smooths volatility, thereby increasing disposable income to meet other immediate needs or investments. A range of outcomes is possible, including better nutrition. A quasi-experimental design analysis found that India's school feeding program mitigated the effects of drought on physical growth, which had occurred earlier in the lives of the beneficiaries (Singh, Park, and Dercon 2014). In response to the food and fuel price crises of 2007–08, at least 38 LMICs scaled up school feeding programs, in recognition of its potential as a social safety net (WFP 2013). A global review of social safety net programs found that school feeding was one of the largest in estimated number of beneficiaries (World Bank 2014; also see chapter 8 in this volume, Watkins and others 2017).

Several factors determine the effectiveness of school feeding as a social protection tool. One factor is targeting the poorest and most vulnerable households and communities (Alderman and Bundy 2011). The efficiency of geographic targeting is conditioned by the degree to which poverty and food insecurity are concentrated in one or multiple areas, as well as the smallest geographic unit at which targeting can be applied. Poor accessibility to these areas and insufficient infrastructure to deliver school feeding may present barriers. An evaluation from the Lao People's Democratic Republic (Lao PDR) indicated that, because of similar barriers, only one-half to two-thirds of schools eligible for school feeding in select districts actually received school feeding (Buttenheim, Alderman, and Friedman 2011). Rising urban poverty and income inequality may justify individual or school-targeting approaches, although care must be taken to ensure that food provided in targeted schools does not inadvertently draw students from nearby schools receiving no food. Moreover, individual targeting may be challenging if some children in a classroom receive food while other children do not.

A review of eight social protection programs in Latin America and the Caribbean found that school feeding focused on the most disadvantaged households in most countries. However, in some countries such as Guatemala where the poorest children do not attend school, school feeding was less well targeted (Lindert, Skoufias, and Shapiro 2006). We replicated Lindert, Skoufias, and Shapiro (2006) by using data from Malawi, Tanzania, and Uganda. The share of households in the lowest income quintile were more likely to receive school meals, with the largest population share evident in Tanzania (figure 12.3).

In Ghana, the Ministry of Employment and Social Welfare, in a review of targeting in the national school feeding program in 2010, found that higher investment was not consistently made in districts with greater poverty and food insecurity (WFP 2013). The program was retargeted in 2012.

Figure 12.3 Targeting Efficiency of School Feeding in Malawi, Tanzania, and Uganda



Source: Analysis based on the Atlas of Social Protection: Indicators of Resilience and Equity, World Bank.

Education

School feeding can promote access to education, as measured by indicators such as enrollment, attendance, and retention (Krishnaratne, White, and Carpenter 2013). Evidence for these links helped identify school feeding as a means for contributing to the Millennium Development Goal 2 of universal enrollment in primary education. Given the links between nutrition status and cognition, school feeding programs, if integrated with interventions to improve education quality, can also contribute to learning and academic achievement (Adelman, Gilligan, and Lehrer 2008; Krishnaratne, White, and Carpenter 2013). Moreover, school feeding may directly or indirectly reduce gender disparities in education outcomes. The following section reviews the evidence, giving greater weight to systematic reviews

and studies with rigorous designs, such as randomized controlled trials.

Access to Education

A review of rigorously designed studies indicated a standardized effect size of 0.156 for enrollment ($p < 0.05$, three studies), 0.449 for drop-out ($p < 0.001$, two studies), and 0.690 for progression ($p < 0.001$, one study) (Krishnaratne, White, and Carpenter 2013). The review did not find statistically significant effects on attendance and learning, although the coefficients were positive (Krishnaratne, White, and Carpenter 2013). In addition to providing an incentive to attend school, evidence indicates that school feeding reduces absenteeism. A review of studies from multiple LMICs found that school feeding was associated with an average of four to six more days attendance at school per year (Kristjansson and others 2009).

The choice of modality may also play an important role. For example, Afridi, Barooah, and Somanathan (2014) showed that monthly attendance increases in response to a switch to a cooked meal from snacks, with modest increases in the state budget in India. Fortified biscuits in Bangladesh improved school enrollment by 14.2 percent, reduced the probability of drop out by 7.5 percent, and raised attendance by about 1.3 days a month (Ahmed 2004). Adelman, Gilligan, and Lehrer (2012) in Northern Uganda, and Kazianga, de Walque, and Alderman (2009) in Burkina Faso found that both school meals and take-home rations effectively increased enrollment. Ahmed and del Ninno (2002) showed that take-home rations for poor households in rural Bangladesh increased school access, with an 8 percent increase in school enrollment and 12 percent increase in attendance.

Moreover, the evidence suggests that school feeding can mitigate gender disparities in school enrollment where girls face greater barriers (Gelli, Meir, and Espejo 2007). In particular, the provision of take-home rations to girls can represent a significant income transfer to households, outweighing the forgone benefits of nonattendance (Bundy and others 2009). The WFP experience suggests that making provision of take-home rations conditional on attendance rates of more than 80 percent was effective, especially in low-resource communities where child labor is common (WFP 2013). In Burkina Faso, the provision of school meals or monthly take-home rations of 10 kilograms of cereal flour conditional on a 90 percent attendance rate increased the enrollment of girls ages 6–12 years by about 6 percent (Kazianga, de Walque, and Alderman 2014).

Learning and Academic Achievement

A smaller but still substantial body of evidence explores the impacts of school feeding on learning and academic achievement. Although some indications of a positive relationship have been documented, other studies have not found statistically significant results. The mixed findings may be due to several factors, including differences in school quality. These differences are consistent with other types of schooling interventions, for which evidence on what works is inconclusive (Glewwe and others 2013).

In Chile, more frequent consumption of dairy products improved education outcomes for primary and secondary students (WHO 1998). Preliminary evidence from Ghana suggests improved learning outcomes for girls in schools where micronutrients were given in the meals. The improvements related to literacy (14 percent), mathematics (13 percent), and reasoning ability (8 percent) (Aurino and others 2016). Other studies, in contrast, have found minimal to no impact of school feeding on academic achievement. Timing of delivery of the feeding and overall learning environments can contribute to explaining the inconsistency of evidence related to school feeding and academic achievement (Powell and others 1998; Vermeersch and Kremer 2004). For instance, Vermeersch and Kremer (2004) attribute their negative finding to the disruptive role of school feeding in the school day, whereas the positive outcome from Powell and others (1998) may be due to the timing of the program (just before the school start). In addition, Chang and others (1996) found that school feeding was associated with improved on-task behaviors in well-organized classrooms but not in disorganized classrooms.

Table 12.2 presents overall average estimates for the impact of school feeding on educational outcomes

Table 12.2 Summary of Educational Impacts of School Feeding

	Overall weighted average effect	Number of studies
Access to schooling		
Enrollment	0.14	7
Attendance	0.09	6
Drop-out	–0.06	3
Completion	0	2
Learning outcomes		
Language arts scores	0.09	8
Math scores	0.10	10
Composite test score	0.14	3

Source: Snilstveit and others 2015.
Note: Weighted average effects are based on the Cohen's index and were estimated based on the standardized mean differences calculated from individual studies. These effects reflect the estimated change in percentile rank for an average student in the control group had he or she received school feeding.

drawing from a systematic review of studies with rigorous design undertaken in LMICs between 1990 and 2015 (Snilstveit and others 2015). These studies primarily included randomized controlled trials, as well as quasi-randomized trials, with adjustments for nonrandom selection to groups such as propensity score matching or regression discontinuity design. Standardized effect sizes were estimated for individual studies, and meta-analysis was used to obtain overall estimates.

Nutrition

The World Health Organization recommends that school feeding programs contribute 30 percent to 45 percent of the recommended daily allowance of energy and nutrients for half-day schools, and 60 percent to 75 percent for full-day schools (WHO 1998). HICs, including Chile, Mexico, the United Kingdom, and the United States, have introduced nutrient-based standards in school feeding programs to enhance the contribution of school meals to recommended dietary intake. Nutrient-based standards are less common in LMICs, however, with the exception of India (Drake and others 2016). A review of national school feeding programs in 12 LMICs indicated that many seek to provide more diversified food baskets that include fresh produce, although this objective is often only aspirational (Aliyar, Gelli, and Hamdani 2015).

School feeding may help children and adolescents receive sufficient nutrients and grow. The inclusion of micronutrient-rich foods or powders may address anemia and support improved cognition (Abizari and others 2012; Abizari and others 2014; Finkelstein and others 2015). School meals may also foster understanding of healthy diets and behaviors that can extend beyond school and throughout life, particularly if nutrition education is incorporated into the program (Kubik and others 2003; Story, Neumark-Sztainer, and French 2002).

However, counteracting factors may weaken these relationships. For example, households may allocate food to siblings not receiving the school meals, possibly offsetting the impact of school feeding on the nutritional status of the target child. Studies analyzing this issue show, nevertheless, that overall energy intake increases almost as much as the transfer provided at school—the flypaper effect (Afridi 2010; Ahmed 2004; IFPRI 2008; Jacoby 2002). In addition, Jacoby (2002) and Ahmed (2004) have shown that children who received snacks shared them with their younger siblings. Few studies have tracked the nutritional status of siblings too young to attend school, however, although Adelman, Gilligan, and Lehrer (2012) and Kazianga, de Walque, and Alderman (2014) have shown that take-home rations improved weight-for-age by 0.4 standard deviations for the younger siblings of the beneficiaries compared with control groups.

Nutrient Adequacy

Evidence suggests that school feeding can be effective in promoting macronutrient and micronutrient adequacy in the diet (Jomaa, McDonnell, and Probart 2011). For food supplementation programs, evidence from a randomized controlled trial in Kenya showed that the inclusion of meat or milk in the school feeding menus improved plasma vitamin B_{12} concentrations. No other measures of micronutrient status were affected, however, probably because of concurrent incidence of malaria or other infectious diseases (Jomaa, McDonnell, and Probart 2011; Siekmann and others 2003). In a quasi-randomized study, Afridi (2010) found that in the state of Andhra Pradesh in India, the Mid-Day Meal Scheme eliminated daily protein deficiency and decreased calorie deficiency by almost 30 percent and daily iron deficiency by nearly 10 percent (Afridi 2010). Regarding efficacy, Best and others (2011) reported in a review that micronutrient supplementation increased micronutrients and reduced anemia more than supplementation of a single micronutrient or no supplementation.

In 8 out of 10 studies reviewed in Best and others (2011), school feeding raised serum concentrations of iron, iodine, vitamin A, and vitamin B, while improving hemoglobin levels. Two studies identified increased levels of zinc (Nga and others 2009; Winichagoon and others 2006). The impact of school feeding on micronutrient status may depend on the dose, initial micronutrient status, and interactions with other micronutrients supplemented. The iron status of Kenyan schoolchildren was associated with the dosage of iron-fortified flour (Andang'o and others 2007), while a randomized controlled trial in Vietnam showed that only multifortified biscuits reduced anemia more than iron supplementation, which suggests that other micronutrients affect anemia status (Hieu and others 2012).

Food-based strategies in school feeding programs can effectively address micronutrient deficiencies. The introduction of orange-flesh sweet potato in meals, for example, improved vitamin A status in South Africa (van Jaarsveld and others 2005), while consumption of carotene-rich yellow and green leafy vegetables improved vitamin A and hemoglobin concentration and decreased anemia rates in Filipino schoolchildren (Maramag and others 2010). The incorporation of locally available, micronutrient-rich

foods may also promote local agriculture. Homegrown school feeding programs follow this approach (box 12.1). A survey of 36 LMICs (mostly Sub-Saharan African) indicated that national sourcing (local purchasing) resulted in the inclusion of more diverse and fresh foods (GCNF 2014).

Last, mixed approaches that combine food supplementation and micronutrient supplementation or food fortification can also promote nutrient adequacy. In Northern Uganda, school meals and take-home rations were found to reduce anemia prevalence in girls ages 10–13 years by 17 to 20 percentage points (Adelman, Gilligan, and Lehrer 2012). In contrast, impacts on anemia were not detected in randomized controlled trials from Burkina Faso and Lao PDR, where the rations did not include multifortified foods (Buttenheim, Alderman, and Friedman 2011; Kazianga, de Walque, and Alderman 2014). The success of these approaches critically depends on the regularity of the supplementation throughout the school year.

Nutrition and Cognition

A large body of literature shows the links between malnutrition, including micronutrient deficiencies, and poor cognition (Glewwe and Miguel 2008; Grantham-McGregor and Ani 2001). In this area, studies have focused on how school feeding can promote cognitive skills such as better attention and short-term memory by reducing deficiencies in iron and other micronutrients. One randomized controlled study found that regular provision of fortified biscuits improved the micronutrient status and cognitive function of children (van Stuijvenberg and others 1999). Two randomized controlled studies from Kenya found that the inclusion of animal source foods improved cognition and child learning, although the magnitude of effects were small (Neumann and others 2003; Whaley and others 2003). Afridi, Barooah, and Somanathan (2013) found that the provision of free meals increased student effort, as measured by their performance in solving puzzles of increasing difficulty, in India.

The timing of the meal may be important. Breakfast programs may support cognitive function during school hours, especially for children who had previously skipped breakfast. Findings from two rigorous studies suggest that eating breakfast improves on-task time (amount of time spent focused on the school activity) and attention (Bro and others 1994; Bro and others 1996). A universal, free breakfast program in Boston public schools in the United States improved school attendance and math achievement, and decreased days tardy for children at nutritional risk as assessed in a pre-post study during a six-month period (Kleinman and others 2002). Nutritional risk in this study was defined as less than 50 percent of the recommended daily allowance of total energy intake or of two or more micronutrients, or both. A study from Mexico found that children in schools participating in a school breakfast program had higher response speed and memory compared with children from nearby schools that did not participate in the program (Vera Noriega and others 2000). A review did not find that the timing of meal delivery affects cognition, although one study from Israel did find that children performed better shortly after a meal (Vaisman and others 1996).

Anthropometry and Nutrition

A Cochrane review on school feeding (Kristjansson and others 2009) conducted a meta-analysis of three randomized controlled trials in three LMICs: Jamaica (Powell and others 1998), Kenya (Grillenberger and others 2003), and China (Du and others 2004). The meta-analysis found a small yet significant effect on weight (0.39 kilogram, 95 percent confidence interval 0.11, 0.67) and a small nonsignificant effect on height gain (0.38 centimeters, 95 percent confidence interval –0.32, 1.08). The three school feeding programs differed greatly in modality of implementation and target population. In the Jamaica study, 395 children in grades 2–5 were given breakfast for a year (Powell and others 1998). In Kenya, grade 1 schoolchildren were given meat, milk, or an energy supplement for 18 months (Grillenberger and others 2003). In China, the study focused on girls age 10 years who received milk supplementation (Du and others 2004). A more recent review (Watkins and others 2015), which broadened the inclusion criteria by considering studies such as controlled before-and-after studies, found that school feeding had significant effects on weight and height gain.

Micronutrient supplementation and fortified foods delivered through school feeding programs may also affect nutrition outcomes of children. Best and others (2011) reported that 10 studies found that school meals with micronutrient supplementation had statistically significant impacts on micronutrient status even after controlling for baseline status. Findings from several controlled before-and-after studies suggest that micronutrient supplementation may also have statistically significant impacts on height and weight. Table 12.3 summarizes the evidence.

Dietary Behaviors

Schools and school feeding programs, through nutrition education, can serve as a platform for shaping behaviors and food preferences for healthier nutrition

Table 12.3 Summary of Nutrition and Cognitive Impacts of School Feeding

School feeding activity	Anthropometric Status		Micronutrient Status						Cognition
	Height or stunting	Weight or underweight	Iron	Hemoglobin or anemia	Iodine	Vitamin A	Zinc	B vitamins	
In-school meals	+++	+++	+	++	n.a.	+	+	+	+++
Take-home rations	++	++	—	+	n.a.	—	—	—	++
Multiple micronutrient fortification	++	++	+++	+++	+	+++	+++	+	++
Multiple micronutrient powder	++	++	++	++	+	++	++	+	++

Source: Watkins and others 2015.
Note: RCT = randomized controlled trial.
n.a. = not assessed by an RCT; + = evidence from one RCT; ++ = evidence from two RCTs; +++ = evidence from more than two RCTs; — = lack of any evidence.

(Hawkes and others 2015). The development of healthy dietary habits during childhood can also help prevent diet-related diseases later in life, with the evidence showing that dietary habits tend to be persistent from childhood through adulthood (Dunn and others 2000). Dietary diversity may provide an indicator of better diets among children and adolescents. The inclusion of animal-source foods in school snacks increased dietary diversity in Kenya (Murphy and others 2003).

Encouraging lifelong healthy diet choices has so far received more attention in HICs; however, it is increasingly relevant in LMICs, where childhood overweight and obesity are increasing (Lobstein and others 2015). Some studies conducted in HICs found a positive association between school meals and overweight and obesity (Schanzenbach 2009). Others suggest instead that programs targeted to primary-school-age children most effectively reduced obesity, especially when healthy meals were accompanied by communication promoting behavioral change (Corcoran, Elbel, and Schwartz 2014). Initiatives at school that combine healthy eating and active living have been introduced in HICs to support child and adolescent development (De Bourdeaudhuij and others 2011; Herforth and Ahmed 2015; Story, Nanney, and Schwartz 2009). Similar action in LMICs may be needed to respond to the nutrition transition (Faber and others 2014).

Communication materials aimed at changing behavior, alongside school meals, can help inculcate these ideas in schoolchildren and influence household diet. For example, radio jingles and posters were developed in Ghana to complement initiatives undertaken in the Ghana School Feeding Programme to improve nutrition among children, adolescents, and their communities (Gelli and others 2016). Evidence on the impact of nutrition education is scant, particularly in developing countries, and more research is needed.

Agriculture

Initial evidence has shown that home-grown school feeding can change the eating preferences of households, improve community incomes, support smallholder production, and facilitate better market access. Thereby, it has an impact on rural economies. The impact on rural investments and agricultural development has increasingly gained attention through links to the school feeding market. It is also clear that to enable the transition to sustainable, scalable government-run programs, the inclusion of the agricultural sector is critical (Bundy and others 2009; Drake and others 2016).

Initial evidence has shown that homegrown school feeding can not only change eating preferences of households, community incomes, and smalholder production and market access, but can also benefit smallholder farmers and investments in rural economies.

Preliminary findings from an impact evaluation in Ghana show a 33 percent increase in agricultural sales and a strong increase in household income in interventions in which homegrown school feeding is implemented (Aurino and others 2016). However, it is clear that rigorous evidence regarding the impacts that school feeding has on employment and income in the agricultural sector needs to be reinforced (Aurino and others 2016; Drake and others 2016; GCNF 2014; Masset and others 2012).

The following issues need further exploration:

- Transparency in price and payment is key for smallholder trust.
- Timely access to price, quality, and quantity information enhances operational efficiencies of aggregators and market systems.

- Adaptation of quantity and quality requirements and effective communication on them can ease the transition to supplying structured markets.
- The mobile phone platform can allow easier aggregation and management of commodities despite the short period of aggregation.

WEIGHING THE COSTS AGAINST BENEFITS: AN ECONOMIC ASSESSMENT OF SCHOOL FEEDING

This section reviews the literature on quantifiable costs and benefits for an overall assessment of the economics of school feeding. Three issues are particularly salient:

- The heterogeneity in the design and implementation of school feeding interventions across countries underscores the need for standardization when possible. A comparison of costs with benefits is essential for any economic assessment of school feeding or modification to the intervention. For example, retargeting school feeding to the most disadvantaged areas, or shifting from geographic to individual targeting, may reach disadvantaged populations more efficiently.
- Such changes may also entail significant monetary and other costs, including resistance from local government officials whose districts will no longer receive the intervention, or risk of stigma that children and adolescents may experience for receiving free or reduced-price meals if the program is not designed to mitigate that risk.
- Some important drivers of costs may be outside the scope of the intervention, such as global food prices or poor road conditions.

Costs of School Feeding

Costs of school feeding include costs associated with procuring food, transportation and storage, and staff time to monitor program implementation. Some programs hire cooks or caterers to prepare meals; others rely on community volunteers. Communities may provide other, in-kind contributions, such as fresh fruit or vegetables, fuel, condiments, and utensils. The provision of multifortified biscuits and take-home rations entails costs in staffing and delivery. Efficiencies may be gained through integrating school feeding with other school health interventions, such as water, hygiene and sanitation, or deworming (Azomahou, Diallo, and Raymond 2014).

Modality is a key determinant of school feeding costs. On average, school meals, biscuits, and take-home rations cost US$27, US$11, and US$43, respectively, per child per year (Gelli and others 2011). The differences are driven largely by differences in meal size or modality of the transfer; take-home rations cost more because they provide an additional transfer to the household beyond the food delivered in school.

Significant variation in cost is also evident across countries. Drawing from a sample of 74 low-, middle-, and high-income countries, school feeding costs an average of US$173 per child per year, ranging from US$54 in LICs to US$82 in middle-income countries and US$693 in HICs (Gelli and Daryanani 2013). These estimates are standardized for several parameters to support cross-country comparability, including the number of kilocalories in the ration and the number of days school feeding was provided. Food costs were typically the largest component, accounting for more than half of total program costs (Galloway and others 2009; Gelli and others 2011).[3] Although the contributions of communities are not usually reflected in these estimates,[4] they are estimated to be about 5 percent of total cost in LICs, or about US$2 per year (Galloway and others 2009).

The benchmarking of school feeding costs as a percentage of primary school education costs can also support comparability across countries. As table 12.4 shows, school feeding costs become a smaller proportion of primary education costs as the income level of the country increases. For LICs, the share is 68 percent, compared with 19 percent for MICs and 11 percent for HICs.

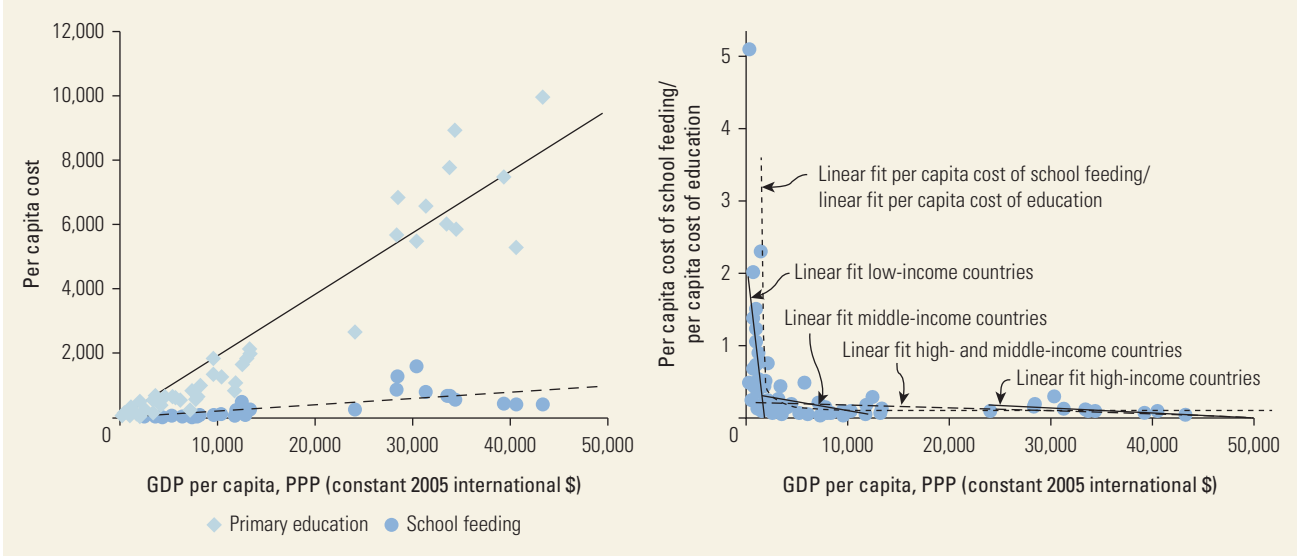
As gross domestic product increases, the per capita cost of primary school education increases more rapidly than the per capita cost of school feeding, which drives this finding (figure 12.4) (Bundy and others

Table 12.4 School Feeding Costs in 74 Countries

Income level of country	Total cost (US$)	Share of per capita cost of primary education (%)
Low (n = 22)	54	68
Middle (n = 40)	82	19
High (n = 12)	693	11
Total (n = 74)	173	33

Source: Gelli and Daryanani 2013.
Note: n = number of observations.

Figure 12.4 School Feeding and Primary Education Costs per Child per Year



Sources: Bundy and others 2009; Gelli and Daryanani 2013.
Note: GDP = gross domestic product; PPP = purchasing power parity.

2009; Gelli and Daryanani 2013). The high cost of school feeding relative to education is notable, particularly in LICs.

Assessing Costs against Benefits

This section reviews the cost of school feeding by output and outcome. For output, figure B12.2.1 presents the cost of delivering 30 percent of the recommended daily allowances of key micronutrients in 12 countries based on school feeding menus (Drake and others 2016). The composition of school meals varies widely, and diversification may lead to higher costs. Some studies have found positive effects on anthropometric indicators from meat or milk in the meals (Du and others 2004; Grillenberger and others 2003). However, LICs are unlikely to be able to sustain the higher costs of meat, and possibly milk, in meal programs. As economies develop, these food items can be gradually introduced and governments might be able to use schools to encourage the development of dairy sectors. Bangladesh, Rwanda, and Vietnam are encouraging these links through their school feeding programs.

For decentralized programs, setting the appropriate reimbursement rate to meet recommended nutrient levels is critical (Parish and Gelli 2015). Tools such as the School Meals Planner can support the design of costed menus that incorporate nutrient-rich foods (box 12.2). The addition of supplements such as micronutrient powders to school meals may also increase cost efficiency relative to nutrient content. In Ghana, the provision of micronutrient powders in school meals costs only an estimated additional US$2.92 per child for the entire school year (Stopford and others, forthcoming).

Estimation of the overall cost-effectiveness of school feeding is complicated by the multiple benefits of the intervention and the need to transform the units of different outcomes into the same unit. To simplify the problem, school feeding can be viewed as increasing the quantity and quality of education obtained, with improved nutrition outcomes contributing to quality (Gelli and others 2014). Capturing both education and nutrition outcomes in such calculations is critical for comparisons with other interventions, such as conditional cash transfers,[5] as well as direct schooling investment. Compared with conditional cash transfers, school feeding has high nontransfer costs of approximately 20 percent to 40 percent (Bundy and others 2009).

Previous studies (Jamison and Leslie 1990; Schuh 1981) have hypothesized that the benefit-cost of school feeding programs are attractive. A recent systematic review and meta-analysis (Snilstveit and others 2015) found that school feeding had significant effects on school attendance equivalent to an additional 8 days attended. There were also effects in the expected direction on improving enrollment, decreasing dropout, and improving various measures of attainment

Box 12.2

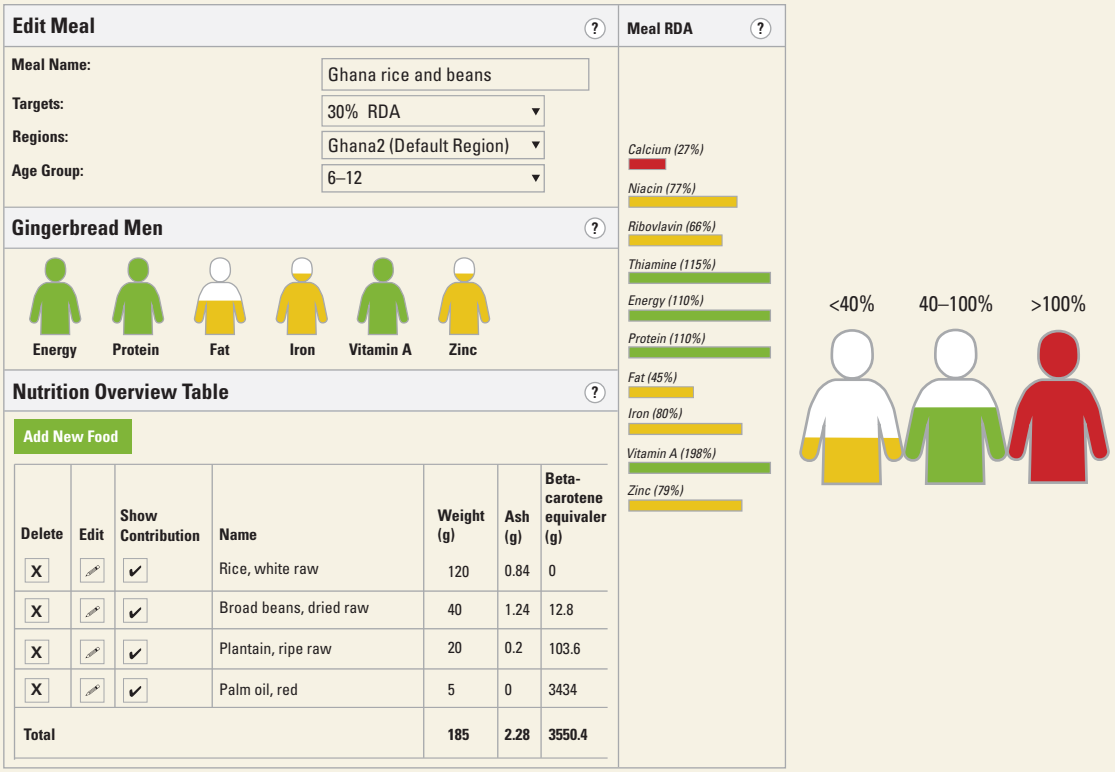
School Meals Planner

The School Meals Planner software and accompanying materials were developed in response to demand from governments to support the design of nutritious, well-balanced meals for homegrown school feeding programs.

The tool is a user-friendly dashboard that helps planning officials who may not be nutritionists (figure B12.2.1). It was adapted to Ghana and tested during the 2014/15 school year. Food composition tables and nutrition recommendations specific to Ghana were developed through high-level political engagement. Officials from 42 districts located across the 10 regions of Ghana designed menus using the School Meals Planner. These menus reached more than 320,000 children.

A set of handy calibrated measures was provided to each school caterer to ensure provision of food quantities listed on the menus. A communication campaign sensitized schools and communities to the health and broader developmental benefits of locally grown, healthy diets.

Figure B12.2.1 The School Meals Planner



Source: Fernandes and others 2016.
Note: RDA = recommended daily allowance.

(cognitive scores, maths scores, and language arts scores), although none of these was significant. Higher school attendance, in turn, has returns in higher wages upon graduation, and the returns to education in Sub-Saharan Africa are high. Fernandes and Aurino (2017, chapter 25 in this volume) estimate the benefit-cost of the effect of attendance as around 3 for low-income countries, and around 7 for lower-middle-income countries. If there are additional effects of improved cognition, the returns could be even higher.

CONCLUSIONS

School feeding is commonly implemented across low-, middle-, and high-income countries; however, there is significant variation driven by context to a large degree. The research most strongly indicates that school feeding has social protection and educational benefits; more recent studies have explored its nutritional benefits.

School feeding can serve to protect earlier investments in child welfare, buffering the effects of early shocks and contributing to the continuum of interventions from childhood through adolescence and into adulthood. Furthermore, school feeding also has the potential to address emerging issues such as the nutrition transition and could be integrated with other school health interventions, such as deworming, for greater impact.

Homegrown school feeding can not only change eating preferences of households, improve community incomes, and smalholder production and market access, but can also benefit investments in rural economies and contribute to national food security.

Much still needs to be learned about the barriers to these potential benefits. The costs of school feeding vary significantly across countries. An economic modeling exercise indicates that the returns to greater quantity and quality of education are a primary contributor to benefits. Future research is needed on the quantification of benefits to ensure more valid comparisons with other interventions.

NOTES

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. The nutrition transition is the rapid transition in LMICs from traditional diets rich in cereals and fiber to westernized diets high in fat, sugars, and animal-source food.
2. Calculation by authors using data from WFP (2013).
3. One study estimated that commodities contributed 57 percent to overall costs (Galloway and others 2009). Gelli and others (2011) found that commodity costs were, on average, 58 percent of total costs, and were highest for take-home rations and biscuit programs (68 percent and 71 percent, respectively).
4. Gelli and Daryanani's (2013) study is an exception because the authors were able to calculate projections for community contributions, where relevant.
5. The value of increased equity in both school feeding and conditional cash transfers is a benefit that is often part of the design but not one that is easily quantified (Alderman, Behrman, and Tasneem 2015).

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Chapter 13

Mass Deworming Programs in Middle Childhood and Adolescence

Donald A. P. Bundy, Laura J. Appleby, Mark Bradley, Kevin Croke, T. Deirdre Hollingsworth, Rachel Pullan, Hugo C. Turner, and Nilanthi de Silva

INTRODUCTION

The current debate on deworming presents an interesting public health paradox. Self-treatment for intestinal worm infection is among the most common self-administered public health interventions, and the delivery of donated drugs through mass drug administration (MDA) programs for soil-transmitted helminths (STHs) exceeds 1 billion doses annually. The clinical literature, especially the older historical work, shows significant impacts of intense STH infection on health; a burgeoning economics literature shows the long-run consequences for development (see, for example, chapter 29 in this volume, Ahuja and others 2017; Fitzpatrick and others 2017). Yet, the literature on clinical trials shows conflicting results, and the resulting controversy has been characterized as the *worm wars*.

The two previous editions of *Disease Control Priorities* contain chapters on STH and deworming programs (Hotez and others 2006; Warren and others 1993). Much of the biological and clinical understanding reflected in those chapters remains largely unchanged. This chapter presents current estimates of the numbers infected and the disease burden attributable to STH infections to illuminate current program efforts, advances in the understanding of epidemiology and program design, and the controversy regarding the measurement of impact. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017).

ESTIMATED NUMBER OF INFECTIONS AND DISEASE BURDEN

Three types of STH commonly infect humans: roundworm (*Ascaris lumbricoides*), hookworm (comprising two species, *Ancylostoma duodenale* and *Necator americanus*), and whipworm (*Trichuris trichiura*). Recent use of geographic information systems and interpolated climatic data have identified the distributional limits of STHs on the basis of temperature and rainfall patterns as well as socioeconomic factors (Pullan and Brooker 2012). Globally, in 2010 an estimated 5.3 billion people, including 1 billion school-age children, lived in areas stable for transmission of at least one STH species; 69 percent of these individuals lived in Asia.

Map 13.1 is based on clear limiting relationships observed between infection and climatic factors for each species. For example, experimental and observational findings suggest that transmission is implausible in extremely hot, arid, or cold environments, particularly in Africa and the Middle East (Brooker, Clements, and

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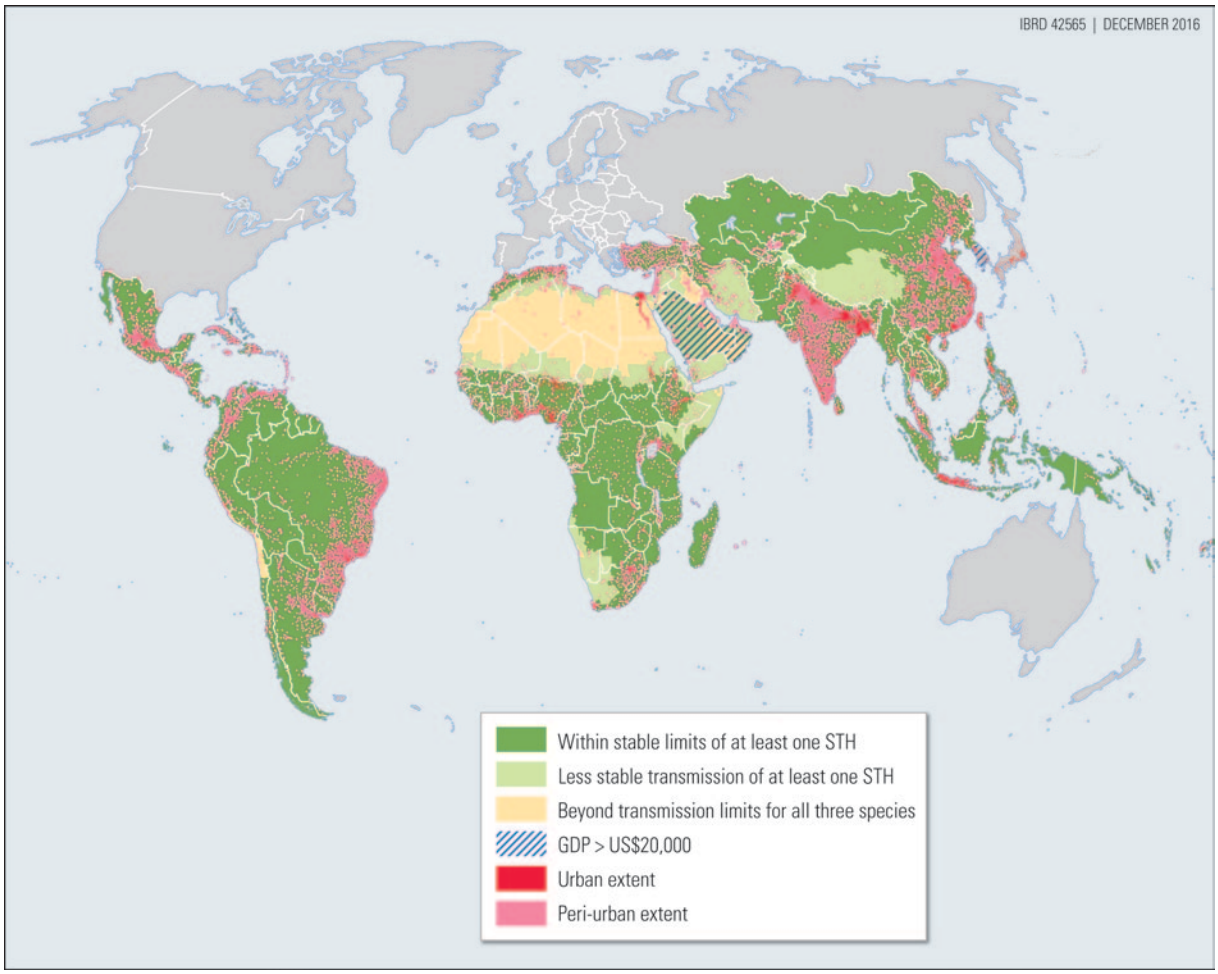
Map 13.1 Distribution of Soil-Transmitted Helminth Infection Risk, Applying Climatic Exclusion Limits



Source: Adapted from Pullan and Brooker 2012.
Note: Analysis includes only regions considered endemic for STHs. GDP = gross domestic product; STH = soil-transmitted helminth.

Bundy 2006; Brooker and Michael 2000; Pullan and Brooker 2012). Relationships are less clear in Asia, especially for roundworm, for which positive survey data exist even in extremely hot and arid regions of India and Pakistan, perhaps because resistant transmission stages allow for seasonal transmission in environments otherwise hostile for much of the year.

Several attempts have been made to estimate worldwide prevalence of STHs since the first estimates assembled by Norman Stoll in the seminal paper titled "This Wormy World" (Stoll 1947); this section provides revised estimates of the burden of disease for STHs in 2013. The number of persons infected with STHs is generated by applying the revised estimates from 2010 (Pullan and others 2014) to age-stratified population estimates for 2013. These estimates build on a modeling framework that exploits relationships between infection prevalence, intensity, and potential morbidity originally proposed by Chan and Bundy (1999) for use in the first Global Burden of Disease study (Chan 1997). In brief, the age-stratified mean prevalence was estimated for all endemic regions at subnational scales. The approach used to map the mean prevalence of infection within the boundaries of transmission differed by region, determined by the progress in control, environmental associations, and data availability considerations. For Asia, Latin America and the Caribbean, the Middle East and North Africa, and Oceania, empirical estimates were generated directly from the data. For countries within Sub-Saharan Africa—where detailed data were lacking for several countries but where relationships between infection patterns and environmental factors were clearer—a geostatistical space-time modeling

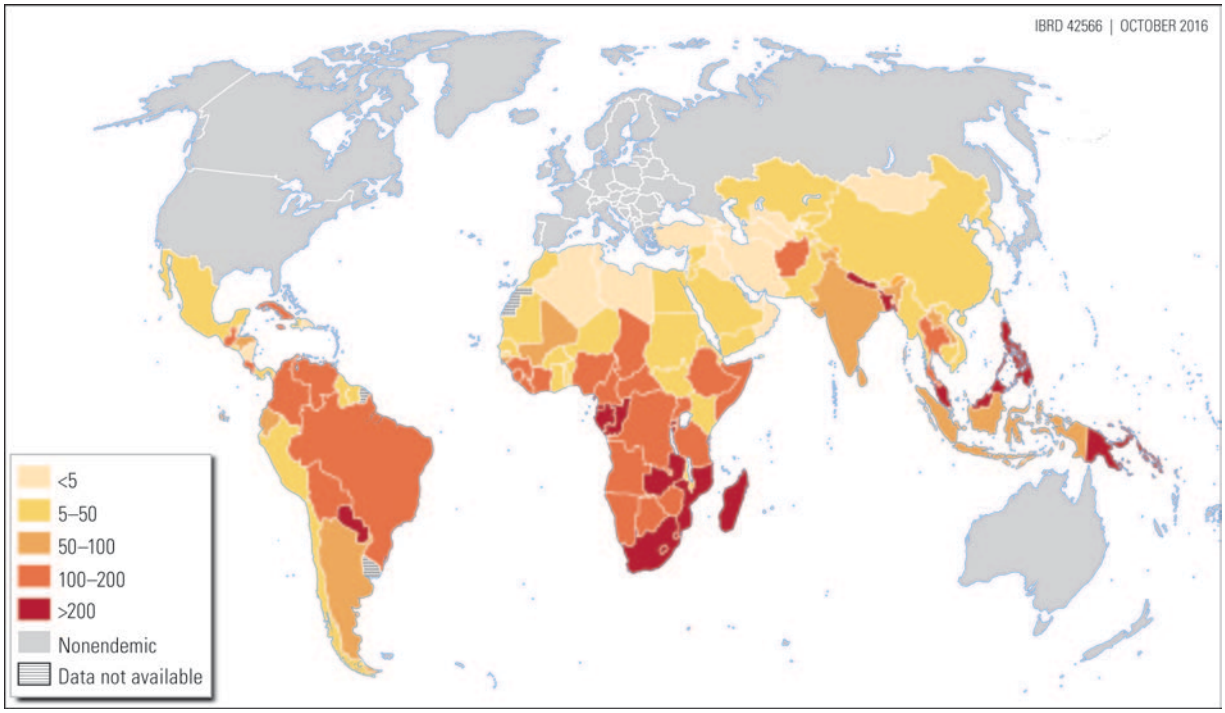
framework was used to predict the prevalence of each infection across the continent, following the approach of Hay and others (2009).

For STHs, prevalence alone does not provide a useful measure of potential morbidity because only a small number of infections will be associated with ill health. Instead, morbidity is related to the intensity of infection, with the most intense infections occurring in only a minority of infected individuals (Bundy and Medley 1992). As prevalence increases, the prevalence of high-intensity infections increases at a higher rate, such that high-prevalence communities experience disproportionate amounts of morbidity (Chan and others 1994). Heterogeneity between communities within subnational areas was therefore approximated using modeled distributions, and the number of persons with infection intensities greater than age-dependent thresholds was estimated indirectly for each species. The frequency distributions of worms, and thus the numbers exceeding these thresholds, were estimated using negative binomial distributions that assumed general species-specific aggregation parameters based on data from Brazil, Kenya, and Uganda (Pullan and others 2014). The Institute for Health Metrics and Evaluation then used these estimates to estimate disability-adjusted life years (DALYs) for 2013 (Murray and others 2015).

In 2013, an estimated 0.4 billion children under age 15 years worldwide were infected with at least one species of intestinal nematode, resulting in 1.46 million DALYs. Although the greatest number of DALYs occur in Sub-Saharan Africa and Latin America (map 13.2), a large at-risk population means that the vast majority of total infections occur in Asia, where at least one-fourth of preschool and school-age children are host to at least one STH species (table 13.1). The most important STH infection globally for children is roundworm, reflecting the age distribution of infection. Roundworm is of particular concern for preschool-age children in Sub-Saharan Africa, resulting in 143 DALYs per 100,000 population (table 13.2)—mostly attributable to wasting resulting from high-intensity infections. These figures are substantially lower than previous estimates (de Silva and others 2003), attributable in part to several methodological improvements:

- Limitation of populations at risk to areas suitable for transmission
- Increased availability of contributing survey data
- Generation of estimates at higher spatial resolutions.

Map 13.2 Distribution of DALYs for Soil-Transmitted Helminth Infections, per 100,000 Population



Sources: IHME (Institute for Health Metrics and Evaluation). 2014. "Global Burden of Disease Study 2013: Age-Specific All-Cause and Cause-Specific Mortality 1990–2013." IHME, Seattle, Washington.
Note: DALY = disability-adjusted life year. Soil-transmitted helminths include hookworm, roundworm, and whipworm.

Table 13.1 Total Population, Number of Infected Persons, and Overall Prevalence, 2015

Indicator	Total population (millions)	Number of Persons Infected (millions) (95% CI)				Overall Prevalence (95% CI)			
		Hookworm (millions)	Roundworm (millions)	Whipworm (millions)	Any STH (millions)	Hookworm	Roundworm	Whipworm	Any STH
Preschool age (younger than age five years)									
Middle East and North Africa	55.6	0.3 (0.2–0.3)	1.9 (1.2–2.8)	0.6 (0.4–1.0)	2.5 (1.7–3.7)	0.5 (0.3–0.6)	3.4 (2.2–4.9)	1.2 (0.8–1.7)	4.6 (3.1–6.6)
Latin America and the Caribbean	54.5	1.7 (1.1–2.6)	5.3 (3.1–8.4)	4.6 (2.9–7.1)	10.1 (6.3–14.8)	3.2 (2.0–4.8)	9.7 (5.7–15.4)	8.5 (5.3–13.0)	18.4 (11.6–27.2)
Sub-Saharan Africa	210.7	12.5 (7.7–19.1)	17.8 (10.6–27.8)	13.4 (7.7–21.5)	37.4 (23.1–55.3)	5.9 (3.7–9.1)	8.4 (5.0–13.2)	6.4 (3.7–10.2)	17.7 (11.0–26.3)
East Asia and Pacific	151.0	14.6 (8.9–22.6)	13.4 (7.0–22.5)	12.5 (6.8–20.2)	34.1 (20.2–51.6)	9.6 (5.9–14.9)	8.8 (4.7–14.9)	8.1 (4.5–13.4)	22.6 (13.4–34.2)
South Asia	172.4	7.5 (4.8–11.1)	20.0 (11.8–30.6)	6.8 (4.0–11.0)	30.0 (18.4–43.6)	4.4 (2.8–6.4)	11.6 (6.8–17.8)	4.0 (2.3–6.4)	17.3 (10.7–25.3)
Total	644.2	36.6 (22.7–55.7)	58.4 (33.9–93.0)	37.9 (21.7–60.8)	114.1 (70.0–170.0)	5.7 (3.5–8.7)	9.1 (5.3–14.4)	5.9 (3.4–9.4)	17.8 (10.9–26.4)
School age (ages 5–14 years)									
Middle East and North Africa	94.4	0.7 (0.4–0.9)	5.0 (3.4–7.2)	1.8 (1.2–2.6)	6.8 (4.6–9.6)	0.7 (0.5–1.0)	5.3 (3.6–7.6)	1.9 (1.2–2.8)	7.2 (4.9–10.2)
Latin America and the Caribbean	107.0	4.5 (2.9–6.8)	15.0 (9.4–22.6)	13.0 (8.5–19.2)	27.3 (18.1–38.4)	4.2 (2.7–6.3)	14.0 (8.8–21.1)	12.2 (7.9–17.9)	25.5 (16.9–35.9)
Sub-Saharan Africa	354.3	34.0 (21.6–50.4)	47.2 (30.0–70.1)	36.4 (22.2–55.5)	94.8 (62.7–131.0)	9.6 (6.1–14.2)	13.3 (8.4–19.8)	10.3 (6.3–15.7)	26.7 (17.7–37.0)
East Asia and Pacific	294.0	44.3 (27.8–63.2)	34.2 (18.5–55.8)	32.0 (18.7–50.8)	88.0 (55.1–127.1)	15.1 (9.4–21.5)	11.6 (6.3–19.0)	10.9 (6.4–17.3)	30.0 (18.7–43.2)
South Asia	343.0	24.7 (16.3–35.4)	63.0 (39.1–91.5)	21.7 (12.8–33.7)	90.5 (59.5–124.3)	7.2 (4.7–10.3)	18.3 (11.4–26.7)	6.3 (3.7–9.8)	26.4 (17.3–36.2)
Total	1,192.8	108.2 (68.0–156.6)	164.4 (100.6–249.2)	105.0 (63.3–161.9)	307.4 (200.7–432.4)	8.9 (5.7–13.1)	13.9 (8.4–20.9)	8.8 (5.3–13.6)	25.9 (16.8–36.2)

Source: Adapted from Pullan and others 2014.

Note: CI = confidence interval; STH = soil-transmitted helminth. Numbers in parentheses indicate range at 95 percent confidence interval.

Table 13.2 DALYs per 100,000 Population, by Region and Type of Soil-Transmitted Helminth

	DALYs per 100,000		
	Hookworm	Roundworm	Whipworm
Preschool age (younger than age 5 years)			
Middle East and North Africa	4.2 (2.4–6.4)	14.3 (9.9–19.7)	0.0 (0.0–0.1)
Latin America and the Caribbean	21.8 (13.1–34.1)	34.1 (24.6–46.1)	8.2 (4.3–15.2)
Sub-Saharan Africa	39.7 (25.3–59.7)	143.2 (117.6–173.7)	6.5 (3.7–10.6)
East Asia and Pacific	21.7 (13.4–34.2)	19.7 (13.3–28.9)	7.3 (3.3–14.0)
South Asia	19.3 (11.4–29.8)	43.1 (32.2–58.0)	2.0 (0.9–3.8)
School age (ages 5–14 years)			
Middle East and North Africa	7.3 (4.4–11.0)	4.8 (2.7–8.2)	0.1 (0.0–0.3)
Latin America and the Caribbean	73.7 (47.0–107.7)	19.2 (10.7–31.8)	16.9 (8.7–30.2)
Sub-Saharan Africa	80.7 (51.8–120.2)	33.7 (22.5–49.6)	18.1 (10.0–30.2)
East Asia and Pacific	52.7 (34.0–78.5)	11.6 (6.0–20.9)	14.4 (6.3–28.5)
South Asia	38.1 (22.8–58.4)	36.6 (21.4–60.6)	5.2 (2.5–9.5)

Source: Institute for Health Metrics and Evaluation, Global Health Data Exchange, http://ghdx.healthdata.org/.
Note: CI = confidence interval. Numbers in parentheses indicate range at 95 percent CI.

Results are still limited by the paucity of recent data, especially for much of Asia. These prevalence estimates were informed by a comprehensive review of population-based surveys conducted between 1980 and 2010. However, a number of coordinated efforts have been underway recently to scale up and complete the mapping for neglected tropical diseases (NTDs), including STHs. It will be important to ensure that future revisions of the Global Burden of Diseases, Injuries, and Risk Factors Study incorporate these new prevalence estimates when producing revised DALYs for STHs.

Map 13.3 shows the current distribution of STH infections. These infections were historically prevalent in many parts of the world where they are now uncommon. These areas include parts of Europe; Japan; the Republic of Korea; Taiwan, China; and the Caribbean and North America (Mexico and the United States), where sustained control efforts and economic development have led to their elimination, at least as a public health problem (Hong and others 2006; Kobayashi, Hara, and Kajima 2006; Tikasingh, Chadee, and Rawlins 2011). The distribution of worm species also reflects social and environmental factors, with greater transmission of hookworm infection in rural areas, and greater prevalence of roundworm and whipworm in periurban environments (Pullan and Brooker 2012).

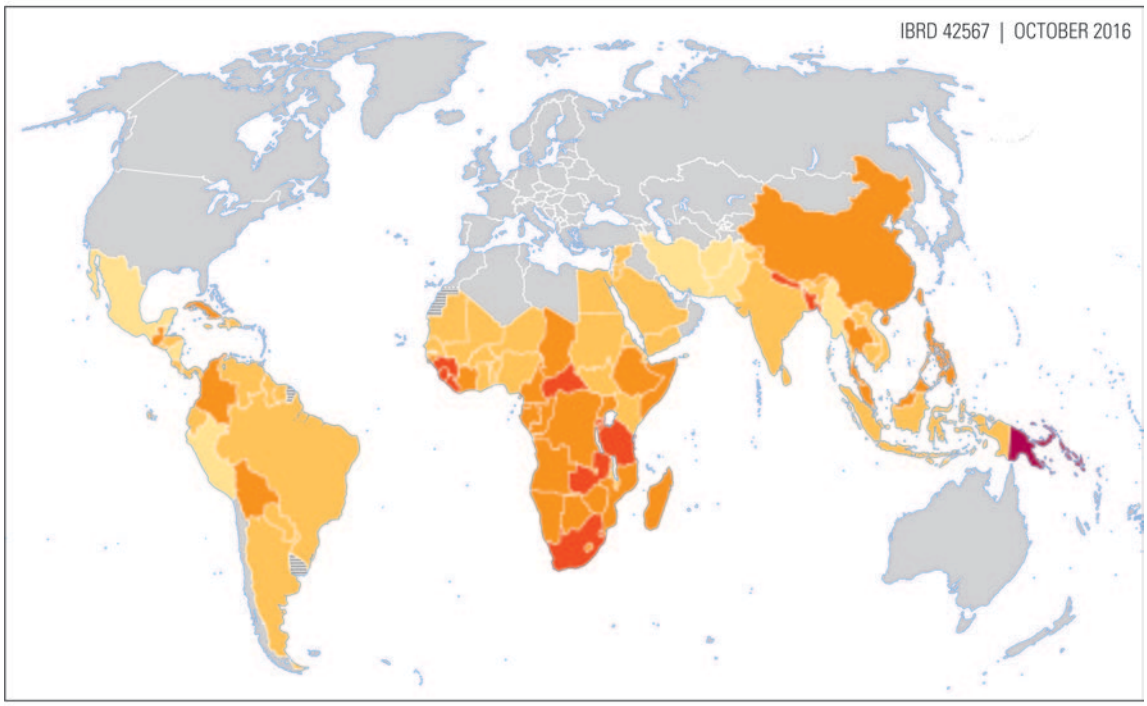
The distribution of STH infection is declining, partially as a result of global economic development, declining poverty, and greater access to health services and sanitation programs, especially in poor communities. It seems probable that the targeting of more than 1 billion deworming treatments a year in poor communities has also contributed. More contemporary surveys and joined-up databases are needed for reliable estimates, but crude estimates suggest that the number of school-age children living with worm infection was cut in half from 2010 to 2015.

SCALE OF DEWORMING PROGRAMS

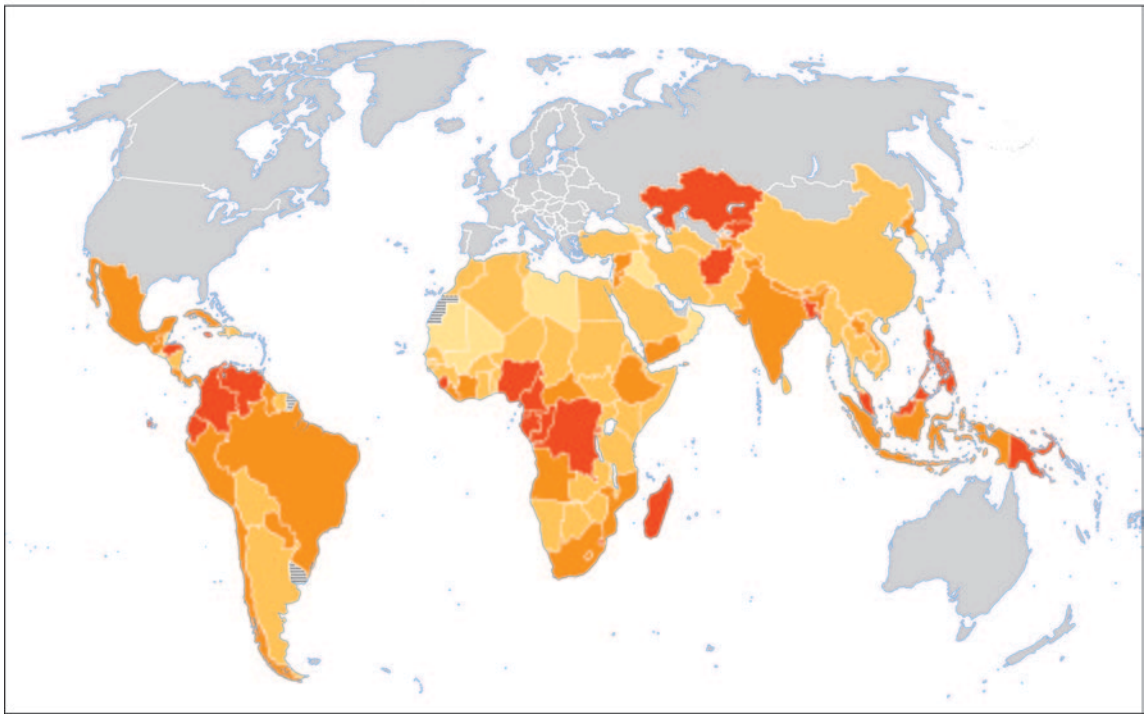
Deworming programs have long been popular with public health teams and the people exposed to infection. Norman Stoll's "This Wormy World" provided a clear vision of the ubiquity of infection and the scale of deworming programs in the then-endemic areas, including the U.S. South (Stoll 1947). Since the beginning of the twentieth century, schools have been viewed as the natural base for programs because they provide an existing infrastructure to reach the age group for whom infection is often most intense and who might benefit the most from deworming at a stage when they are still learning and growing (Bundy, Schultz, and others 2017, chapter 20 in this volume). In Dakar in 2000, at the World Education Forum that relaunched the Education for All program, the role of schools in delivering health programs, including deworming, was reinvigorated by the launch of the global partnership Focusing Resources on Effective School Health (FRESH).

Map 13.3 Distribution of Soil-Transmitted Helminth Infection Prevalence for Children Younger than Age 15 Years, by Species, 2015

a. Hookworm



b. Roundworm



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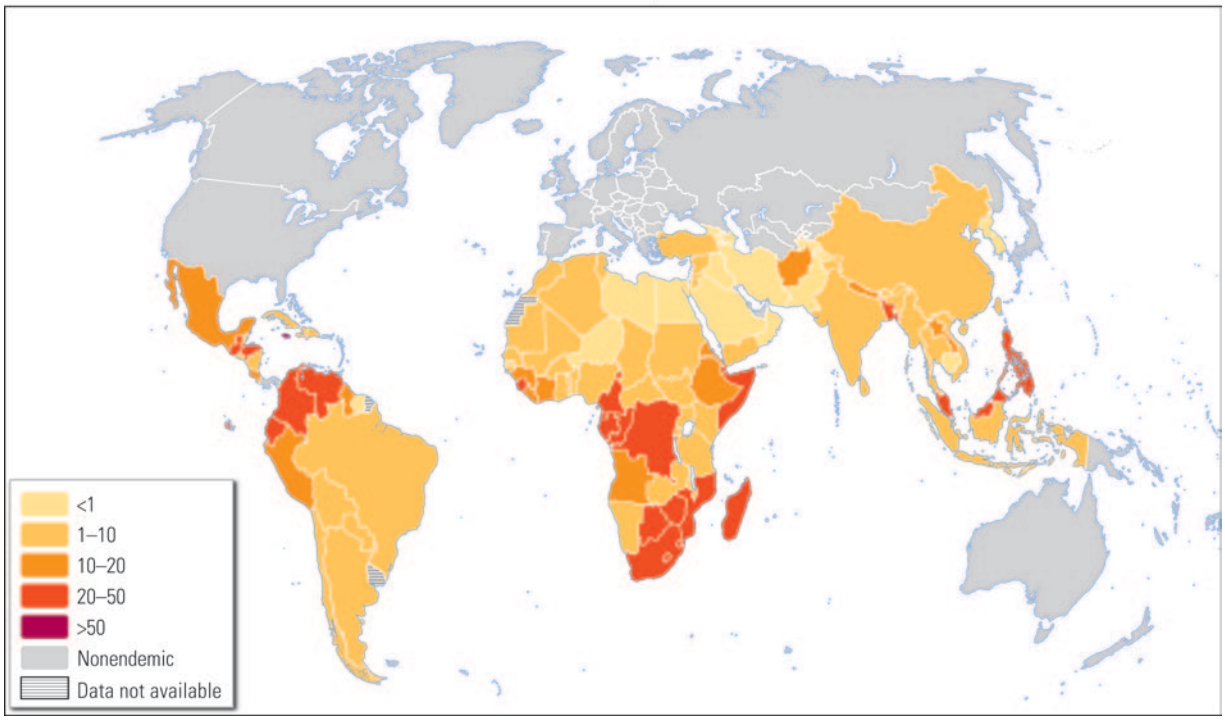
Map 13.3 Distribution of Soil-Transmitted Helminth Infection Prevalence for Children Younger than Age 15 Years, by Species, 2015 (continued)

c. Whipworm



Source: Adapted from Pullan and others 2014 and updated to 2015.
Note: Based on geostatistical models for Sub-Saharan Africa and empirical data for all other regions.

FRESH was given greater vitality a year later when the World Health Assembly endorsed a target of deworming 75 percent of schoolchildren in member states with endemic STH infections. The FRESH principles continue to guide school health programs and are still being used and cited, for example, in the strategic plan for national deworming announced in Ethiopia in 2012.

From these beginnings, deworming, especially school-based deworming, has become a major public health program. In the London Declaration on Neglected Tropical Diseases announced in 2012, 14 pharmaceutical companies committed to donating medicines for 10 of the most prevalent NTDs, including STHs. The specific donations for STHs are targeted at school-age children and comprise 400 million treatments of albendazole (GlaxoSmithKline) and 200 million treatments of mebendazole (Johnson & Johnson). Medicines donated for other purposes, such as ivermectin for onchocerciasis and lymphatic filariasis, are also effective against STHs, and additional albendazole is donated specifically for lymphatic filariasis.

This progress adds up to a substantial volume of treatments efficacious against STHs. In 2015, the latest date for which treatment data are available for all three commonly used anthelmintics, the World Health Organization (WHO) reports that approximately 564 million children (150 million preschool-age children and 416 million school-age children) were treated with albendazole or mebendazole for STHs (WHO 2015a) (table 13.3). While 556.2 million persons (including approximately 36 million preschool-age children and 139 million school-age children) were treated with albendazole under MDA programs targeting elimination of lymphatic filariasis (WHO 2015b), approximately 113.2 million persons were treated with ivermectin under the onchocerciasis elimination program in Africa (WHO 2015a). These figures suggest that in 2015, more than 1 billion persons were treated with drugs that are efficacious against STHs during the course of just one year.

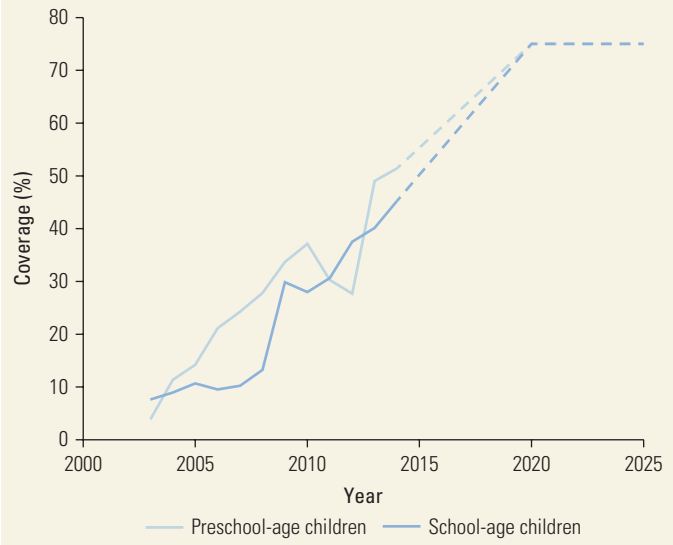
The official estimates of treatment coverage in school-age children continue to show relatively low, albeit rising, levels of coverage, estimated to be about 45 percent in 2014 (figure 13.1 and table 13.3). These estimates are based on the donated drugs provided through WHO mechanisms, expressed as a proportion of the world's school-age children. Both the supply (that is, the numerator) and the demand (that is, the denominator) continue to rise

Table 13.3 Total Number of Preschool-Age and School-Age Children Estimated to Require Preventive Chemotherapy for Soil-Transmitted Helminths, by WHO Region, 2009 and 2015

WHO region	2009			2015		
	Requiring PC for STHs (millions)	Receiving PC for STHs (millions)	Regional coverage (%)	Requiring PC for STHs (millions)	Receiving PC for STHs (millions)	Regional coverage (%)
African	283.8	91.0	32	298.0	153.0	51
Americas	45.5	21.1	46	46.9	24.3	52
Eastern Mediterranean	78.0	2.5	3	74.4	17.9	24
European	4.3	0.4	9	2.3	0.5	23
South-East Asia	372.0	144.8	39	354.4	172.1	49
Western Pacific	99.1	14.1	14	75.2	32.4	43
Total	**882.7**	**273.9**	**31**	**851.2**	**400.2**	**47**

Source: WHO 2011, 2016.
Note: PC = preventive chemotherapy; STHs = soil-transmitted helminths; WHO = World Health Organization.

Figure 13.1 Reported Global Coverage of Preschool- and School-Age Children, 2003–14, with a Projection to the 2020 Target of 75 Percent Coverage



Source: Adapted from figure 1 of Trusscott, Turner, and Anderson 2015. The data on reported coverage are from the World Health Organization, "Neglected Tropical Diseases: PCT Databank," http://www.who.int/neglected_diseases/preventive_chemotherapy/lf/en/.
Note: Figure shows the treatment coverage of preschool-age and school-age children up to 2014. The dashed lines are indicative of the change necessary to reach the goal of 75 percent treatment by 2020.

leading to little change in coverage year over year reported by the WHO. These estimates report the number of doses that are donated specifically for school-based deworming (about 379 million tablets in 2015); they do not report the number of other donated drugs that are efficacious against STHs (an additional 900 million doses in 2014) or the large number of nongovernmental organization and self-administered treatments in the unprogrammed category that go unreported. The scale of actual treatment of schoolchildren in any year could easily be twice that reported in the official statistics.

HEALTH IMPACT OF WORMS AND DEWORMING

Although the WHO recommends MDA for vulnerable groups, such as children and pregnant women, who live in areas with endemic intestinal worm infection, a series of reviews from both the Cochrane Collaboration (most recently, Taylor-Robinson and others [2015]) and the Campbell Collaboration (Welch and others 2016) argues that there is substantial evidence that mass deworming does not produce health benefits and does not support the use of MDA. How can these two views be reconciled?

Substantial Historical Literature on the Clinical Consequences of STH Infection

The clinical literature, gathered over the early part of the last century, shows significant impacts of intense STH infection on health. Through collation of data from several different studies that described the occurrence of *Ascaris*-induced intestinal obstruction in specific regions of endemic countries, and studies on the community prevalence of ascariasis in the same regions, the incidence of *Ascaris*-induced intestinal obstruction was shown to clearly increase, in a nonlinear fashion, as community prevalence of infection increased (de Silva, Guyatt, and Bundy 1997a). Similar data collations

showed patients with acute intestinal obstruction due to ascariasis harbored more than 60 worms in most instances, with a 10-fold higher worm burden in fatal cases. Children younger than age five years were shown to develop obstruction with much smaller worm burdens (de Silva, Guyatt, and Bundy 1997b). A model of the global numbers at risk of morbidity and death due to ascariasis estimated that in 1990, some 11.5 million children were at risk of clinically overt acute illness and that some 200,000 children developed serious complications such as intestinal obstruction, biliary or pancreatic disease, appendicitis, and peritonitis, resulting in about 10,000 deaths each year (de Silva, Chan, and Bundy 1997).

Evidence also points to the effects of *Trichuris* infection on growth and development of infected children, in particular in those children who have a heavy burden of infection. Reports from Jung and Beaver (1951) described dysentery, diarrhea, and colitis in children with *Trichuris* infection; heavily infected children more frequently presented with the more severe symptom of rectal prolapse. This heavy infection can lead to a well-described *Trichuris* dysentery syndrome, characterized by dysentery, anemia, growth retardation, finger clubbing, rectal prolapse, and a specific trichuriasis colitis (Cooper and Bundy 1988). Furthermore, curative treatment for parasite infection leads to rapid alleviation of these symptoms (Cooper and Bundy 1988; Jung and Beaver 1951). Studies have recorded significant catch-up growth in middle childhood—especially ages four to eight years—following curative treatment, with significant increases in height and weight as well as improvements in cognition (Callender and others 1998; Cooper and others 1990; Cooper and others 1995; Nokes and others 1992).

Anemia is associated with trichuriasis colitis and is the defining characteristic of hookworm infection. On maturation and migration to the gut, hookworms attach to the intestinal mucosa and submucosa, rupturing capillaries mechanically as well as through release of anticlotting agents to maintain blood flow (Hotez and others 2004). The development of anemia is related to infection intensity as well as to the duration of infection and nutritional status of individuals (Crompton and Whitehead 1993; Hall and others 2008). A seminal trial by Stoltzfus and others (1997) showed a significant association between hookworm infection and severe anemia, as well as iron deficiency over and above dietary intake of iron. The authors predicted that eliminating hookworm infections from their study population could lead to a reduction in anemia of 25 percent and severe anemia by as much as 73 percent.

Thus, the pathology for each of these helminth infections can be severe in both immediate effects and medium-term consequences for growth and development. Furthermore, for each of these infections, curative treatment leads to alleviation of the immediate symptoms as well as to accelerated gains in growth and development, indicating that the pathology of worm infection can largely be reversed if treated in a timely manner.

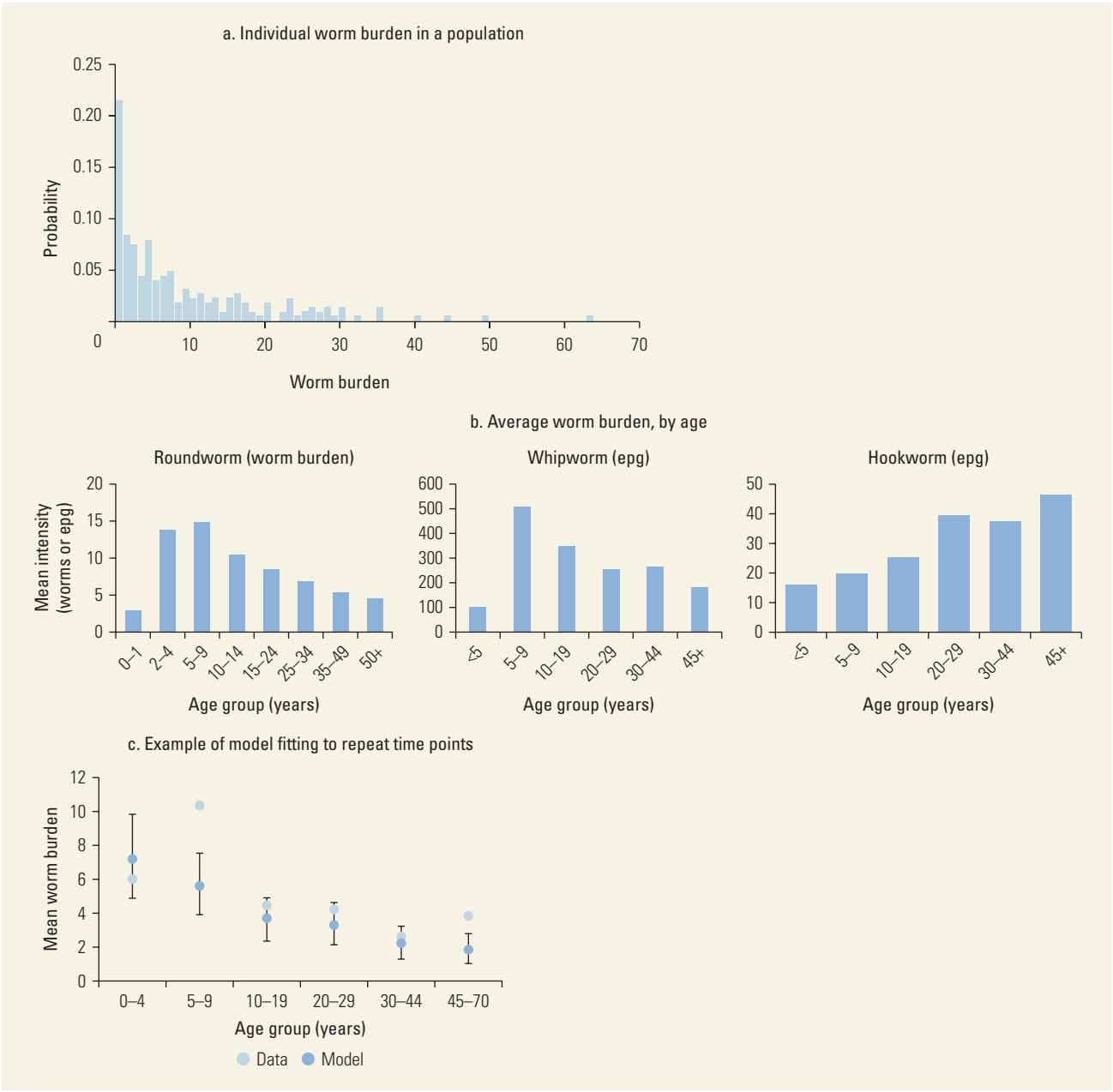
This literature, now largely historical, on clinical trials of patients with known and intense infection compared with untreated controls, offers convincing evidence on both the effect of infection on patients and the benefits of treatment. Such trials should no longer be conducted because it would be unethical to withhold treatment from patients known to be infected.

Impact of Current MDA-Based Trial Design

The majority of deworming trials today are designed quite differently from traditional clinical trials. They are based on the operational design of deworming programs, in which MDA covers all of the target population, usually an age class, living in an area where infection is endemic, with no measure of individual infection status or intensity. Because infection intensity is overdispersed, such that most people have lower-than-average infection and a minority have intense infection (figure 13.2), there will be considerable and unknown variance in the intensity of individual infection. Because the intensity is unknown in any individual, so too is the likelihood of morbidity and the potential scale of benefit from treatment. With the current trial design, the population outcome can only be measured as some average of individual benefits. Even were there to be considerable benefit for the minority of intensely infected individuals, if there is little or no benefit for the majority with light infections then the average effect will be small. The underlying situation across the population is unknowable with current MDA-based trial designs.

To illustrate what the analyses show in practice, we compare two comprehensive analyses drawing on the same small pool of trials available in this area of research. In the first analysis, Taylor-Robinson and others (2015) examined both randomized trials of universal deworming programs, which include children both with and without worms, and studies among groups of infected children already screened and diagnosed. They then conducted formal meta-analysis for eight outcomes: weight, height, middle-upper-arm circumference, triceps skinfold thickness, subscapular skinfold thickness, body mass index, hemoglobin, and school attendance. They concluded that, while *targeted* deworming of infected children may increase weight gain, for mass deworming programs that cover children with and without worms,

Figure 13.2 Distribution of Worm Burden



Sources: Panel a, adapted from Hollingsworth, Truscott, and Anderson 2013; panel b, adapted from Truscott and others 2014; panel c, adapted from Truscott, Turner, and Anderson 2015.
Note: epg = eggs per gram of stool. Worm burden indicates the expected number of worms harbored by an individual.

"There is now substantial evidence that [mass treatment of all children in endemic areas] does not improve *average* [emphasis added] nutritional status, hemoglobin, cognition, school performance, or survival" Taylor-Robinson and others (2015, 2). They included a maximum of 11 estimates from 10 trials for weight gain, with many fewer trials for most of the other outcome measures.

In the other analysis, Croke and others (2016) augmented Taylor-Robinson and others' (2015) sample with information from published studies as well as several excluded studies and then conducted meta-analysis on this augmented sample. Focusing on weight gain, for which the number of available studies is greatest, they noted that the appropriate test for the

hypothesis of no treatment effect in all cases is a fixed-effect meta-analysis. Using this model, the hypothesis of zero weight gain from deworming was rejected at the 10 percent level using the original data from the Taylor-Robinson and others (2015) study. Using the augmented sample, they found a 0.111 kilogram weight gain ($p < 0.001$) from deworming in a fixed-effects model and a 0.134 kilogram weight gain ($p = 0.01$) in a random-effects model.

Noting that including trials from settings with minimal STH prevalence and mass deworming is not recommended because such a policy may minimize the estimated impact of deworming, they then estimated positive and statistically significant impacts in settings in which the WHO recommends multiple doses of mass treatment annually (greater than 50 percent prevalence), and in settings where the WHO recommends mass deworming at least once per year (greater than 20 percent prevalence). For high- and medium-prevalence areas (greater than 50 percent prevalence of any single STH species), the fixed-effects estimate was 0.157 kilogram, while the random-effects estimate was 0.182 kilogram. For trials in settings with greater than 20 percent prevalence, the fixed-effects estimate was 0.142 kilogram, while the random-effects estimate was 0.148 kilogram.

Accordingly, while Taylor-Robinson and others (2015) highlighted an apparent contradiction between the evidence on treatment of infected individuals (evidence of benefit) and mass treatment (no evidence of benefit), Croke and others (2016) demonstrated that mass deworming also has evidence of benefit, albeit of smaller magnitude than the effects identified in targeted studies. Evidence for this benefit is particularly strong in high- and medium-prevalence settings. The estimated weight gain in these universal treatment studies is notably smaller than in studies of individuals known to be infected—on the order of 0.13 and 0.75 kilogram, respectively—which would be the logical consequence of averaging across a population with an overdispersed distribution of intensity of infection and probability of morbidity.

The similar results but very different conclusions of these two analyses of the same trial datasets may be helpful for understanding the paradoxical literature in the deworming area. Both analyses found effects with targeted treatment trials, as is well documented in the clinical literature. Both analyses found small effects on weight gain (the measure for which most trials are available for meta-analysis) when exploring the effects across whole populations with unknown distribution of infection intensity—finding these effects significant in one analysis and not significant in the other. Resolving this debate requires exploring the distribution of individual morbidity and infection intensity. One important point is that the targeted treatment trials are also the earlier trials: detecting average effects in populations will only become more difficult as infection levels continue to decline.

OPTIMIZING PROGRAM DESIGN BY MODELING POPULATION DYNAMICS

Both chapters on deworming in the earlier editions of *Disease Control Priorities* emphasized the importance of understanding population dynamics as a determinant of good program design (Hotez and others 2006; Warren and others 1993). This section explores how the population dynamics modeling is being used to optimize program design and, in particular, what the modeling says about the value of MDA versus screen and treat and of school-based deworming versus universal coverage.

A common epidemiological feature of STH infections is the overdispersed distribution of worms (figure 13.2, panel a): while many people have a medium to low burden of infection, a minority of people have a high burden of infection. Because of the linear relationship between infection intensity and morbidity, individuals with high burdens are most likely to suffer health impacts of STHs, to contribute the largest number of infectious eggs, and to be reinfected following mass treatment, raising the possibility that targeting these individuals would be the most effective way to control both the health impact and the transmission of STHs. However, this approach has some practical challenges.

- First, commonly used diagnostics—wet smear in saline or Kato-Katz examination of stool samples to count eggs—are poor diagnostics of the underlying worm burden because of both variations in egg output and the nonlinear relationship to worm burden (Anderson and Schad 1985).
- Second, selective diagnosis and treatment involves expensive fieldwork, including collecting and analyzing stool samples and finding, reidentifying, and treating highly infected individuals (see next section on costs).
- Third, the nature of the overdispersed distribution means that a large proportion of the population has to be sampled to detect the few who have to be treated.

The few field studies that have been performed have found that selective treatment of persons with high parasite burden is less effective than mass treatment at

reducing population-level prevalence (Asaolu, Holland, and Crompton 1991); that mass treatment is more cost-effective than selective treatment (Holland and others 1996); and that school-based deworming is a highly cost-effective way to reduce anemia (Brooker and others 2008; Guyatt and others 2001) in particular settings, reflecting the results of modeling studies (Guyatt, Bundy, and Evans 1993) and a recent review of costs and cost-effectiveness (Turner and others 2015). Current evidence suggests that the most cost-effective way to reduce high-burden infections in children is through school-based deworming rather than selective treatment.

Epidemiological studies have also found indirect benefits to mass treatment of children, such as reductions in prevalence of infection in untreated adults (Asaolu, Holland, and Crompton 1991; Bundy and others 1990). These indirect effects have been found for roundworm and whipworm, but different effects were found in different settings, reflecting local differences in prevalence and distribution of infection. The population-level impact of a school-based deworming program and the impact on transmission to other members of the community and reinfection after treatment depend on the epidemiology of the parasite, efficacy of the treatments, age distribution of the population, and coverage of the treatment program. For roundworm and whipworm, the highest burden of infection is usually in children (figure 13.2, panel b); therefore, a school-based program covering preschool- and school-age children could have a large impact on transmission, particularly in settings with a high proportion of school-age population, provided the treatment used is effective for whipworm (Chan and others 1994; Turner and others 2016) and prevalence is at moderate to low levels. For hookworm, the burden of infection tends to be higher in adults; therefore, a school-based deworming program is likely to be less effective at reducing both morbidity (Coffeng and others 2015; Truscott, Turner, and Anderson 2015) and transmission at the population level (Anderson, Truscott, and Hollingsworth 2014; Anderson and others 2013; Anderson and others 2015; Chan and others 1994). However, systematically excluding a portion of the community from treatment can undermine elimination programs (Coffeng and others 2015), although it also helps slow the emergence of drug resistance.

Many of these results are from mathematical modeling studies, which have become more complex in recent years. An important development has been the validation of models against repeat time-point data (figure 13.2, panel c); these models are being expanded to include the most recent data (Coffeng and others 2015; Truscott, Turner, and Anderson 2015). Given that coverage of adults is likely to be required to break transmission, analyses have shown that in many settings the higher cost of coverage is offset by the lower number of rounds required, given that treatment can be stopped when transmission has been permanently interrupted (Lo and others 2015; Turner and others 2015; Turner and others 2016).

This section considers two issues: how treatment can bring down intensity and morbidity, and how treatment might break transmission. Empirical evidence is available for the former, but caution should remain about the latter. Although MDA has proven to be effective with onchocerciasis and lymphatic filariasis, these diseases have much slower epidemic growth rates than do STHs, and both require vectors for transmission rather than fecal contamination of the environment with infective stages.

ESTIMATED COST OF MDA

One of the main arguments for deworming, and the basis of the WHO recommendation for the use of MDA, especially school-based deworming, is the cost-effectiveness arising from an exceptionally low-cost intervention delivered infrequently without the need for costly screening. The value for money of this approach for low-income countries has recently been greatly enhanced by the availability of donated treatments. This section explores the costs in more detail.

MDA offers notable economies of scale (Brooker and others 2008; Evans and others 2011) because the cost per treatment decreases as the number treated rises (figure 13.3, panel a). This effect occurs because some of the most significant costs associated with MDA delivery are fixed and do not depend on the number treated: increasing the number treated therefore reduces the average fixed cost per treatment (Turner and others 2016). These economies of scale may account for much of the observed variation in the costs of delivering NTD treatment (Turner and others 2015).

Table 13.4 lists the costs of STHs delivered through a variety of MDA program designs. Integrating STH programs with other NTD programs or indeed other control programs, such as child health days, can produce economies of scope, by which the average cost per treatment declines as a result of delivering two or more interventions at once (figure 13.3, panel b); for example, integrating NTD programs reduces the overall cost between 16 percent and 40 percent (Evans and others 2011; Leslie and others 2013). Furthermore, the incremental cost of adding deworming into established immunization campaigns or child health days

Figure 13.3 Observed Economies of Scale and Scope Associated with Preventive Chemotherapy

Sources: Panel a, data from Brooker and others 2008; panel b, data from Evans and others 2011.
Note: Triple drug administration refers to the co-administration of albendazole, ivermectin, and praziquantel on a single delivery platform in communities where multiple neglected tropical diseases are prevalent.

Table 13.4 Key Preventive Chemotherapy Costing Studies Using Albendazole and Mebendazole

Study	Country	Target of intervention	Primary distribution method	Results
Brooker and others 2008	Uganda	STHs and SCH	School based (annually)	The overall economic cost per child treated in the six districts was US$0.54, which ranged from US$0.41 to US$0.91 (delivery costs: US$0.19–US$0.69). The overall financial cost per child treated was US$0.39. Costs are in 2005 US$.
Goldman and others 2007	Multicountry study	LF (and STHs indirectly)	Community based (annually)	The financial cost per treatment ranged from US$0.06 to US$2.23. Costs are in 2000–03 US$ (base year 2002).
Evans and others 2011	Nigeria	STHs, SCH, LF, and onchocerciasis	Community based (annually)	In 2008, school-age children in eight local government areas received a single round of ivermectin and albendazole followed at least one week later by praziquantel. The following year, a single round of triple drug administration was given, reducing the programmatic costs for MDA, not including drug and overhead costs, 41 percent (from US$0.078 to US$0.046 per treatment). Costs are in 2008–09 US$.
Goldman and others 2011	Haiti	STHs and LF	School based and community based (annually)	The cost per treatment was US$0.64, including the value of donated drugs. The program cost, excluding the value of the donated drugs, was US$0.42 per person treated. Costs are in 2008–09 US$.
Leslie and others 2011	Niger	STHs and SCH	School based and community based (annually)	The full economic cost of delivering the school-based and community-based treatment was US$0.76 and US$0.46, respectively. Including program costs alone, the values were US$0.47 and US$0.41, respectively. Costs are in 2005 US$.
Leslie and others 2013	Niger	STHs, SCH, LF, and trachoma	School based and community based (annually)	The average economic cost of integrated preventive chemotherapy was US$0.19 per treatment, excluding drug costs. The average financial cost per treatment of the vertical SCH and STH control program (before the NTD programs were integrated) was US$0.10. Costs in are 2009 US$.

table continues next page

Table 13.4 Key Preventive Chemotherapy Costing Studies Using Albendazole and Mebendazole (continued)

Study	Country	Target of intervention	Primary distribution method	Results
Boselli and others 2011	Lao PDR	STHs within a child health day campaign	Child health days (annually)	The incremental cost of adding deworming into the national immunization campaign was US$0.03 per treatment (delivery costs: US$0.007). The cost per treatment for the vertical school-based national deworming campaign (targeting school-age children) was US$0.23. Costs are in 2009 US$.
Fiedler and Semakula 2014	Uganda	STHs within a vitamin A supplementation campaign	Child health days (one round)	The average economic cost per child reached by the child health day program was US$0.22 (per round). Costs are in 2010 US$.

Note: LF = lymphatic filariasis; MDA = mass drug administration; NTD = neglected tropical disease; SCH = schistosomiasis; STHs = soil-transmitted helminths. For a more detailed summary of cost data for preventive chemotherapy, see Keating and others (2014) and Turner and others (2015).

with an already developed delivery infrastructure is very small—approximately US$0.03 per treatment (Boselli and others 2011)—and much lower than delivering treatment through vertical national deworming programs (Turner and others 2015); however, it may target younger children only and not access the age group with intense infection. This possibility highlights the critical need to consider the local context of NTD control programs when comparing the reported costs of MDA.

CONCLUSIONS

STH deworming programs are among the largest public health programs in low- and lower-middle-income countries as measured by coverage. The actual scale of these programs is unknown but is substantial; more than 1 billion donated doses of medicines effective against STHs are delivered by formal programs and supplemented by widespread self-treatment and unprogrammed activities. Deworming is one of the most common self-administered treatments in low-income countries; there is no question that there is strong community demand for this intervention. The large majority of formal MDA programs for STHs is school based.

STH infection is declining worldwide, likely reflecting the influence of improved hygiene and sanitation associated with global declines in poverty. The decline also reflects control efforts during the twentieth century that have largely eliminated STHs as a public health problem in previously endemic areas of North America (Mexico and the United States), Japan, Korea, and upper-middle-income countries throughout southern and eastern Asia.

This trend accelerated during the past decade, especially in the poorest countries where infection was previously most intense. Estimates are crude, but suggest that infection prevalence in school-age children was halved between 2010 and 2015. Efforts are underway to provide more extensive and more accurate surveys of infection status, supported by the creation of integrated databases that provide contemporary estimates of infection and treatment coverage. Efforts to monitor the potential emergence of drug resistance in treated populations are also increasing.

Much of the treatment is delivered through schools and targets school-age children. In 2015, India had the largest public health intervention ever conducted in a single day, deworming 89 million schoolchildren during the Annual School Deworming Day. The target for 2016 is 270 million schoolchildren. Modeling suggests that expanding programs to include other age groups might break transmission, and studies are exploring the utility of this approach in practice. Increasingly, countries are combining MDA for lymphatic filariasis and STHs since both use the same anthelmintics.

STH infection has been shown to be associated with clinical and developmental outcomes that are largely reversible by treatment (box 13.1). Both historical and contemporary trials of targeted treatment of individuals known to be infected have also demonstrated benefit from treatment.

Box 13.1

WHO Recommendations for the Control of Morbidity Attributable to Soil-Transmitted Helminths

Present recommendations

Since 2001, the World Health Organization (WHO) has recommended, for the prevention and control of the morbidity due soil-transmitted helminth (STH) infection, the implementation of preventive chemotherapy (PC) in the form of periodical, large-scale administration of anthelmintics to population groups at risk of morbidity due to infection.

Children and women of childbearing age are considered the population groups with the highest risk of morbidity from STH infection, because they are in a period of life in which they are particularly vulnerable to nutrient deficiencies associated with infection.

The current recommendation is for treatment once a year when the prevalence of STH infection is more than 20 percent and twice a year when prevalence exceeds 50 percent. The PC strategy is being implemented worldwide; in 2015, more than 50 percent of preschool children and more than 63 percent of school-age children in areas endemic for STHs were treated with anthelmintics.

Updating the recommendations

A WHO Guideline Review Committee (GRC) comprising independent experts met in Geneva in April 2016 to reassess the WHO recommendations on STHs control in light of scientific and programmatic evidence cumulated during the last 15 years of PC interventions. The conclusions of the GRC are presently being finalized and are expected to be published in early 2017.

Source: WHO 2001.

The findings of a small group of more recent clinical trials based on MDA have been controversial. These trials measure average change in health metrics for the whole population treated, irrespective of the infection status of individuals. Since morbidity is related to intensity, and intensity has an overdispersed distribution in populations, the average change in health metrics likely reflects the outcomes for a majority of people who are lightly infected and may derive limited benefit from treatment and for a minority who are more intensely infected and may derive greater benefit. The actual distribution of intensity and infection in these trial populations is unknown because individual screening is not necessary for MDA. The controversy arises because the change when averaged across the whole population is typically small, and there are insufficient data to determine with confidence whether the small size of the change reflects the underlying population distribution or the scale of benefit. An additional factor is that these more recent trials are conducted against the background of successful control efforts and the correspondingly low intensity of infection in most of the study populations. Studies are now being designed that aim to separate these factors.

The controversy in this area has extended from the results themselves to their policy implications. There is general agreement that STH infection can affect health, but disagreement regarding the circumstances that would justify an MDA program. While this debate continues, demand for MDA is continuing in the endemic countries and self-treatment is continuing on a massive scale. The debate would benefit from quantitative policy analysis setting out the population parameters that would and would not justify an MDA approach (see chapter 29 in this volume, Ahuja and others 2017, for an example of how this analysis has been approached from an economic perspective). The trend toward integrated MDA programs that target both lymphatic filariasis and STHs would also change the policy question being asked.

Looking to the future, we can expect infection levels to continue to decline as a result of the combination of high levels of treatment and continuing economic development trends in poor communities. We can also hope for a resolution of the worm wars as methods for assessing impact improve to reflect epidemiological realities, but this goal may be compromised if levels of impact continue to fall with sustained control.

NOTE

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.

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Chapter 14

Malaria in Middle Childhood and Adolescence

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INTRODUCTION

The age distribution of cases of malaria is influenced by the intensity of transmission. In areas where the population has low exposure to infection, malaria occurs in all age groups. In high transmission areas, in contrast, the main burden of malaria, including nearly all malaria-related deaths, is borne by young children (figure 14.1). These different age patterns are seen because exposure to repeated malaria infections induces some protection against subsequent attacks; but protection is rarely complete.

The age pattern of clinical malaria is determined by the level of transmission and the consequent level of acquired immunity, so it is sensitive to changes in the level of transmission (Carneiro and others 2010; Snow and others 1997). In many malaria-endemic areas, successful control programs have reduced the level of transmission substantially (Noor and others 2014; O'Meara and others 2010; WHO 2015). Consequently, in such communities, the peak age of clinical attacks of malaria is shifting from very young to older children. In The Gambia, the peak age of hospital admission for severe malaria increased from 3.9 years in 1999–2003 to 5.6 years in 2005–07 (Ceesay and others 2008); similar changes have been seen in Kenya (O'Meara and others 2008).

If the financial support for malaria control continues, further decreases in the intensity of transmission can be anticipated in many highly endemic areas; these decreases will increase the incidence of clinical attacks of malaria, including severe attacks, in school-age children (ages 5–14 years). However, the epidemiology and management of malaria in school-age children has, until recently, received little attention. This chapter reviews the current burden of malaria in school-age children, its clinical consequences, and approaches to controlling the disease in this increasingly vulnerable group. The review focuses largely on Sub-Saharan Africa, in part because this region has the greatest burden of malaria in school-age children, but also because of the lack of information on the impact of malaria in school-age children in other parts of the world, including those where *Plasmodium vivax* is the dominant malaria parasite. An earlier version of the review has been published (Nankabirwa, Brooker, and others 2014). Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017).

PREVALENCE OF MALARIA PARASITEMIA IN SCHOOL-AGE CHILDREN

The burden of malaria in school-age children is poorly defined because this age group is not routinely included in household-based cluster surveys. Information on the prevalence of malaria in this group is derived mainly from school-based surveys and from World Health Organization (WHO) estimates (WHO 2015).

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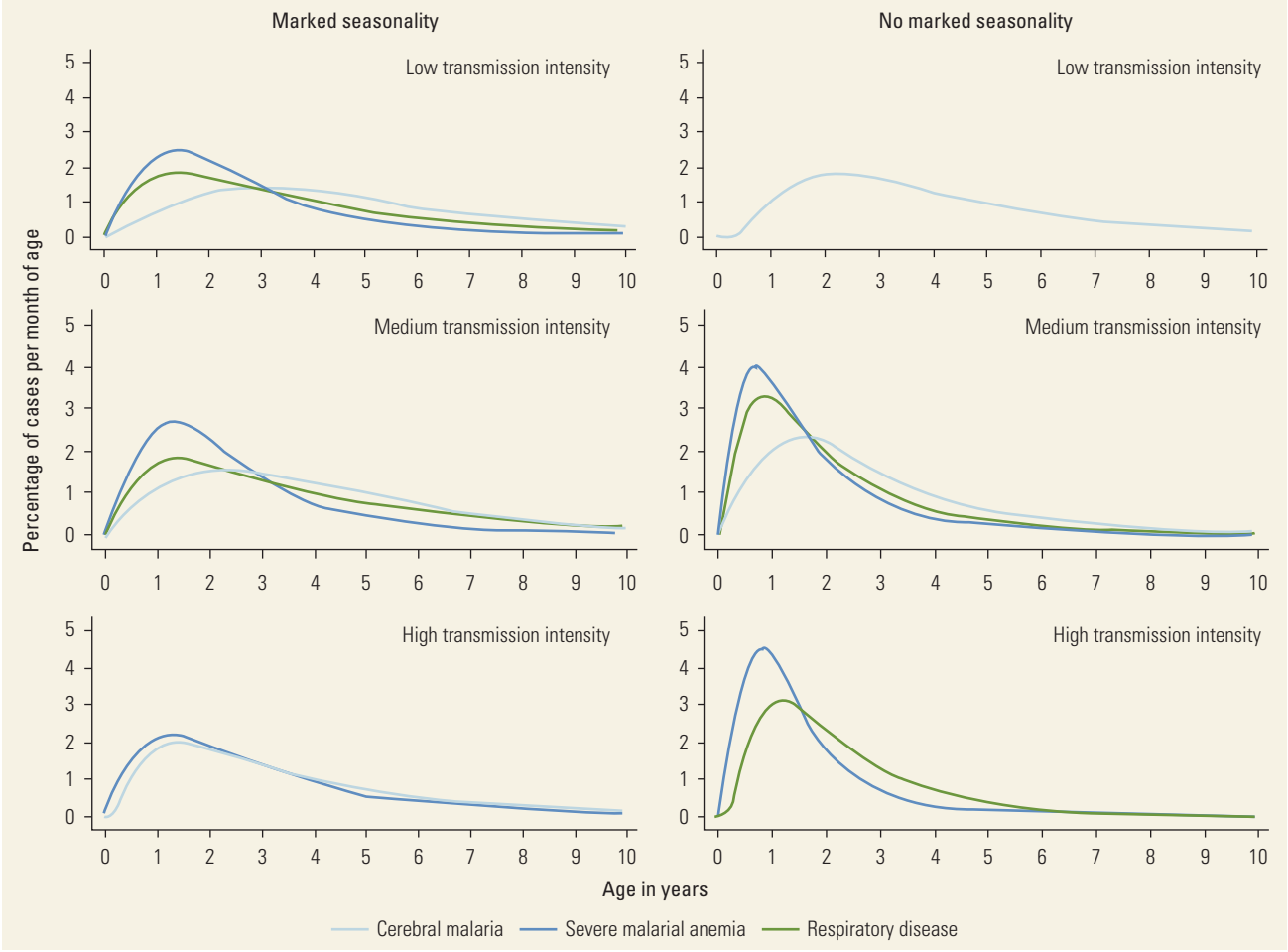
Figure 14.1 Age Distribution of Cases of Severe Malaria by Intensity of Malaria



Source: Roca-Feltrer and others 2010.
Note: The figure shows the percentage distribution of each severe malaria syndrome by age for children under age 10 years according to seasonality and transmission intensity, such that the integral of the curve is equal to 100 percent of expected cases.

Understanding the burden of malaria among school-age children is essential to justify investment in school-based malaria control interventions (Bundy and others 2000) and to identify delivery mechanisms to help control malaria in this underserved population.

More than 500 million school-age children worldwide are at risk of malaria infection; 200 million of those at risk live in Sub-Saharan Africa (table 14.1) (Gething and others 2011). Annex 14A, table 14.1 summarizes the results of studies on the prevalence of asymptomatic malaria parasitemia in this population. Map 14.1 shows the frequency with which malaria surveys have been undertaken in school-age children, with an increase in recent years in East Africa. Map 14.2 shows the prevalence observed in school-age children by geographical area.

The majority of malariometric surveys are conducted in children ages 2–10 years. Relatively few studies have been undertaken in older school-age children in Sub-Saharan Africa, and many of those are out of date following improvements in malaria control. In general, higher prevalence rates have been observed in West and Central Africa than in East Africa, but a great deal of heterogeneity has been observed with rates ranging from less than 5 percent to greater than 50 percent in different surveys. Recent studies in Malawi have emphasized the burden of malaria in school-age children and the role that those children play in acting as a reservoir of infection (Mathanga and others 2015; Walldorf and others 2015).

Few reports on the prevalence of asymptomatic malaria in school-age children outside of Sub-Saharan Africa are available (annex 14A, table 14.1). In the Republic of Yemen, Bin Mohanna, Bin Ghouth, and

Table 14.1 Estimated School-Age (5–14 Years) Population at Risk of *Plasmodium falciparum* Malaria in Millions by Region,[a] 2010

Region	Unstable risk	Stable risk	Total
Andean Latin America	1.0	0.6	1.7
Caribbean	2.4	1.8	4.2
Central Asia	0.2	–	0.2
Central Latin America	3.9	2.3	6.2
Central Sub-Saharan Africa	<0.1	26.1	26.1
East Asia	1.6	0.6	2.2
Eastern Sub-Saharan Africa	3.3	80.7	84.0
Middle East and North Africa	4.0	2.5	6.5
Oceania	<0.1	1.4	1.4
South Asia	165.6	98.6	264.3
South-East Asia	37.8	31.6	69.4
Southern Sub-Saharan Africa	2.3	4.8	7.1
Tropical Latin America	4.6	1.7	6.3
Western Sub-Saharan Africa	1.6	86.8	88.4
World	**228.5**	**339.5**	**568.0**

Source: Adapted from Gething and others 2011; data provided by the Malaria Atlas Project (www.map.ox.ac.uk), with thanks to Pete Gething and Zhi Huang, University of Oxford.
Note: – = not applicable. Rows may not add precisely due to rounding.
a. Based on the Global Burden of Disease study, http://www.healthdata.org/sites/default/files/files/GBD_GBD2010_Regions_countries.pdf.

Rajaa (2007) find a prevalence of 13 percent in children ages 6–11 years in the Hajr valley. In Latin America, malaria transmission is restricted to Amazonian areas and is uniformly low. In Brazil, Vitor-Silva and others (2009) find that *P. vivax* was more common than *P. falciparum* among schoolchildren. On the Thai-Burma border, Luxemburger and others (1994) find that 10 percent of school-age children were infected, mainly with *P. falciparum*.

IMPACT OF MALARIA ON THE HEALTH AND DEVELOPMENT OF SCHOOL-AGE CHILDREN

Most school-age children with malaria parasitemia do not have any symptoms because they have acquired some immunity. However, asymptomatic infections can contribute to anemia and impairment of cognitive development. School-age children may be infected with a malaria parasite that expresses antigens to which they have not been exposed and to which they have little or no immunity; the result is the development of symptoms such as fever and, more rarely, severe diseases such as cerebral malaria, life-threatening anemia, and death.

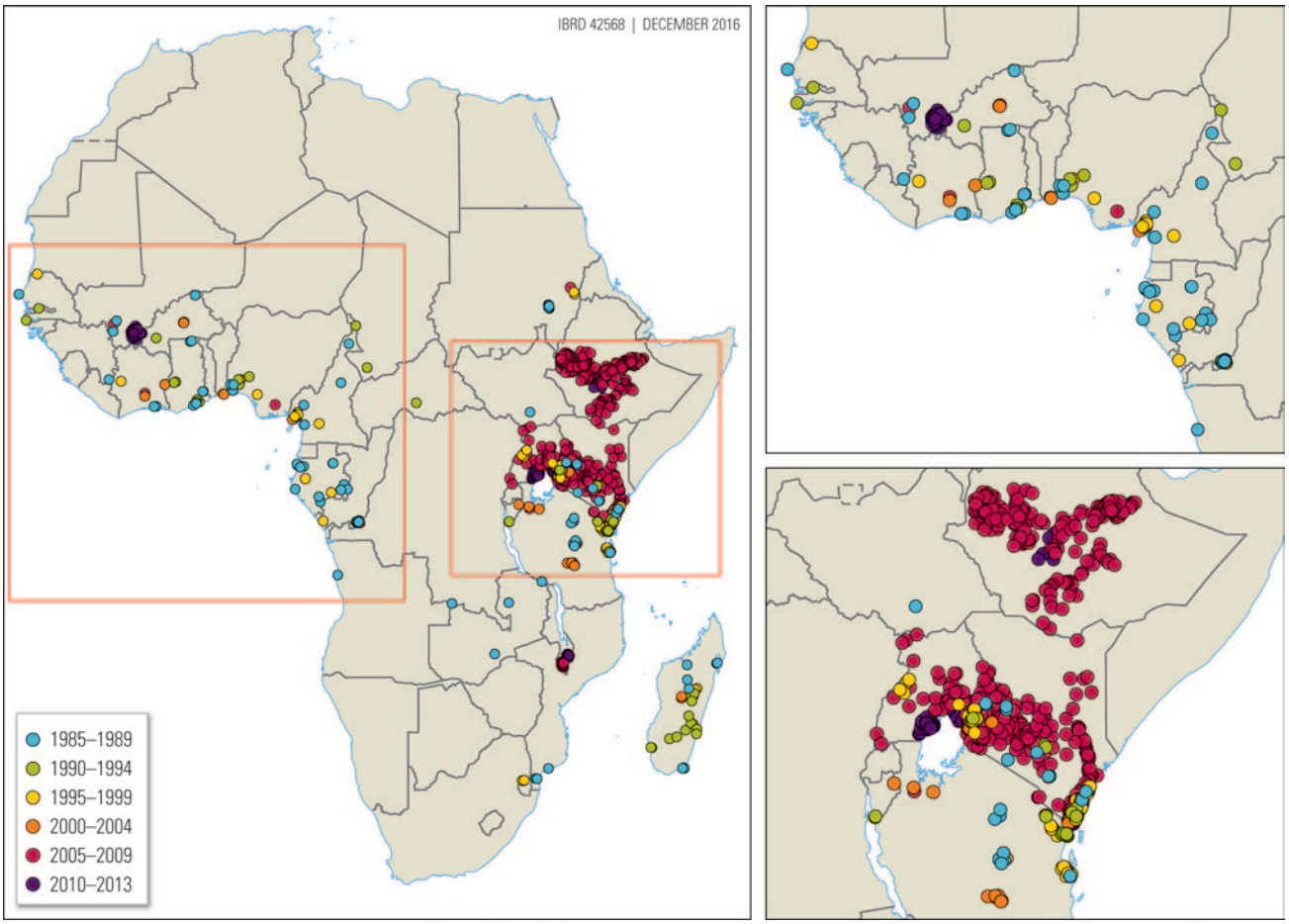
Mortality

The WHO estimates that there were approximately 438,000 (range 236,000–635,000) deaths from malaria in 2015; 90 percent of those deaths occurred in Sub-Saharan Africa (WHO 2015). A comprehensive review of malaria-related deaths between 1980 and 2010 (Murray and others 2012) reports many more deaths than the WHO; the review estimates that 6 percent to 9 percent of malaria deaths occur in children ages 5–14 years, corresponding to an annual figure in the range of 70,000–110,000 deaths. A lower malaria mortality rate was found in school-age children compared with younger children in Bangladesh and Sub-Saharan Africa (Adjuik and others 2006). A similar age pattern was found in India, with an estimated malaria-related death rate of 29 per 1,000 in children ages 5–14 years, compared with 55 per 1,000 in children under age 5 years in 2005 (Dhingra and others 2010).

Incidence of Clinical Malaria in School-Age Children

An estimated 214 million (range 149 million to 303 million) cases of malaria occurred worldwide in 2015; more than 80 percent were in Sub-Saharan Africa (WHO 2015). However, data on the incidence of clinical malaria in school-age children are scarce. Review of the limited

Map 14.1 Location of Malaria Parasite Surveys in School-Age Children, 1985–2013



Source: Malaria Atlas Project (MAP), http://www.map.ox.ac.uk.

information published indicates that annual incidence can vary from 0.03 to 2.7 cases per child per year, depending on the transmission setting (annex 14A, table 14.2). The limited data available suggest that it is not unusual for school-age children to experience one clinical attack of malaria severe enough to warrant treatment once every one to two years (Barger and others 2009; Clarke and others 2004; Nankabirwa and others 2010; Rohner and others 2010).

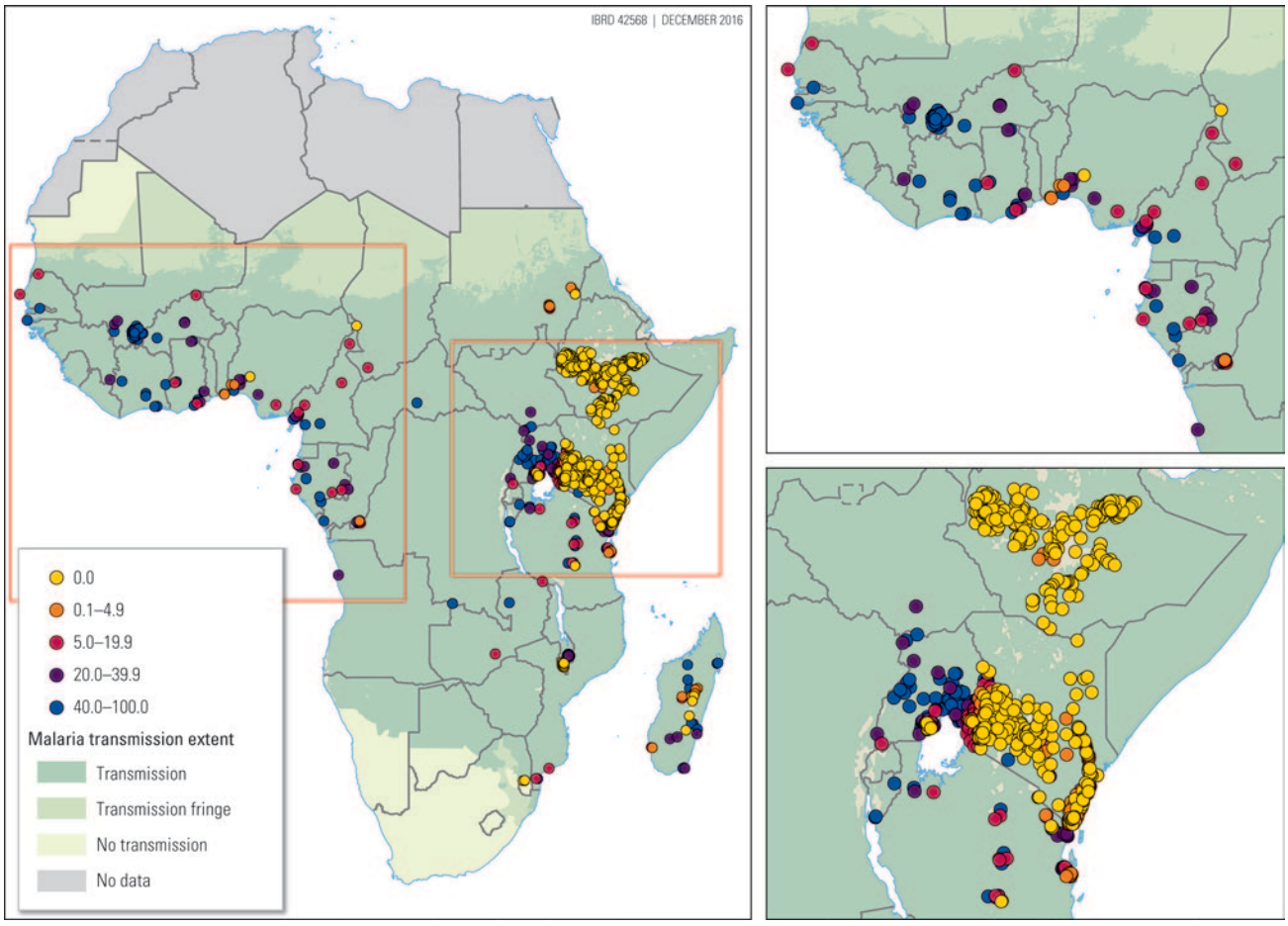
Malaria as a Cause of Anemia in School-Age Children

Anemia is a common problem among school-age children in the tropics. Its etiology is usually multifactorial, and the relative importance of different causes varies from area to area. It is difficult to separate malaria as a causative agent from other factors, such as nutritional deficiencies, helminth infections, and HIV/AIDS, which often coexist in the same communities (Stephenson and others 1985). Many other cross-sectional surveys carried out in highly endemic areas have found a significant association between the prevalence of anemia and parasitemia, but these studies were conducted mainly among preschool-age children.

The strongest evidence for the role of malaria as a cause of anemia in school-age children comes from the results of intervention studies with trials of intermittent preventive treatment (IPT) in school-age children showing improvement in hemoglobin concentration in both East Africa (Clarke and others 2008; Nankabirwa and others 2010) and West Africa (Barger and others 2009; Clarke and others 2013; Tine and others 2011).

Overall, differentiating the effect of malaria on anemia in school-age children from other confounding factors is difficult; the limited evidence available suggests that it has a significant role. Although administration of supplementary iron can increase the incidence of clinical attacks of malaria in some circumstances, most studies have shown only a modest effect (Ojukwu and others 2009). The WHO and other health authorities (Raiten, Namasté, and Brabin 2011) recommend that iron supplementation is indicated in areas in which iron

Map 14.2 Prevalence of Malaria Parasitemia in School-Age Children in Sub-Saharan Africa
Percent



Source: Malaria Atlas Project (MAP), http://www.map.ox.ac.uk.

deficiency is a major problem, even if these areas are endemic for malaria, provided that malaria control measures, such as distribution of insecticide-treated bednets (ITNs), are put in place at the same time.

Malaria as a Cause of School Absenteeism

The estimated annual loss of school time in Kenya attributable to malaria in 2000 was 4 million to 10 million school days (Brooker and others 2000). Because malaria is an important cause of school absenteeism, preventive efforts should significantly improve school attendance. In a randomized clinical trial in Sri Lanka, Fernando and others (2006) report a 55 percent reduction in malaria incidence and a 62.5 percent reduction in school absenteeism among children who received chloroquine prophylaxis.

Despite the limited number of studies, the available evidence suggests that the cumulative effect of school absenteeism attributable to malaria for children in endemic areas is considerable, preventing children from achieving their full academic potential and causing a loss to the state with respect to its investment in education.

Impact of Malaria on Cognitive Function

Studies in Africa and Asia provide strong evidence that malaria can impair the cognitive function of school-age children (Fernando, Rodrigo, and Rajapakse 2010; Kihara, Carter, and Newton 2006). Descriptive studies have evaluated the impact of severe malaria, uncomplicated malaria, and asymptomatic parasitemia on various aspects of cognition.

In Kenya, a retrospective assessment of children ages six to nine years who had had an episode of cerebral malaria found significant differences in speech and language and cognition, compared with the healthy control group (Carter, Mung'ala-Odera, and others 2005; Carter, Ross, and others 2005; Carter and others 2006); in Uganda, cerebral malaria was associated with persistent impairment of one or more cognitive domains

Table 14.2 Summary of the Results of Recent Trials of Chemoprevention in School-Age Children

Study setting	Population	Type	Treatment regimen	Study drug	Protective efficacy			Source
					Clinical malaria Percent (95% CI)	Malaria parasitemia Percent (95% CI)	Anemia Percent (95% CI)	
Year-round transmission								
Western Kenya	6,735 children ages 5–18 years; 30 schools	IPCs	Treatment once every school term (3 treatments per year)	SP + AQ	Not examined	89 (73–95)	48 (8–71)	Clarke and others 2008
Sierra Leone	591 children ages 6–14 years; 1 school	IPCs	Treatment at month 0 and month 3 (2 treatments per year)	SP	Not examined	No impact	No impact	Rohner and others 2010
Uganda	780 children; 3 schools	IPCs	Single course of treatment; protective efficacy measured after 42 days	SP	Not examined	No impact	No impact	Nankabirwa and others 2010
				SP + AQ	Not examined	48.0 (38.4–51.2)	Mean change Hb +0.37 (0.18–0.56)	
				DP	Not examined	86.1 (79.5–90.6)	Mean change Hb +0.34 (0.15–0.53)	
Uganda	740 children; 1 school	IPCs	Treatment once a school term (4 treatments per year)	DP	No impact	54 (47–60)	No impact	Nankabirwa, Wandera, and others 2014
		IPCs	Treatment once every month (12 treatments per year)	DP	96 (88–99)	94 (92–98)	40 (19–56)	
Highly seasonal transmission								
Mali	262 children ages 5–10 years; 1 village	SMC	Two treatments 8 weeks apart during the malaria season (2 treatments per year)	SP	36 (12–53)	Not examined	Not examined	Dicko and others 2008
Mali	296 children ages 6–13 years; 1 village	SMC	Two treatments 8 weeks apart during the malaria season (2 treatments per year)	SP + AS	66.6	80.7	59.8	Barger and others 2009
				AQ + AS	46.5	75.5	54.1	
Mali	1,815 children ages 6–14 years; 38 schools	IPCs	Single treatment at end of the malaria season (1 treatment per year)	SP + AS	Not examined	99 (98–100)	38 (9–58)	Clarke and others 2013
Senegal	1,000 children under age 10 years; 8 villages	SMC	Two treatments given monthly toward end of malaria season (2 treatments per year)	SP + AQ	79 (10–96)	57 (5–81)	41 (18–58)	Tine and others 2011

Note: AQ = amodiaquine; AS = artesunate; CI = confidence interval; DP = dihydroartemisinin-piperaquine; Hb = hemoglobin; IPCs = intermittent parasite clearance in schools; IST = intermittent screening and treatment; SMC = seasonal malaria chemoprevention; SP = sulphadoxine-pyrimethamine.

(John and others 2008). Similar findings were recorded in Malawian children with retinopathy-positive cerebral malaria (Boivin and others 2011).

Cerebral malaria is not a prerequisite for cognitive impairment as a consequence of malaria infection; studies have suggested that uncomplicated episodes of malaria can adversely affect cognition. Studies in Sri Lanka show that school-age children scored significantly lower on tests of mathematics and language during an episode of clinical malaria than children in the control group (Fernando, de Silva, and Wickremasinghe 2003). In a study in Sri Lanka, Fernando and others (2003) find a negative correlation between mathematical and language skills and a past history of repeated attacks of malaria during the preceding six years among children ages 6–14 years, even after correcting for socioeconomic factors. A history of one or more malaria attacks was associated with poor performance in mathematics and language in a cohort of 198 schoolchildren studied in Brazil (Vitor-Silva and others 2009). A study of school-age children in Mali, where *P. falciparum* malaria predominates, reaches similar conclusions (Thuilliez and others 2010).

Many of the studies considered were primarily descriptive, and their results are open to potential confounding by social or economic factors not included in the analysis. Accordingly, the strongest evidence to support the view that malaria impairs cognitive function comes from intervention trials. In Sri Lanka, a randomized, placebo-controlled, double-blind trial of chloroquine prophylaxis in children ages 6–12 years showed that educational attainment improved and that school absenteeism was reduced significantly ($p < 0.0001$) in children who took chloroquine prophylaxis (Fernando and others 2006). Children in The Gambia ages 3–59 months who were randomized to receive malaria prophylaxis with dapsone-pyrimethamine or placebo during the malaria transmission season for three successive years (Greenwood and others 1988) were reassessed when their mean age was 17 years (Jukes and others 2006). Educational attainment was better in children who had received prophylactic treatment than in the placebo group, but the scores for the cognitive tests were not significantly different between groups. Prophylaxis substantially increased the school enrollment of girls. The intervention also reduced school drop out for students in government schools (Zuilkowski and Jukes 2014).

In a large, stratified, cluster-randomized, double-blind, placebo-controlled trial conducted in schools in Kenya, IPT with sulphadoxine-pyrimethamine plus amodiaquine (SP + AQ) significantly improved sustained attention of schoolchildren ages 10–12 years (Clarke and others 2008). Significant effects on sustained attention are also reported from a trial in schools in southern Mali (Clarke and others 2013).

Overall, these studies strongly suggest that both clinical malaria and asymptomatic parasitemia can adversely affect the cognitive skills of school-age children, but the mechanism by which this occurs remains uncertain.

APPROACHES TO THE CONTROL OF MALARIA IN SCHOOL-AGE CHILDREN

A range of strategies is available for the control of malaria in this age group, delivered through schools or communities. The optimal approach to delivering interventions, including frequency and timing, and their ultimate effectiveness will vary according to the local intensity of malaria transmission. Malaria interventions are best delivered as part of an integrated package, for example, as part of a school health program that also delivers deworming (see chapter 13, Bundy, Appleby, and others [2017]) or school feeding (chapter 12, Drake and others [2017]).

Treatment of Clinical Attacks

Ease of access of school-age children to effective treatment for clinical attacks of malaria is an essential component of any effective national malaria control program. However, in many parts of Sub-Saharan Africa, geographic and financial barriers prevent children from obtaining rapid access to diagnosis and treatment (see volume 6, chapter 14, Babigumira and others 2017).

Schools can play a vital role in ensuring that their pupils obtain rapid access to diagnosis and treatment by providing appropriate health education activities in school, but information about the treatment of malaria is rarely part of the curriculum. A content analysis of school textbooks in nine endemic countries found that most included information on modes of transmission, mosquitoes, and signs and symptoms of malaria, but little about ITNs or the need for prompt and appropriate treatment (Nonaka and others 2012). These findings suggest that improving textbook content in accordance with the national malaria control strategy should become a priority.

Access to prompt treatment can be improved by providing antimalarials to schools and by training teachers to administer antimalarial treatments correctly. In the past, when first-line treatment was either chloroquine or SP given presumptively, training teachers to provide treatment was shown to be feasible and to reduce school absenteeism and malaria deaths (Afenyadu and others 2005; Pasha and others 2003). However, the WHO now recommends diagnosis before any antimalarial

treatment is given (WHO 2015). Building on recent efforts to expand diagnosis and treatment of malaria outside of the formal health sector (Ansah and others 2015), an ongoing study in Malawi is evaluating the impact on school attendance and health outcomes of training teachers to use rapid diagnostic tests (RDTs) (Witek-McManus and others 2015). If this approach is effective, operational issues, including supply chains, blood safety, and teacher attrition, will require careful consideration before the strategy is scaled up.

Vector Control

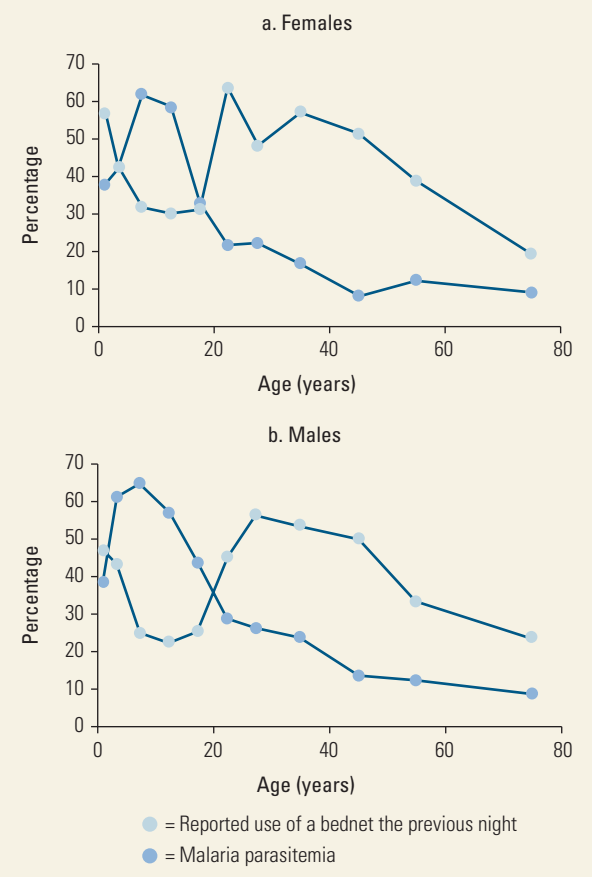
The main methods of vector control of malaria are ITNs, indoor residual spraying (IRS), and reduction of mosquito breeding sites.

Insecticide-Treated Nets

Strong evidence indicates that regular use of ITNs substantially lowers the risks of clinical malaria and all-cause mortality in children under age five years and reduces the burden of malaria among pregnant women (Lengeler 2004; Lim and others 2011). For these reasons, large-scale ITN distribution programs initially focused on these two vulnerable groups. However, following appreciation of the indirect herd effect of a high level of ITN coverage in a community, the development of long-lasting ITNs, and an increase in the financial and political support for ITN programs, there has been a shift from prioritizing vulnerable populations to protecting everyone with an ITN, including school-age children. However, an analysis of household surveys undertaken between 2005 and 2009 in 18 African countries found that school-age children were the group least likely to sleep under an ITN the previous night; between 38 percent and 42 percent of school-age children were unprotected (Noor and others 2009). Similar low ITN usage has been observed among school-age children in Cameroon (Tchinda and others 2012), Kenya (Atieli and others 2011), and Uganda (Pullan and others 2010) (figure 14.2). Substantial progress in population coverage with ITNs has been made since 2000, with more than 50 percent of the population of Sub-Saharan Africa sleeping under ITNs in 2015; nevertheless, ITN use among those ages 5–19 years remains lower than among the population as a whole (WHO 2015). Thus, even in countries with existing national policies of universal access to ITNs, school-based distribution of nets could have a complementary short-term role in addressing this gap.

Few studies have investigated the efficacy of ITNs in school-age children. An early trial among children in a rural boarding school in central Kenya showed that sleeping under an untreated mosquito net following a

Figure 14.2 Age Patterns in the Prevalence of Malaria Parasitemia and of Reported Use of a Bednet on the Previous Night in Uganda.



Source: Pullan and others 2010.

round of effective antimalarial treatment reduced the incidence of clinical malaria by 97 percent, but it did not reduce anemia (Nevill and others 1988). A reduction in the incidence of malaria was shown in a randomized trial of children ages 4–15 years in an area of low and unstable transmission on the Thai-Burmese border (Luxemburger and others 1994). In a rural area of western Kenya, where malaria transmission is perennial and high, a community-based trial showed that ITNs halved the prevalence of anemia in girls ages 12–13 years; ITNs were less effective in preventing anemia among girls ages 6–10 years (Leenstra and others 2003). Additional evidence provided by cross-sectional survey data suggests that net use among school-age children is associated with a 71 percent and 43 percent lower risk of *P. falciparum* infection in Somalia (Noor and others 2008) and Uganda (Pullan and others 2010), respectively. An analysis of country-wide data from school surveys in Kenya (Gitonga and others 2012) shows that ITN use was associated with a

reduction in the odds of malaria infection and anemia in coastal areas, where malaria transmission is low to moderate, and among boys in western lakeshore Kenya, where transmission is high. In addition, ITN use reduced the risk of parasitemia in the western highland epidemic zones and the risk of anemia in coastal areas where transmission is low.

As children become more independent with increasing age, parents have less control over their bedtimes, where they sleep, and whether they use nets. Education targeted directly to older children, for example, through malaria education in schools, could increase regular use of ITNs among teenage children.

Indoor Residual Spraying

IRS, the application of long-acting insecticides to the walls and roofs of houses and, in some cases, public buildings and domestic animal shelters, is an effective method of malaria control. IRS implemented as a community-wide campaign can achieve substantial reductions in the incidence and prevalence of malaria infection in all age groups (Pluess and others 2010). Repeated IRS campaigns conducted between 1955 and 1959 in the Pare-Taveta area of Tanzania were associated with a reduction in malaria parasitemia from 73 percent to 7 percent in children ages 5–9 years, and from 62 percent to 4 percent in children ages 10–14 years (Draper 1960). Targeted IRS conducted over 12 months in the epidemic-prone Kenyan highlands halved the monthly prevalence of asymptomatic infection in school-age children and reduced the incidence of clinical disease (Zhou and others 2010). Studies that have investigated the impact of combining vector control with ITNs and IRS have produced mixed results, with some showing a benefit and others no added effect.

Reduction of Breeding Sites

Breeding sites of malaria anopheline vector mosquitoes can be controlled in some epidemiological situations through application of larvicides, introduction of predator species, and habitat destruction and drainage (Tusting and others 2013). However, achieving a significant reduction in malaria transmission in many parts of Sub-Saharan Africa is difficult because of the multiplicity and changing nature of breeding sites of the main vector species, such as *Anopheles gambiae* (Fillinger and Lindsay 2011). It is unlikely that encouraging schoolchildren to destroy potential breeding sites of *An. gambiae* in school grounds will have any impact on the prevalence of malaria, although it could help reduce the numbers of other mosquito species, including those that transmit dengue.

Malaria Chemoprevention

The two main approaches to the use of antimalarial drugs to prevent malaria infection are chemoprophylaxis and IPT.

Chemoprophylaxis

Chemoprophylaxis involves the regular administration of antimalarial drugs to those at risk over a sustained period to provide persistent, protective blood levels. Compelling evidence indicates the benefits of chemoprophylaxis in school-age children. A review of trials of malaria chemoprophylaxis in the population of malaria-endemic areas reports significant health impacts in nearly all studies (Prinsens Geerligs, Brabin, and Eggelete 2003). Most of these studies focus on young children, but in 30 of the 36 trials that examined infection rates in children over age five years, reductions in malaria parasitemia ranged from 21 percent to 100 percent (Prinsens Geerligs, Brabin, and Eggelete 2003). A 2008 review confirms these findings (Meremikwu, Donegan, and Esu 2008). Chemoprophylaxis with chloroquine not only reduced the incidence of clinical malaria and absenteeism in Sri Lankan schoolchildren, it also significantly improved educational attainment (Fernando and others 2006).

Intermittent Preventive Treatment

An alternative to chemoprophylaxis is IPT, the periodic administration of a full therapeutic dose of an antimalarial or antimalarial combination to groups at increased risk of malaria. IPT clears existing asymptomatic infections and prevents new infections during the period immediately after treatment when protective blood levels are present. IPT is being evaluated in schoolchildren in two ways: intermittent parasite clearance in schools (IPCs) and seasonal malaria chemoprevention (SMC).

IPCs involves the administration of IPT on a periodic basis to schoolchildren, with the aim of clearing asymptomatic malaria infections and aiding hematologic recovery during the ensuing malaria-free period. Studies that have evaluated IPCs in school-age children are summarized in table 14.2. The first study of IPCs (called IPT in that study), conducted in schools in western Kenya, shows that IPCs with SP + AQ given once a term significantly reduced malaria parasitemia and anemia and significantly improved sustained attention (Clarke and others 2008). However, the spread of parasites resistant to SP, and the consequent withdrawal of SP and AQ in many East African countries, precluded further investigation of IPCs using these drugs in this area. Studies using alternative drugs, including dihydroartemisinin-piperaquine, conducted in a range of settings, show

effects on parasitemia, anemia, and clinical malaria similar to those obtained with SP + AQ, with a protective efficacy ranging between 54 percent and 99 percent reduction in malaria infection, and 38 percent to 60 percent reduction in anemia (Barger and others 2009; Clarke and others 2013; Nankabirwa and others 2010).

Several conclusions can be drawn from these studies.

- First, IPCs is highly effective in reducing the burden of malaria among school-age children.
- Second, the medication used for IPCs, and the timing of treatments, needs to be adapted to the local epidemiology.
- Third, IPCs is likely to be most effective in settings where a high proportion of children harbor asymptomatic infections, where malaria is a major cause of anemia, or both.

Seasonal Malaria Chemoprevention

SMC involves administration of treatment on a monthly basis to coincide with the annual peak in malaria transmission. This intervention is highly effective in reducing the incidence of clinical malaria and anemia in young children (Wilson 2011). In 2012, the WHO recommended implementation of SMC for children under age five years in areas of the Sahel subregion of Africa with highly seasonal transmission. This recommendation is being implemented increasingly widely in countries of the Sahel. Although less extensively researched, and not yet recommended by the WHO, evidence suggests that SMC is as effective in school-age children as in children under age five years (Barger and others 2009; Dicko and others 2008; Tine and others 2011, 2014), and Senegal provides SMC to children up to age 10 years.

Intermittent Screening and Treatment

An alternative to IPCs or SMC is intermittent screening and treatment (IST), an intervention in which individuals are screened periodically for malaria infection using an RDT, and those infected (whether symptomatic or not) are treated with a full course of an effective antimalarial agent or combination of agents. A population-based study of IST in Burkina Faso shows no impact on the incidence of clinical malaria in children under age five years or on malaria transmission (Tiono and others 2013); a cluster randomized trial in schools on the coast of Kenya, where transmission is low to moderate, finds no impact on health or cognition (Halliday and others 2014). Possible reasons for the absence of an impact in these studies are the inability of some of the currently available RDTs to detect low-density parasitemia, and the rapid rate of reinfection following treatment in the areas in which these studies were done. The potential of this approach to control malaria in school-age children needs further investigation.

Vaccination

Development of an effective malaria vaccine has proved to be a major challenge, despite the exploration of many innovative approaches. One vaccine (RTS,S/AS01) has shown partial efficacy in a large-scale Phase 3 clinical trial and was given a positive opinion by the European Medicines Agency in July 2015 (RTS,S Clinical Trials Partnership 2015). However, the duration of protection provided by RTS,S/AS01 is relatively short, and vaccination in early life is unlikely to provide protection that lasts into school age. Only very limited data are available on the safety and immunogenicity of RTS,S/AS01 in school-age children (Bojang and others 2005). RTS,S/AS01 is the most advanced malaria vaccine, but several other vaccines are making steady progress (Schwartz and others 2012); in the longer term, vaccination may have an important role in the prevention of malaria in school-age children.

ECONOMICS OF MALARIA CONTROL IN SCHOOLS

Few economic analyses have evaluated malaria control among school-age children. A 2011 systematic review identified 48 studies that evaluated the cost-effectiveness of malaria interventions (White and others 2011), of which only two were conducted among school-age populations. The first study evaluated the cost-effectiveness of community-wide IRS programs among children ages 2–15 years in southern Mozambique (Conteh and others 2004). The financial costs per person covered in the rural area and peri-urban areas were US$3.86 and US$2.41, respectively. Using health facility records to estimate the number of infections averted, the economic cost per case of malaria parasitemia averted among those ages 2–15 years was US$21.23.

The second study evaluated the cost-effectiveness of IPCs (Temperley and others 2008). The study estimated that the cost of IPCs delivered by teachers was US$1.88 per child per year, with drug and teacher training constituting the largest cost components. The estimated cost per anemia case averted through IPCs was US$29.84, and the estimated cost per case of malaria parasitemia averted was US$5.36 (Temperley and others 2008). Another study investigates the cost of IST delivered through schools and estimates the cost of IST per child screened to be US$6.61 (Drake and others 2011). These estimates

of cost and cost-effectiveness fall within the range of per capita costs of other malaria control strategies (White and others 2011), but they are more expensive than school-based deworming programs. However, the simultaneous delivery by teachers of both IPCs and deworming as part of an integrated school health package may yield economies of scope and increase cost-effectiveness. More studies are required on the cost-effectiveness of malaria control in schoolchildren.

It is also important to consider the effect of other ongoing malaria control measures because they will reduce malaria transmission in the wider community. In this situation, mathematical models of malaria can provide insight because they can simultaneously model multiple interventions and take into account the dynamics of malaria transmission, especially the mass effects of community interventions. For example, modeling of the cost-effectiveness of community-wide IST highlighted its value in medium-high transmission settings among school-age children, but only if it was continued indefinitely (Crowell and others 2013). The combined use of mathematical modeling and economic evaluation can help identify which interventions should be targeted specifically toward school-age children and which interventions should be delivered as part of community-wide malaria control.

CONCLUSIONS

On the basis of the available data, some recommendations can be made about the management of malaria in school-age children (box 14.1), but much more needs to be learned about the effectiveness of different approaches (box 14.2).

Better data are needed on the burden of malaria in school-age children. A standardized approach to data collection would improve the ability to monitor progress in this at-risk group. Systems to capture episodes of clinical and fatal malaria in school-age children do not need to be school based, but they should summarize data for this specific risk group.

The potential of serological tests to help in evaluating the burden of malaria in school-age children needs to be studied further. Improved information on the extent of the burden of malaria and on the socioeconomic consequences of malaria in this age group would enhance awareness at multiple levels.

- **Global level**: Policy makers and multilateral funding organizations would pay more attention to this issue.
- **National level**: Interactions among education, health, and potentially other sectors would be catalyzed.

Box 14.1

Policy Recommendations for the Control of Malaria in School-Age Children

National malaria control programs need to pay increasing attention to the problem of malaria in school-age children, as the proportion of cases of malaria in older children increases. Education about causes of malaria; its clinical features; and ways of diagnosing, treating, and preventing the infection should be an integral part of the curriculum of all schools in areas where the school-age population is at risk of malaria infection. All school-age children in high-transmission areas need to sleep under insecticide-treated bednets. School-age children who develop clinical malaria need to be able to recognize the nature of their illness and have easy and rapid access to reliable diagnosis and effective treatment, either in their schools or at nearby health facilities.

- **Local and individual levels**: Families that include schoolchildren would be better able to take the necessary steps to prevent and treat malaria.

Operational research is needed to determine how best to raise awareness of the importance of malaria, how to manage it, and how to improve the use of established control measures in this group. Improving the malaria-relevant content of school curricula will help children help themselves and equip them with the understanding needed to accept new approaches to the control of malaria, such as the value of blood testing for parasitological diagnosis to guide appropriate treatment. School-age children can become an important route for disseminating information on malaria control to the rest of the family.

Further studies are needed to understand the potential role of medications in preventing malaria in school-age children. Chemoprophylaxis, SMC, IPCs, and IST may all be beneficial, but it is not clear yet in which settings each might be most effective or cost-effective. Some chemoprevention is likely to be useful in high transmission settings. The cost-effectiveness of chemoprevention is likely to be lower in low transmission settings, where most recipients are unlikely to have malaria. However, the transmission threshold at which to introduce, or withdraw, chemoprevention will only become clear through the modeling of empirical data. The optimal characteristics of drugs for SMC, IPCs, and IST are likely to include low cost, a very good safety profile, exceptional tolerability, long

Box 14.2

Key Research Priorities for Malaria in School-Age Children

Epidemiology

- Acquisition of better knowledge of the magnitude and features of malaria in school-age children, especially in areas in which the overall incidence of malaria is declining

Pathogenesis

- Investigation both of the importance of malaria as a cause of anemia in school-age children and of how anemia is caused by the malaria parasite
- Investigation of the mechanisms by which severe, uncomplicated, and asymptomatic malaria impair cognition

Treatment

- Investigation of how malaria can be diagnosed using a rapid diagnostic test and treated effectively by school staff in different settings

Prevention

- Exploration of ways to improve coverage with insecticide-treated bednets among school-age children
- Investigation of the comparative advantages and cost-effectiveness of screening and treatment programs and of intermittent preventive treatment in the prevention of malaria in school-age children in high-risk areas, and investigation of the circumstances that favor either approach
- Exploration of the potential for vaccination to prevent malaria in school-age children

Economic and social consequences

- Acquisition of better knowledge of the socioeconomic consequences of malaria in school-age children, and the costs and benefits of individual malaria control measures in this age group

half-life, and single-dose treatment. The development of a rigorous target product profile would help guide the development of drugs suitable for use in the prevention of malaria in school-age children. The potential of IST programs to identify and help not only individuals but also communities at elevated risk of malaria warrants further exploration.

More effective control of malaria is only one part of the drive to improve the health and potential of school-age children. More work is needed to determine how and when to integrate malaria control strategies with other school-based programs at the local and national levels.

ANNEX

The annex to this chapter is as follows. It is available at http://www.dcp-3.org/CAHD.

- Annex 14A. Estimates of Parasitemia and Clinical Disease among School-Aged Children in Africa

NOTES

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- Nankabirwa J., S. J. Brooker, S. E. Clarke, D. Fernando, C. W. Gitonga, D. Schellenberg, and B. Greenwood. 2014. "Malaria in school-age children in Africa: an increasing important challenge." Trop med Int Health, 19:1294-1309.

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–US$4,125
  b) upper-middle-income (UMICs) = US$4,126–US$12,745
- High-income countries (HICs) = US$12,746 or more

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Chapter 15

School-Based Delivery of Vaccines to 5- to 19-Year Olds

D. Scott LaMontagne, Tania Cernuschi, Ahmadu Yakubu, Paul Bloem, Deborah Watson-Jones, and Jane J. Kim

INTRODUCTION

Significant progress has been achieved in the social, economic, educational, and health status of many populations. Compared with previous generations, the educational status of those born after 1990 has improved, as reflected in higher rates of school enrollment, especially in low- and middle-income countries (LMICs) (UNESCO 2014). Countries have started to expand their immunization programs beyond infants to young children, adolescents, and adults, with the goal of preventing, controlling, and where possible, eliminating vaccine-preventable diseases (WHO 2013a).

The combination of increased school attendance and expanded target populations for vaccines has created a rich opportunity for exploring vaccine delivery in schools (annex 15A, figure 15A.1). Meningitis, measles, hepatitis B, tetanus toxoid (TT), and human papillomavirus (HPV) are examples of vaccines offered in schools, either as routine primary or booster vaccinations or through campaigns for catch-up strategies or disease control (Grabowsky and others 2005; Mackroth and others 2010; WHO 2012a). These vaccines have demonstrated efficacy in preventing significant morbidity and mortality among school-age children, adolescents, and adults (Mehlhorn, Balcer, and Sucher 2006; WHO 2009). Understanding country experiences with the operational and logistical factors that have enabled successful delivery of vaccines through school-based programs—and the challenges encountered—can provide salient lessons for other countries, irrespective of income status. This chapter highlights the promise of school-based delivery of vaccines in LMICs, using the experience of TT and HPV vaccine delivery as examples. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017).

TETANUS AND HPV EPIDEMIOLOGY AND PREVENTION

Tetanus

Tetanus is caused by the bacterium *Clostridium tetani*, the spores of which are widespread in the environment (Black, Huber, and Curlin 1980). The bacterium is introduced into umbilical stump tissue during unclean delivery or unclean cord care practices, or occasionally at the site of traditional surgery and deep penetrating wounds. The disease is caused by the action of a neurotoxin produced by the bacteria when they grow in the absence of oxygen. Tetanus is characterized by muscle spasms, initially in the jaw. As the disease progresses, mild stimuli may trigger generalized tetanic seizure-like activity, which contributes to serious complications and eventually to death unless supportive treatment is given (Black, Huber, and Curlin 1980).

Vaccines containing TT are the primary prevention strategy against infection and have been in use

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for decades. Both the efficacy and the effectiveness of the TT vaccine are well documented (Newell and others 1971). TT vaccines, particularly the widespread expansion of maternal tetanus immunization services, have been largely responsible for the marked reduction in neonatal tetanus deaths, from 787,000 deaths in 1988 to 49,000 by 2013 (Liu and others 2015; Vandelaer and others 2003).

According to the World Health Organization (WHO), effective and full immunization against the tetanus infection requires five doses between infancy and adolescence (WHO 2006). An additional dose during the first pregnancy will protect a woman and her fetus throughout this and future pregnancies, provided that she has received all previous recommended doses (Rahman and others 1982). Countries have been using TT vaccines, including school-based vaccination, as a main strategy to eliminate maternal and neonatal tetanus and to maintain elimination status. The success of such strategies has been demonstrated in Tanzania (WHO 2013c).

Cervical Cancer

Cervical cancer is caused by several types of HPV (zur Hausen 1977). Two types, 16 and 18, account for approximately 70 percent of all cases (Denny and others 2015; Ferlay and others 2010). This virus is sexually transmitted, and most people are exposed within the first few years of engaging in sexual relations (Moscicki 2007). If the infection persists long term, women can develop precancerous lesions; if left untreated, these lesions can develop into cervical cancer (zur Hausen 1977). The progression from infection to disease takes, on average, 20 years. Globally, there are more than 528,000 new cases of cervical cancer and more than 266,000 deaths each year among women; more than 85 percent of the disease burden occurs in LMICs (Ferlay and others 2010).

Cervical cancer can be prevented through either primary prevention (vaccination) or secondary prevention (screening and treatment) (Denny and others 2015). Vaccines against HPV are effective when administered to individuals not yet exposed to HPV vaccine types, which for most people is before sexual debut (Denny and others 2015). Screening through cervical smears (Papanicolaou or Pap smears), visual inspection with acetic acid, or HPV DNA (deoxyribonucleic acid)-based testing is effective in detecting precancerous lesions that can be treated. Accordingly, HPV vaccination is recommended for girls ages 9–13 years (WHO 2014b), and screening is recommended for adult women generally beginning at age 25 or 30 years to age 49 years (Denny and others 2015).

Prevention

Both TT and HPV vaccinations have been demonstrated to be cost-effective in schools (Goldie and others 2008; Griffiths and others 2004). Targeting children at the beginning and end of primary school for booster doses of TT vaccines and targeting young adolescents before completing primary school for HPV vaccines have been two successful delivery strategies (LaMontagne and others 2011; Steinglass 1998). Young adolescents ages 9–11 years produce higher levels of antibodies to HPV vaccines, which are maintained at higher levels over time, compared with older adolescents (Block and others 2006). Additionally, delivering HPV vaccines at this young age generally ensures that girls receive the vaccine before sexual exposure to HPV (Moscicki 2007; WHO 2014b).

Since adolescents do not regularly attend health facilities, schools may offer advantages for reaching this population (Mackroth and others 2010). Increasingly high levels of primary school enrollment and attendance throughout LMICs have created an opportunity to identify and efficiently reach a large proportion of the population eligible for school-based vaccination (Grabowsky and others 2005; UNESCO 2014). Schools can also be used to leverage additional services or interventions (Broutet and others 2013) that might be needed by the age groups receiving TT or HPV vaccine, such as antihelmintics for deworming, vision screening, and bednet distribution (Broutet and others 2013).

PROGRAM DESIGN FOR SCHOOL-BASED VACCINE DELIVERY OF TT AND HPV VACCINES

TT Vaccine Delivery Strategies

The childhood tetanus immunization schedule recommended by the WHO includes five doses:

- Primary series of three doses of DTP (diphtheria/tetanus/pertussis) or other tetanus-containing vaccine, such as DTwP (diphtheria/tetanus/whole pertussis) or DTaP/TDaP (diphtheria/tetanus/acellular pertussis) given before age one year
- Booster dose of a TT vaccine at ages four to seven years
- Second booster dose between ages 12 and 15 years (WHO 2006).

Resources available through existing school health services are used to give the TT booster doses in adolescence while ensuring that out-of-school children are also served through routine activities of national immunization programs (WHO 2008b).

Many low- and lower-middle-income countries implement some school-based vaccination (annex 15A, table 15A.1), targeting the school grades where the largest proportion of children are found. Several countries have conducted household and school-based surveys to tabulate age-by-grade distributions to determine which grade is most appropriate for capturing the largest proportion of children—ages 4–7 years or ages 12–15 years. Indonesia found that most children ages 6–9 years are enrolled in grades one to three (Kim-Farley and others 1987). Nepal and Tunisia determined that entry in primary school was the optimal time to provide TT vaccination (Vandelaer, Partridge, and Suvedi 2009; WHO 2008c).

An email survey was sent to all 192 WHO member countries in 2008 (WHO-UNICEF 2009). Of the 143 countries responding, 61 countries (43 percent) reported conducting some school-based immunization. Among these 61 countries, the TT-containing vaccine was one of the interventions given; 41 countries (67 percent) start from primary school grade 1, and 54 percent target ages 9–13 years. Data from the 2012 WHO-UNICEF Expanded Programme on Immunization Joint Reporting Form indicate that, among 86 low- and lower-middle-income countries, 21 countries (24 percent) administer TT-containing vaccines; 10 of these countries deliver the vaccine in grade 1, and 16 deliver TT vaccines through grade 6 (on average, capturing children ages 12–15 years) (WHO-UNICEF 2013). The relatively low levels of school vaccination in these countries, combined with increasing school enrollment, particularly among girls, suggests an untapped opportunity to increase vaccination coverage through school-based programs.

Information, education, and communication components are essential in ensuring the success of school-based TT vaccination in LMICs. Parents and community leaders need to know why the children are being vaccinated; have resources for further information, as well as know when the vaccination activities will take place; and understand what to do if their children miss the vaccine. To prevent rumors that TT vaccination is connected to fertility control and to address the immunity gap that results in lack of a second opportunity for TT vaccination in adolescent boys and adult men, both boys and girls are often vaccinated. Information on the protection conferred by the vaccine against tetanus caused by injuries during sports, planting, and other activities helps achieve community acceptance (Steinglass 1998). The active engagement, collaboration, and training of the ministries of health and education on the requirements of the school-based TT vaccination are crucial (WHO 2008c).

HPV Vaccine Delivery Strategies

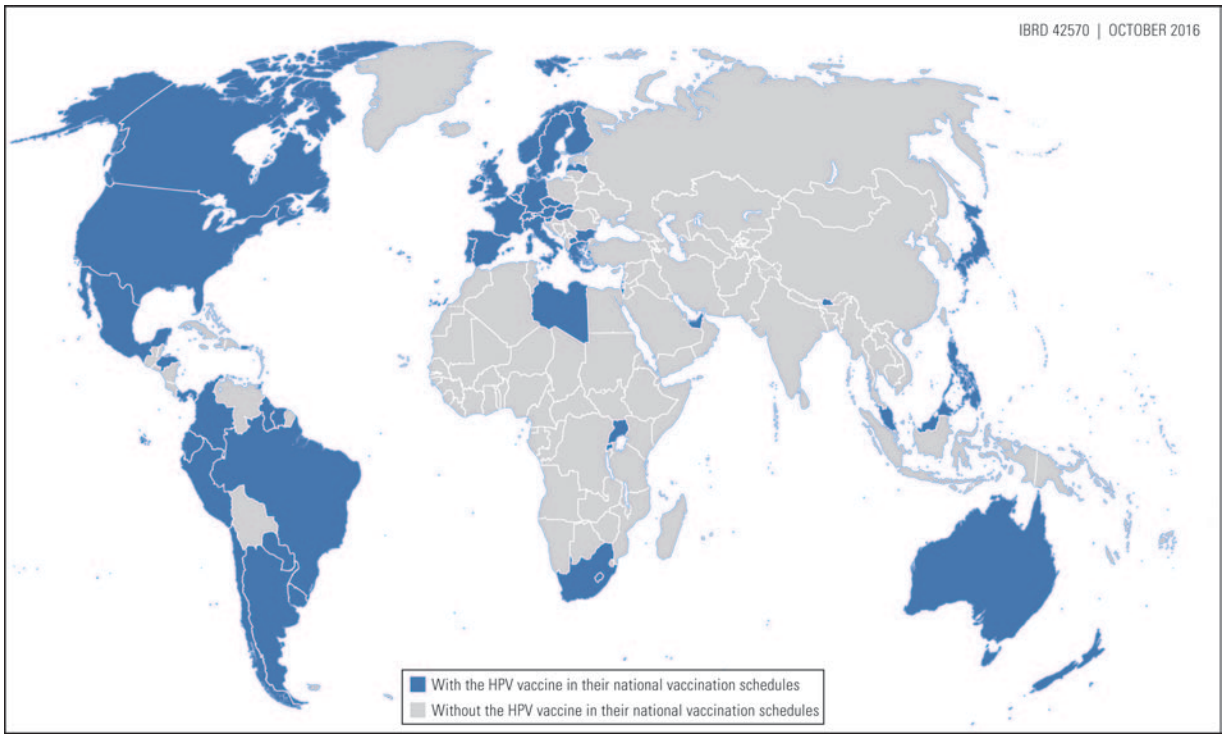
The WHO recommends that the HPV vaccine be given to girls between ages 9 and 13 years, including immunocompromised individuals (WHO 2014b). As of early 2016, three HPV vaccines are available—a quadrivalent vaccine (Gardasil, Merck & Co.), a bivalent vaccine (Cervarix, GlaxoSmithKline), and a nonavalent vaccine (Gardasil9, Merck & Co.). Licensure recommendations vary by country; in general, Gardasil and Gardasil9 are registered for use in females ages 9–26 years in 130 and 39 countries, respectively. In some countries, these two HPV vaccines are also registered for use in males of the same age for the prevention of genital warts. Cervarix is generally registered for use in females ages 9–44 years in more than 120 countries; it is not registered for males because no clinical trial of the efficacy of this vaccine in males has been conducted.

Although all HPV vaccines were licensed for a three-dose schedule, the European Medicines Agency (EMA) (EMA 2013, 2014) and the WHO Strategic Advisory Group of Experts on Immunization recently concluded there was sufficient evidence for the bivalent and quadrivalent HPV vaccines to recommend a two-dose schedule for young immunocompetent adolescent girls up to age 14 years, with a minimum interval of six months between doses (WHO 2014c). As of early 2016, 46 countries had adopted the revised two-dose schedule, or schedules with two initial doses and a delayed third-dose booster after five years, for young immunocompetent adolescent girls in their national immunization programs (Brotherton and Bloem 2015; Institute of Social and Preventive Medicine 2014).

As of early 2016, HPV vaccination is part of the recommended national schedule in nearly 80 countries or territories, of which approximately 25 percent are low- or middle-income (comprising both lower-middle and upper-middle income) countries. As of June 2016, 89 countries and territories have HPV vaccination on a national schedule (map 15.1; annex 15A, table 15A.2). However, an additional 37 LMICs have piloted the introduction of the vaccine in one or more urban and rural districts, 20 of which are in Sub-Saharan Africa (annex 15A, table 15A.3).

Based on experiences with pilot demonstration programs, school-based vaccination is most often used as the primary delivery strategy, usually accompanied by a secondary strategy based in health centers to reach out-of-school and underserved girls (Ladner and others 2012; LaMontagne and others 2011; Paul and Fabio 2014; Watson-Jones and others 2012). Countries introducing HPV vaccines through schools seem to use grade- and age-based eligibility equally (Gallagher and others 2016; LaMontagne and others 2011; Paul and Fabio 2014).

Map 15.1 HPV National Vaccine Introduction Globally, June 2016



Note: HPV = human papillomavirus.

Several elements make HPV vaccine delivery unique. These considerations may create operational challenges for implementation (WHO 2014a).

- There is often lack of awareness of cervical cancer and of HPV infection as a causal agent (Rama and others 2010).
- Unlike other immunization programs that target infants of both genders, HPV vaccination is targeted to girls ages 9–13 years (before sexual debut) (WHO 2014b).
- Because the recommended age group for HPV vaccination may not routinely attend health facilities, and visits by health workers to schools for vaccination may be one-time events, such as vaccination campaigns, delivery platforms and strategies used for HPV vaccine delivery may be new for LMICs (WHO 2012b).
- Consent procedures for HPV vaccines are not standardized; both opt-in and opt-out are used (Cover and others 2012; Moodley and others 2013; WHO 2014a).

HPV vaccination can be integrated with other health services for this underserved age group, which may enhance the efficiency and sustainability of vaccination programs (Broutet and others 2013; Mugisha and others 2015; Watson-Jones and others 2016). Some countries also use the opportunity to sensitize girls and women to the importance of adhering to the screening guidelines, the delivery of cervical cancer screening of adult women, or other child health programs (Wamai and others 2012).

HPV vaccination requires special attention to social mobilization and communication efforts to ensure acceptability and high coverage (Bingham, Drake, and LaMontagne 2009). In most low- and lower-middle-income countries, messages were disseminated through meetings in schools and communities, during home visits, and through written materials and radio announcements (Kabakama and others 2016; LaMontagne and others 2011). In Rwanda, Uganda, and Vietnam, teachers play an important role in communication efforts (Binagwaho and others 2012; Galagan and others 2013). The WHO encourages all countries to develop communication strategies with multisectoral stakeholders and engage communities at the start of planning the program (WHO 2013b). Among LMICs that have completed pilot delivery of HPV vaccine, all have chosen to focus messages on cervical cancer prevention and the importance of vaccination rather than to stress the sexual transmission of HPV because these messages have been proven to be

the most important for parental acceptability (Bingham, Drake, and LaMontagne 2009; Kabakama and others 2016; LaMontagne and others 2011).

Some pilot programs followed extensive informed consent processes (Moodley and others 2013). In others, the government used the same consenting procedures applied to other vaccines, including those delivered to children up to age 17 years, principally through an opt-out or implied consent approach (LaMontagne and others 2011). Pending developments that could facilitate easier delivery of HPV vaccines to young adolescent populations include expanded in-country licensure for delivery to boys (Markowitz and others 2012), alternative dosing schedules for three-dose regimens (Esposito and others 2011; LaMontagne and others 2013), and the recent approval of two-dose schedules for immunocompetent adolescent girls younger than age 15 years (WHO 2014c). Moreover, opportunities for reduced procurement prices through Gavi, the Vaccine Alliance and the Pan American Health Organization Revolving Fund, as well as potential cost reductions through the pooled purchase for middle-income countries by the United Nations Children's Fund, are likely to increase the number of countries that will introduce HPV vaccines by 2020 (Gavi, the Vaccine Alliance 2016).

EVIDENCE OF EFFECTIVE SCHOOL-BASED DELIVERY OF HPV AND TT VACCINES

TT Vaccine

Although some country programs have added delivery of TT vaccines to those as young as age 10 years, documentation of the implementation method, successes, and challenges has been largely absent in the literature. Among the 27 low- and lower-middle-income countries administering TT-containing vaccines in schools, 19 have reported coverage data (WHO-UNICEF 2013). In Indonesia, consistently high coverage of more than 95 percent of children enrolled in schools has been reported (Kim-Farley and others 1987; WHO-UNICEF 2013). Sri Lanka monitors the proportion of schools reached for immunization in each province, and 92 percent of all schools were covered by 2005 (WHO 2008b). Data from the 2014 WHO-UNICEF Joint Reporting Form show nine additional countries (Afghanistan, the Arab Republic of Egypt, Honduras, Mongolia, Mozambique, Nepal, Sierra Leone, Tonga, and Vanuatu) reported coverage levels for TT-containing vaccines of more than 80 percent for the population targeted in schools between 2011 and 2013 (WHO-UNICEF 2014). However, the lack of adequate documentation of TT-containing vaccines in schools continues to be a major obstacle to meaningful conclusions about school-based delivery for this intervention. A summary of facilitators and barriers to TT-containing vaccine delivery in schools is provided in annex 15A, table 15A.4).

HPV Vaccine

Schools have been a primary delivery strategy for HPV vaccine in a number of LMICs (Gallagher and others 2016; Ladner and others 2012; LaMontagne and others 2011; Raesima and others 2015). The rising levels of primary school attendance in many LMICs has enhanced this delivery approach (UNESCO 2014). The vaccine is usually offered at specific times during the school year, and school-based delivery may be combined with outreach or health facility vaccine delivery. High three-dose coverage (75 percent to 100 percent) has been achieved in pilot studies and demonstration programs using school-based delivery strategies, which is similar to the coverage levels achieved in national programs that also used school-based delivery (Brotherton and Bloem 2015; Markowitz and others 2012; Sinka and others 2013). A systematic review of HPV vaccine delivery experiences in 47 LMICs reported coverage levels of 70 percent or greater in the vast majority of programs that used a school-based delivery component (Gallagher and others 2016). Differences in coverage between the previously recommended three-dose schedule and the revised two-dose schedule were not observed; however, only 10 countries had reported coverage data from two-dose delivery. Further information about the possible impact of fewer doses on feasibility of school-based HPV vaccine delivery will be available in future years as this schedule becomes established.

Countries implementing school-based programs need to decide whether to establish age- or grade-based eligibility. A demonstration project in Tanzania found significantly higher coverage with grade-based vaccination, compared with age-based vaccination, at slightly lower cost (Watson-Jones and others 2012). Bhutan has reported national coverage of more than 90 percent through school-based delivery (Dorji and others 2015). A summary of facilitators and barriers to HPV vaccine delivery in schools can be found in annex 15A, table 15A.5.

COSTS AND COST-EFFECTIVENESS OF SCHOOL-BASED TT AND HPV VACCINE DELIVERY

Consideration of the costs and cost-effectiveness of school-based vaccination programs are instrumental in decisions for national introduction and scale-up (WHO 2006, 2014b). Given the shortage of routine

health services for adolescents (UNICEF 2007), the opportunities to leverage existing programs are limited (Broutet and others 2013; WHO 2008a). Accordingly, the incremental costs associated with implementation and delivery of TT and HPV vaccinations, both targeted to adolescents, are expected to be high relative to new childhood interventions. School-based delivery of vaccines provides an opportunity to access young adolescent populations who may not attend regular health services. To date, the empirical data on the added costs of school-based vaccination programs have been limited, with little to no coverage of TT vaccination (Griffiths and others 2004). However, several demonstration studies have emerged on the financial and economic costs of school-based HPV vaccination (Levin and others 2013; Levin and others 2014; Levin and others 2015).

Costs of HPV Vaccine Delivery

Several published studies have estimated the incremental costs of school-based HPV vaccine delivery in Bhutan, India, Peru, Tanzania, Uganda, and Vietnam, which are all LMICs (Levin and others 2015). Each of the analyses distinguished financial costs, reflecting actual expenditures, from economic costs, including the value of donated and shared resources, to more fully assess the opportunity costs of the HPV vaccination program. Results from three studies largely resulted in consistent estimates for economic and financial costs per HPV vaccine dose and per fully immunized girl (table 15.1; Levin and others 2013). In these studies, the incremental financial cost ranged from US$1.65 to US$2.25 per dose and US$4.96 to US$7.49 per fully immunized girl for a three-dose vaccination schedule. The economic costs were higher, ranging from US$2.11 to US$4.62 per dose and US$6.37 to US$16.10 per fully immunized girl. A two-dose vaccine schedule would reduce both financial and economic costs per fully immunized girl, but start-up costs are expected to be similar. As hypothesized, these costs are higher than the delivery costs of other routine immunizations reported in LMICs, which have ranged between US$0.75 and US$1.40 per dose, depending upon vaccine, country, and year of implementation (Brenzel and others 2006).

Specific findings from the studies also suggested interesting trends in the cost of HPV vaccine delivery mechanisms. For example, Quentin and others (2012) found that HPV vaccine delivery in urban schools was cheaper than delivery in rural schools, mainly due to higher costs of procurement and transport to rural areas. Irrespective of location, grade-based delivery was less costly by roughly 30 percent than age-based delivery in schools because of higher coverage and number of eligible girls. Hutubessy and others (2012) found that the recurrent costs for delivering HPV vaccines in schools were higher than delivery in health facilities by US$1.65 for three doses per eligible girl (US$0.55 per dose). Similarly, Levin and others (2013) found that school-based delivery had higher economic costs than an integrated (school and health center) approach or delivery solely in a health center, mainly due to the additional personnel and transportation costs required to reach the schools.

Table 15.1 Financial and Economic Costs for School-Based HPV Vaccine Delivery Using a Three-Dose Schedule (Excluding Vaccine Cost), 2013

U.S. dollars

	Tanzania (Hutubessy and others 2012)	Tanzania (Quentin and others 2012)	Peru (Levin and others 2013)	Uganda (Levin and others 2013)	Vietnam (Levin and others 2013)
Program scale	Scaled-up national program	Scaled-up regional program	Demonstration project	Demonstration project	Demonstration project
Method of estimation	Projected (using WHO C4P tool)	Projected	Microcosting approach	Microcosting approach	Microcosting approach
Financial cost, per dose	2.2	2.3	2.2	2.2	1.7
Financial cost, per FIG	7.5	7.1	6.5	6.9	5.0
Economic cost, per dose	4.6	4.0	4.1	3.2	2.1
Economic cost, per FIG	16.1	12.7	12.4	10.4	6.4

Note: FIG = fully immunized girl for recommended three-dose schedules at the time of study; HPV = human papillomavirus; WHO C4P tool = World Health Organization Cervical Cancer Prevention and Control Costing tool. Methods for estimating costs differed across studies, except in Peru, Uganda, and Vietnam.

Main Contributors to Costs

Head-to-head comparison of the main cost contributors across all settings was precluded by differences in categorizations of costs across studies. The cost of procurement, including receiving and transporting vaccines to the appropriate locations, was the largest cost component of scaled-up delivery of HPV vaccination in schools (46 percent to 70 percent of financial costs) (Hutubessy and others 2012; Quentin and others 2012). Of the remaining costs, service delivery, comprising health worker salary and allowances; social mobilization, comprising information, education, and communication (IEC); and supervision of vaccinations were important contributors to the total delivery costs (LSHTM and PATH, forthcoming).

In one study, costs were broadly categorized as start-up costs (for example, social mobilization and IEC, training, and microplanning) and recurrent (for example, personnel) costs (Levin and others 2013). Start-up costs of school-based vaccination programs were a large share of the total financial cost per dose (69 percent in Peru, 41 percent in Uganda, and 72 percent in Vietnam). When shared and donated resources were taken into account, start-up costs were far lower at 36 percent, 27 percent, and 56 percent of the total economic cost per dose, respectively.

The cost estimates may not be widely generalizable to other countries because the unit costs were setting specific. Accordingly, the experience of school-based delivery of HPV vaccines may not be generalizable to other adolescent vaccines such as TT, although the same principles may well apply. Furthermore, simultaneous delivery of TT and HPV vaccines in schools—to the same or different age cohorts or grades—may allow for the sharing of cost drivers, such as transport, which can reduce delivery costs.

Cost-Effectiveness of HPV Vaccination

According to several cost-effectiveness analyses in LMICs, HPV vaccination of preadolescent girls is likely to be good value for money, even at the higher cost of school-based delivery (Levin and others 2015). Several studies have estimated that the economic cost per fully vaccinated girl for a three-dose vaccination schedule was I$25 (25 international dollars) when the vaccine cost was US$5 per dose (Goldie and others 2008). At this vaccine cost, under assumptions of lifelong high vaccine efficacy against HPV-16/18 cervical cancers, the analyses found that HPV vaccination was very cost-effective in most LMICs, according to a cost-effectiveness threshold of per capita gross domestic product (GDP) (Fesenfeld, Hutubessy, and Jit 2013). At lower vaccine costs that are more reflective of the subsidized price of HPV vaccines for countries eligible through Gavi, the Vaccine Alliance (for example, US$0.55–US$2.00 per dose), HPV vaccination was found to be cost-saving or had attractive cost-effectiveness ratios well below per capita GDP (Goldie and others 2008; Kim and others 2013; Levin and others 2015). In these analyses, the most influential drivers of cost-effectiveness were the cost per vaccinated girl (including vaccine price and delivery costs), vaccine coverage and efficacy, overall cancer and genital warts disease burden, and assumptions about the discount rate. With the recent change in the recommended schedule for HPV vaccine among young immunocompetent adolescent girls from three doses to two and increased flexibility in the interval between doses, adjustments to the cost and cost-effectiveness assumptions and analyses are likely to result in an increasingly favorable cost scenario for school-based delivery in a wider range of LMICs.

The question of male HPV vaccination has been evaluated in several high-income countries, but only a few cost-effectiveness analyses have addressed this question in LMICs, and the conclusions have been mixed. In Brazil (Kim, Andres-Beck, and Goldie 2007) and Vietnam (Sharma, Sy, and Kim 2015), including males in the HPV vaccination program yielded marginal health gains relative to vaccinating girls only. While the analysis in Vietnam found that at a low vaccine cost, vaccinating boys had a cost-effectiveness ratio below per capita GDP, both studies concluded that increasing coverage in girls was more cost-effective than extending coverage to boys. In contrast, in Mexico (Insinga and others 2007), the quadrivalent HPV vaccine in both girls and boys was found to be very cost-effective when including genital warts and cervical cancer benefits. As in analyses from high-income countries, the cost-effectiveness of male HPV vaccination depends heavily on the achievable HPV vaccine uptake in females, vaccine price, and health conditions (such as male and female cancers) included in the analysis.

Overall, these findings imply that at the estimated total cost of delivering HPV vaccination in schools, HPV vaccination of preadolescent girls is good value for money, but that vaccination of boys is less certain.

Summary of Cost-Effectiveness Analyses

Although the evidence on the cost of HPV vaccine delivery in LMICs is emerging, findings from a number of studies in selected settings affirm that the cost of school-based delivery of HPV vaccination is slightly higher relative to other traditional and new infant immunizations. Reaching a target group not routinely served by national immunization programs may require new or

modified delivery strategies (LaMontagne and others 2011; WHO 2014b); more intensive IEC activities (Galagan and others 2013; WHO 2013b); and additional logistics and staff time, resulting in higher start-up and recurrent costs. An analysis from Tanzania concluded that the financial cost of introducing HPV vaccination for a three-dose schedule to 26 regions over a five-year period (2011–15) was an estimated US$11.9 million, excluding vaccine cost; or US$40.9 million with vaccine at an unsubsidized price of US$5 per dose (Hutubessy and others 2012). To the extent that scaling up a program to the national level would result in economies of scale; or that the vaccination program could be integrated as part of an existing, efficient program; or that the vaccination schedule would be reduced from three doses to two, both financial and economic costs of HPV vaccine delivery may be lower than what has been estimated in these smaller-scale studies. Countries will need to commit substantial resources to initiate, scale up, and sustain HPV vaccination programs.

Based on the start-up and recurrent cost estimates of school-based delivery from published studies, the majority of cost-effectiveness analyses have found HPV vaccination to be good value for money, even in the poorest countries. Securing a low vaccine cost and achieving high vaccine uptake and adherence in adolescent girls will maximize the return on investment of school-based HPV vaccination in any setting.

CONCLUSIONS

School-based delivery of vaccines is a viable approach for the control of infections and diseases that cause significant morbidity and mortality. Increasing school enrollment and attendance by children and adolescents, particularly girls, has changed the landscape for health service delivery, providing an excellent opportunity to capture large proportions of populations eligible for TT-containing, HPV, and other vaccines. To ensure equitable access for the most vulnerable populations, school-based delivery of vaccines must be complemented by strategies to reach those not attending school, such as mobile teams, outreach, and provision of vaccines at health facilities.

The wide variety of experiences using schools to deliver TT-containing vaccines in 27 LMICs or HPV vaccines in 47 LMICs has provided valuable lessons about the factors that have resulted in success. Pilot programs have been useful in providing countries with the opportunity to test new delivery strategies and learn what works well in their contexts. Community acceptance can be achieved through effective sensitization and mobilization efforts. Feasible delivery strategies for LMICs, especially using two-dose schedules, can be implemented and reach high coverage. And a strong case for the cost-effectiveness of using schools as a location for adolescent vaccinations has been documented.

Government ownership, endorsement, and financial support; active and sustained involvement and leadership from ministries of health and education; and broad-based community support from health workers, teachers, community leaders, civil society, parents, and adolescents are critical elements in the success and sustainability of any vaccine delivery program, but especially those using schools.

Delivery of TT-containing and HPV vaccines is an opportunity to regalvanize school health programs and build a stronger foundation for the delivery of other important health interventions. A holistic approach combining vaccine delivery with other interventions may help sustain both and has the potential to lead to improvements in the overall health of children and adolescents.

ANNEX

The annex to this chapter is as follows. It is available at http://www.dcp-3.org/CAHD.

- Annex 15A. Supplemental Figures and Tables for School-Based Vaccinations

NOTES

Tania Cernuschi, MSc, MPH, represented Gavi, the Vaccine Alliance Secretariat, Geneva, Switzerland, at the time this work was performed.

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.

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Chapter 17

Disability in Middle Childhood and Adolescence

Natasha Graham, Linda Schultz,
Sophie Mitra, and Daniel Mont

INTRODUCTION

Worldwide, people with disabilities have difficulty accessing education, health services, and employment. Disability is an economic development issue because it is linked to poverty: disability may increase the risk of poverty, and poverty may increase the risk of disability (Sen 2009). A growing body of evidence indicates that children with disabilities and their families are more likely than their peers to experience economic disadvantage, especially in low- and middle-income countries (LMICs).

Approximately 15 percent of the world's adult population lives with some form of disability (WHO and World Bank 2011). Children ages 0–14 years account for slightly less than 6 percent of persons with disabilities globally, but the number of disabled children is grossly underestimated in LMICs (UNICEF 2008). The estimates for prevalence of disability among children fall in a wide range because the methods for identifying them in surveys have varied (Cappa, Petrowski, and Njelesani 2015). This variation results from the complexity of identifying childhood disability (Meltzer 2010, 2016). However, new international standards offer hope for good quality, internationally comparable data moving forward.

This chapter expands on a central theme of this volume: the need for a multisectoral approach to addressing the complex interactions between child and adolescent development and physical and mental health. In particular, we have focused on the relationship with education—the gateway to participating fully in society, securing a livelihood, and capitalizing on the opportunities that society offers. Children with disabilities are less likely to attend school; when they do attend school, they are less likely to stay in school and be promoted (Filmer 2005; Mizunoya, Mitra, and Yamasaki 2016; WHO and World Bank 2011). They account for a large proportion of children who do not complete a primary education, reducing their employment opportunities and productivity in adulthood (Burchardt 2005; Filmer 2008; Mete 2008).

The literature has focused on advocacy, reflecting the relative neglect of this important area. This focus is beginning to change, at least with regard to the availability of information, and efforts to provide more quantitatively rigorous information are increasing (see, for example, WHO and World Bank 2011). However, information for children and adolescents ages 5–19 years is notably lacking, especially from LMICs. In this age group, the focus has been on schoolchildren and the development consequences of excluding children from education. In the absence of a comprehensive economic analysis or review of disability and development in children and adolescents, this chapter makes extensive use of case studies, which document real-world efforts in LMICs to address disability in this age group in poor communities.

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Through the use of these case studies, this chapter provides examples of how deprivations can become disability if children are excluded from school in LMICs. The case studies emphasize interventions to ensure that children with disabilities gain access to education, and they examine the design of supportive education systems and the use of school health programs to address the needs of children with impairments. Most assessments have focused on physical disability, especially mobility, and they provide this specific perspective on barriers to education. Little is known about these common forms of disability in LMICs; even less is known about the impact of sociobehavioral constraints, such as those associated with autism, which we know to be prevalent and important constraints in high-income countries (HICs). This chapter explores this issue in a case study of a rare program in a lower-middle-income country in Sub-Saharan Africa. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017).

DISABILITY DEFINITIONS AND MEASUREMENTS

Disability can be defined and measured in several ways. Traditionally, disability was considered a medical issue to prevent or cure (medical model). Later, disability came to be considered a social construct that required societal changes (social model). More recently, interactional models of disability have been developed that combine both medical and social determinants and courses of action. In this bio-psychosocial model, disability is seen as emerging from the interaction between impairments and the environment; environment is understood as going beyond the physical environment to include the cultural and institutional environments. Several interactional models are available (Mitra 2006; Shakespeare 2006); the most influential is the one underlying the International Classification of Functioning, Disability and Health (ICF) (WHO 2002). In the ICF, disability refers to the negative aspects of the interaction between the individual with a health condition and the context of the person (such as physical and attitudinal). Under the ICF, disability is used as an umbrella term for impairments, activity limitations, and participation restrictions. In addition to theoretical definitions for these models, various definitions of disability are used by statistical agencies that collect information on censuses and surveys, as well as by legislative and political bodies to determine eligibility for disability programs or coverage under disability rights laws. The UN Convention on the Rights of Persons with Disabilities uses a concept of disability consistent with the social model.[1]

The differing nuances of the word *disability* and the differing cultural contexts within which people operate have made internationally comparable data on the incidence, distribution, and trends difficult to obtain. Where children are involved, further complexities arise. For example, survey questions developed for adults but used for children may skew the results (WHO and World Bank 2011), and caregivers who complete surveys may not accurately portray children's experiences (Chamie 1994). The setting for data collection can also affect the prevalence estimates for children. For example, HICs often identify disability in medical or educational settings, but many LMICs do not have formal services for identifying children with disabilities (Cappa, Petrowski, and Njelesani 2015).

Progress is being made with respect to measuring disability in an internationally comparable manner, and the United Nations Children's Fund (UNICEF) and the Washington Group on Disability Statistics (WG) have developed a survey for identifying children with disabilities. Data using the child functioning module, or *child questionnaire* have been finalized and ready for use.

The WG has also developed questions for adults that have already been adopted in censuses, general surveys, and disability-specific surveys, creating a growing evidence base for work on disability and development (Altman 2016). Both the WG's adult and the child measures define people with disabilities as those with functional and basic activity limitations that put them at risk of social exclusion due to barriers in the environment (Altman 2016).

Various ethical considerations arise when collecting data on children with disabilities. Data on children come from surveys of mothers or primary caretakers. Caretakers who have responded to questions about children's difficulties functioning might expect that the questions will be followed by services, and a second-stage assessment needs to be linked to service delivery. Another concern is the issue of labeling a child as having a disability. This labeling can cause shame to families in some cultures and can create expectations that limit children. Fortunately, the newer approach to disability identification in surveys, as in the UNICEF/WG instrument, lessens the impact of this issue significantly. The word *disability* is never used, and children are never labeled as having a disability. Children are identified only anonymously in statistical analyses, rather than on a case-by-case basis in person.

This chapter defines disability by a person's functional, activity, and participation limitations based on his or her physical, cultural, and policy environments. The concept of disability is not solely equated with a medical diagnosis; it encompasses an environment that

restricts a person's activity and participation. A lack of assistive devices, an inaccessible physical environment, negative attitudes, and stereotypes all prevent people from participating in society on an equal basis. Because this chapter is a literature review, it also uses the definitions underlying the studies under review, which may be different from the above definition.

PREVALENCE BY AGE AND TYPE OF DISABILITY

The estimated prevalence of childhood disability varies substantially across and within countries, depending on questionnaires and study designs under use. The prevalence estimates in this chapter are not definitive but rather a reflection of available data. A literature review by Cappa, Petrowski, and Njelesani (2015) found that the prevalence of childhood disability in LMICs ranged from less than 1 percent to almost 50 percent. Unfortunately, census data are not good sources of data on disability among children because census questions—even the short set of WG questions recommended for use in censuses by the United Nations Statistical Commission—are not effective in identifying children with developmental disabilities. A special child-functioning survey module is needed to accurately assess disability status, and this module would be too long for use in censuses.

Despite the shortcomings of the measures used to date, there are a number of estimates of disability prevalence among children. Based on the latest Global Burden of Disease (GBD) data (IHME 2016), on average, a greater percentage of children ages 0–14 years in LMICs are estimated to have a disability compared with children of the same age group in HICs (table 17.1). The IHME statistics define disability in a particular way because it is used as the basis for the estimation of disability-adjusted life years. Disability in this context includes the acute, often temporary, and typically reversible disability that arises from, for example, an episode of influenza, a bout of malaria, or a broken limb, as well as the chronic, often permanent, and typically irreversible conditions within the more usual definitions of disability. As a result, the IHME definition leads to estimates that suggest a much larger proportion of the population is affected.

UNICEF (2005) estimates that 150 million children and adolescents younger than age 18 years live with disability. Mizunoya, Mitra, and Yamasaki (2016), using the WG questions for adults, found that the median prevalence stands at 0.8 percent and 1 percent for primary- and secondary-school-age children, respectively, in 15 LMICs. Disability prevalence in primary-school-age children did not surpass 1.5 percent in 12 of 15 countries, but it was much higher in 3 countries (2.9 percent in Uganda; 4.5 percent in South Africa, and 5.0 percent in Maldives). Disability prevalence rates in secondary-school-age children do not exceed about 2.0 percent in 13 of 15 countries. None of these disability prevalence estimates for children is satisfactory, and more research and data collection are needed in this area.

The GBD estimates are inferred from data on health conditions and impairments alone, using available data on distributions of limitations that may result from health conditions and impairments. Mizunoya, Mitra, and Yamasaki (2016) used a questionnaire developed for adults, which is known to be unable to identify certain disabilities that prevail among children, such as developmental disabilities.

There are many types of disability, with varying degrees of severity. A disability can be physical, cognitive, psychosocial, communicative, or sensory. The nature of the causes of the impairments associated with these disabilities can vary significantly by country context, as can the types of barriers that children with those disabilities face. Attention to the type of disability can add a good deal of depth to the analyses of disability data and the development and implementation of disability policies. *Disease Control Priorities in Developing Countries*, second edition, discusses discuss loss of vision and hearing (Frick and others 2006) as well as learning and developmental disabilities (Durkin and others 2006).

Unfortunately, good-quality data on the type of disability—especially data that are internationally comparable—are difficult to obtain (Cappa, Petrowski, and Njelesani 2015; Maulik and Darmstadt 2007). That is one reason that UNICEF and the WG have developed a module on childhood disability. Even data using the Ten Question Screening Instrument adopted in UNICEF's Multiple Indicator Cluster Survey are of limited use in this regard for several reasons. First, the instrument was not designed for complete disaggregation by type of disability. Second, it was designed as part of a two-stage process. The first stage was to cast a wide net to capture all children who might possibly be identified as having a disability, to be followed by more detailed assessment. The second stage, however, is rarely done, which presumably creates false positives for studies using only the Ten Question Screening Instrument. There is no reason to believe that the false positives in the dataset have the same distribution by type of disability as the true positives. Where follow-up assessments have been used (for example, the 2013 Two-Stage Child Disability Study in Bhutan undertaken by the Bhutan National Statistics Bureau), however, there have been questions about their quality because they require personnel with specific training. The Bhutan report notes that some level of issues arose with the cognitive follow-up assessments.

Table 17.1 Estimated Point Prevalence of Disability and Severity among Children and Adolescents Ages 0–14 across WHO Regions

percent

Sex and age group (years)	World	High-income countries	Low- and Middle-Income Countries, WHO Region					
			Africa	Americas	Eastern Mediterranean	Europe	South-East Asia	Western Pacific
No disability								
Male 0–14	30	37	22	31	35	36	30	32
Female 0–14	30	37	22	30	33	36	30	31
Very mild disability								
Male 0–14	12	11	13	11	11	13	12	11
Female 0–14	11	12	13	11	11	13	11	11
Mild disability								
Male 0–14	18	15	20	19	18	17	21	19
Female 0–14	20	17	22	21	20	19	23	20
Moderate disability								
Male 0–14	22	23	23	21	19	20	21	21
Female 0–14	22	22	23	21	20	20	20	21
Severe disability								
Male 0–14	15	12	18	15	14	12	15	14
Female 0–14	14	10	17	14	14	11	14	13
Very severe disability								
Male 0–14	2	2	3	2	2	2	2	2
Female 0–14	2	2	3	3	2	2	2	2

Source: IHME 2016.
Note: High-income countries includes Asia Pacific and North America. Western Pacific includes East Asia, South Asia, Central Asia, Oceania, Australasia, and the Western Pacific.

Comparison problems arise in HICs as well. As table 17.2 shows, data on disability among children and adolescents from Australia and the United States are not comparable; the age categories are different as are the categories of types of disabilities assessed. One common result, even with these differences, is that boys have a higher rate of disability. This is a common finding across almost all child disability surveys.

Using its 10-question Multiple Indicator Cluster Survey, UNICEF screened more than 200,000 children ages two to nine years in 20 countries for risk of disability (UNICEF 2008). Between 14 percent and 35 percent of children screened positive for risk of disability in most countries (UN Statistics Division 2010). However, this finding is an overestimate because the questions were designed to be a first-stage screen to be followed by a more detailed assessment that was not conducted.

The surveys revealed important trends in disability risk among children. For example, children in ethnic minority groups, from poorer households, and with limited early childhood education were more likely than their peers to screen positive for disability (UNICEF 2008). Weight and nutrition are risk factors as well (Groce and others 2013). Low birth weight and a lack of essential dietary nutrients, such as iodine or folic acid, are associated with incidence and prevalence of disability (Hack, Klein, and Taylor 1995; UNICEF 2008; Wang and others 1997). The proportion of children at risk for disability increases among children with severe stunting and nutrient deprivation (UNICEF 2008). An estimated 200 million children younger than age five years do not reach their full cognitive, social, and emotional development potential (Grantham-McGregor and others 2007).

Table 17.2 Prevalence of Disability by Type of Disability, Australia and the United States

percent

	Australia			United States		
	Ages 0–14 years			Ages 5–17 years		
	Boys	Girls	All	Boys	Girls	All
Intellectual or learning	5.2	2.0	3.7	—	—	—
Remembering	—	—	—	5.3	2.8	4.1
Psychiatric	1.5	0.7	1.1	—	—	—
Sensory or speech	4.0	2.1	3.1	—	—	—
Hearing	—	—	—	0.6	0.6	0.6
Vision	—	—	—	0.9	0.8	0.8
Physical	4.2	3.1	3.7	0.7	0.6	0.6
Acquired brain injury	0.5	0.2	0.3	—	—	—
Going outside the home	—	—	—	2.2	1.8	2.0
Dressing	—	—	—	1.2	0.7	0.9
Total	**9.6**	**5.4**	**7.6**	**6.5**	**4.0**	**5.3**

Sources: AIHW 2004; American Community Survey 2014, https://www.census.gov/people/disability.
Note: — = not available. The columns sum to more than the total because some children have multiple disabilities and so are included in more than one row.

DISABILITY AND SOCIOECONOMIC INEQUALITIES: DETERMINANTS, CONSEQUENCES, AND CORRELATION

Disability is both a determinant and a consequence of socioeconomic inequalities. Children in poor families or communities, in LMICs especially, are exposed to poverty-related risk factors that may contribute to the onset of health conditions associated with disability. Low birth weight and cumulative deprivations from malnutrition (Black and others 2008; UNICEF 2008), lack of clean water, and inadequate sanitation can manifest in developmental disabilities (Rauh, Landrigan, and Claudio 2008). In addition, lack of access to health services may convert a health condition into a disability. Finally, a child with a disability might experience further issues that exacerbate the severity of his or her disability (Krahn, Hammond, and Turner 2006). First, certain resources, such as clean water and sanitation or health clinics, may be inaccessible. Second, individuals with disabilities may be subjected to discrimination within their families and receive a disproportionately low share of familial resources (Rosales-Rueda 2014).

Growing evidence suggests a correlation between poverty and disability among children and adults with disability (WHO and World Bank 2011). Overall, in LMICs the evidence points to individuals with disability often being economically worse off in educational attainment; the evidence is more mixed with regard to employment, household assets, and expenditures (Mitra, Posarac, and Vick 2013; Mizunoya and Mitra 2013). However, several studies have provided growing evidence that disability is associated with a higher likelihood of experiencing multiple deprivations simultaneously (Mitra, Posarac, and Vick 2013; Trani and Canning 2013; Trani and others 2015; Trani and others 2016). Although the nature of deprivations may vary across countries, they may include employment, health, educational attainment, household material well-being, social participation, or psychological well-being.

Even with the same levels of income, people with disabilities and their households are likely to be effectively poorer than people without disabilities and their households. This trend is in part due to the direct costs of disability, for example, higher health and transportation costs (Braithwaite and Mont 2009; Cullinan, Gannon, and Lyons 2011; Zaidi and Burchardt 2005). Researchers have attempted to quantify the extra cost of living with a disability, but the findings vary considerably. The costs of disability accounted for an estimated 9 percent of income in Vietnam, 14 percent in Bosnia and Herzegovina, and 11 percent to 69 percent in the United Kingdom (Braithwaite and Mont 2009; Zaidi and Burchardt 2005).

The direct and indirect costs related to disability can worsen social and economic well-being through many channels, including the costs associated with medical care, assistive devices, personal support, and exclusion

from employment (Jenkins and Rigg 2003). People with disabilities can be poorer because of the loss of work productivity resulting from various factors including their exclusion from the workforce, as well as from the more limited labor participation of their family members who might have care-giving responsibilities (Buckup 2009; Palmer and others 2015). The estimated cost of lost productivity due to exclusion from employment among individuals with disabilities is as high as 7 percent of gross domestic product (Buckup 2009). Many of the direct and indirect costs could be reduced if inaccessible environments were more inclusive (WHO and World Bank 2011). This two-way causality between disability and socioeconomic deprivations may also combine with other factors, such as violence and conflict, that may lead to both disability and poverty simultaneously.

Educational opportunities may mitigate some of the associations between disability and poverty. In a cross-country study of 13 LMICs, disability was associated with a higher probability of being poor, but this correlation was no longer statistically significant once educational attainment was controlled for, suggesting that education could mediate this association (Filmer 2008).

DISABILITY AND EDUCATION

Many children with disabilities have been excluded from mainstream educational opportunities in many parts of the world. Education is particularly important for disabled children, who are often stigmatized or excluded. School attendance helps dispel the misconceptions about disability that serve as barriers to inclusion in other spheres (Bundy 2011). Education bolsters human capital, minimizes barriers to entering the workforce, and improves economic earning potential.

Inclusive education is based on the belief that all children can learn and should have access to a curriculum and necessary adaptations to ensure meaningful educational attainment. Support for inclusive education is gaining momentum in LMICs, with a few countries adapting strategies to fit the local context. Durkin and others (2006) examine interventions likely to improve child development and educational outcomes for children in LMICs. At present, no country has a fully inclusive system (WHO and World Bank 2011).

School Attendance

A large body of evidence shows that adults with disabilities in LMICs have lower educational attainment than adults without disabilities: Bulgaria, Georgia, Moldava, Romania (Mete 2008); 15 countries (Mitra, Posarac, and Vick 2013); Vietnam (Mont and Cuong 2011); Afghanistan and Zambia (Trani and Loeb 2012); Morocco and Tunisia (Trani and others 2015); India (World Bank 2007); 51 LMICs and HICs (WHO and World Bank 2011).

This association, consistently found among adults, may result from lower school attendance among children with disabilities, or it may be due to more frequent onsets of disability among adults with limited educational attainment, for example, via malnutrition, lack of access to health care, and risky working conditions.

There is a small but growing literature on school attendance and disability in LMICs. Much of this literature is descriptive and documents the extent of the gap in school attendance across disability status (Filmer 2008; Trani and Canning 2013). Filmer (2008) documents gaps in school attendance across disability status in 13 LMICs from 1992 to 2005, ranging from 10 percent to 60 percent in middle childhood (ages 6–11 years), and 15 percent to 58 percent in adolescence (ages 12–17 years), although the measures of disability vary substantially. Studies in Malawi, Namibia, Zambia, and Zimbabwe found that, while only 9 percent to 18 percent of nondisabled children older than age five years had never attended school, 24 percent to 39 percent of disabled children had never done so (Eide and Loeb 2006; Eide, van Rooy, and Loeb 2003; Eide and others 2003; Loeb and Eide 2004). In India, close to 40 percent of disabled children were not enrolled in school, compared with 8 percent to 10 percent of children in Scheduled Tribes or Castes (World Bank 2007).

Mizunoya, Mitra, and Yamasaki (2016) explored the gap in enrollment in primary and secondary education between children with and without disabilities using the WG measure for adults. Using nationally representative datasets from 15 LMICs, they found consistent and statistically significant disability gaps in both primary and secondary education in all countries. A household fixed effects model shows that disability reduces the probability of school attendance by a median of 30.9 percentage points, and that neither the individual characteristics nor their socioeconomic and unobserved household characteristics explain the disability gap. This finding indicates that general poverty reduction policies through social transfers to the poor will not contribute to closing the disability gap in schooling. Finally, Mizunoya, Mitra, and Yamasaki (2016) found that the disability gaps for primary-school-age children follow an inverted U-shape relationship with gross national income (GNI) per capita. This result suggests that, as GNI per capita rises and more resources become available for improving access to education, children without disabilities increasingly attend school, whereas the situation of children with disabilities may improve only slowly.

Among children with disabilities, enrollment rates differ according to type of impairment. In Burkina Faso, disabled children were more than twice as likely not to attend school as other children, but only 10 percent of deaf children were in school, compared with 40 percent of children with other physical disabilities (UNESCO 2010). In India, more than 50 percent of children with mental disabilities were enrolled, compared with 70 percent of children with poor vision, presumably because both physical access and their ability to communicate with teachers is higher for the latter group (Mont 2014).

Barriers to Education

Beyond enrollment and regular attendance, studies show that children with disabilities are more successful in schools that are accessible for all learners (Dessemontent, Bless, and Morin 2012; Kalambouka and others 2007; Lindsay 2007; Ruijs and Peetsma 2009). Common barriers to education include gaps in policy regarding inclusive education, including limited resources, insufficient number of trained teachers, lack of adaptive learning materials, and inaccessible facilities:

- *Accessible facilities.* Building accessible schools is vital to making the transition to inclusive education. Children who use wheelchairs need ramps to enter the school, elevators to attend classes on upper floors, and accessible toilets. Building an accessible school costs barely 1 percent more than building an inaccessible school (Steinfeld 2005), but retrofitting an inaccessible school is considerably more expensive. Incorporating universal design in the floor plan enables schools to include disabled children and minimizes the need for separate schools.
- *Teacher capacity.* Many LMICs educate children with disabilities in separate classrooms or mainstream them into regular classrooms but provide little support. Teacher training and access to specialists are at the core of full inclusion, but very few receive training in inclusive education through either pre- or in-service training (Ferguson 2008; Odom, Buysse, and Soukakou 2011). Children also have limited access to specialists and teaching assistants. Effective programs often include training in inclusive education for administrators at the school, district, and national levels and have the resources, personnel, and discretion to implement changes suitable to the local context.
- *Curriculum design.* A hallmark of inclusive education is having a child-centered curriculum (McLeskey, Waldron, and Redd 2014; Rose, Meyer, and Hitchcock 2005). Curricula in many countries are not adapted to the learning needs, challenges, and strengths of individual children. Inclusive education policies can benefit all children because such policies are intended to respond to individual differences and abilities.
- *Environmental barriers outside the school system.* Schools exist within an environmental context, and exclusion may result from barriers not within the school's purview. These barriers can include, for example, inaccessible transportation, poor provision of assistive devices, and inaccessible health clinics that make the health of children with disabilities more fragile. Exclusion can also result from parents being less willing to send their children to school because of low expectations of the utility of that education or from feelings of shame.

Addressing these issues requires both policy- and school-level changes, as well as an action plan (McGregor and Vogelsberg 1998; Bundy 2011). Perhaps the most important requirement is school- and policy-level leadership committed to educating all children.

Several avenues are available for financing special needs education. Brazil used the national budget to establish a special national fund; Pakistan allocated funding from its national budget to finance a special education network of schools. Nicaragua and Panama dedicate a fixed amount of the overall education budget, 0.92 percent and 2.3 percent, respectively, to special needs education. Chile and Mexico cover the financial costs of special needs institutions, including materials, training, and teaching aids. Denmark, Finland, Hungary, and New Zealand help individuals offset the additional costs of educating a child with special needs. Switzerland and the United States have implemented combined approaches (Hartman 1992; Parrish 1994).

MEASURING ECONOMIC RETURNS OF INCLUSIVE INTERVENTIONS

Measuring the economic returns to inclusive education is complex because the costs are incurred in the short term, but the benefits accrue in the long term. Rigorous evaluations and economic analyses of how to invest in inclusive education programs or the returns generated by inclusive education are not yet available. As a result, the return on investment, children's income potential, and the increase in caretaker productivity are not well known.

In Nepal, education has a bigger impact on the future earnings of children with disabilities than on those of other children (Lamichhane and Sawada 2013). Gains in

functional capacity can be largest when interventions occur early in children's development. Early detection of developmental delays can improve development and school readiness (WHO and UNICEF 2011). Removing barriers early can minimize the compounding effects of multiple barriers. One approach is to use education as an equalizing platform, especially in the formative years.

The returns to inclusive education, rehabilitation services, or any other intervention depend on future barriers that individuals with disabilities will face as adults. If significant barriers to employment are coupled with discrimination, transportation difficulties, and weak labor laws, the return on childhood interventions may be small.

Following this line of reasoning, countries with fewer barriers to adult activities will gain higher returns from child services. One sectoral reform by itself may not have a substantial return, but improving inclusion in multiple sectors creates synergies that will increase those returns in the future.

CASE STUDIES

These six case studies provide a nuanced look at both the progress in and the barriers to improving educational provision and participation for children with disabilities. They illustrate how the first steps to inclusive education have been taken in different settings. Observing the positive effects of inclusive education in schools and in communities can spur the development of equitable policies in other sectors.

Case Study 1. Vision, Learning, and Free Eyeglasses

Elisabetta Aurino, Lesley Drake, Paul Glewwe, Imran Khan, and Kristine West contributed this case study.

Poor vision can affect the development of children and adolescents and the economic prosperity of a country, costing the world more than US$200 billion a year (Fricke and others 2012).[2] However, data on the prevalence of visual impairments in school-age children and adolescents are limited and varied. In one 2004 study, 1 percent of school-age children ages 5–15 years (almost 13 million) were visually impaired (Resnikoff and others 2008). Country-specific estimates range from 1 percent in Malawi (Lee 2016), to 13 percent in China (Glewwe, Park, and Zhao 2016), and 31 percent in high-poverty school districts in the United States (Glewwe, West, and Lee 2015).

Poor vision may lead to poor educational outcomes (Bundy and others 2003). Primary schoolchildren in Northeast Brazil with poor vision had a 10 percentage point higher probability of dropping out and an 18 percentage point higher probability of repeating a grade (Gomes-Neto and others 1997). In rural China, poor vision lowered students' academic performance 0.2–0.3 standard deviation, equivalent to a loss of 0.3 year of schooling (Glewwe, Park, and Zhao 2016). In high-poverty counties in the United States, students with poor vision who received free screening and eyeglasses had a 3.4 and 5.0 percentage point higher probability of passing standardized tests in reading and math, respectively, than similar students in control schools.

Skilled eye care personnel and infrastructure are lacking in LMICs, and schools have become a platform for delivering eye care services in various contexts (Limburg, Kansara, and d'Souza 1999; Sharma and others 2008; Wedner and others 2000; Zhang and others 2011). In Cambodia, teachers were trained to assess whether children and adolescents needed an eye examination (Ormsby and others 2012). Within four weeks, fewer than 100 teachers screened 13,175 students and referred 44 to a team of refractionists, who provided ready-made or customized glasses.

The costs per child were minimal, including operational costs (travel, per diems, training), vision screening kits, and glasses (about US$2–US$3 for ready-made and US$3–US$7 for custom-made glasses). Teachers' time was covered by their salaries, while equipment was borrowed. The cost of eyeglasses can vary by the type of glasses and the region or country. In eight delivery models, eyeglasses cost between US$2.59 and US$7.06 per pair (Wilson 2011). Costs were similar in Zanzibar (Laviers and others 2010). In China, costs ranged between US$2 and US$15 (Glewwe, Park, and Zhao 2016). In the United States, screenings cost about US$2, and examinations and glasses cost about US$100 (Glewwe, West, and Lee 2015).

Baltussen, Naus, and Limburg (2009) modeled the cost-effectiveness of interventions to determine the prevalence of visual impairment by age and enrollment in Africa, America, Asia, and Europe. They also evaluated cost-effectiveness for 10 years and found that annual screening was more cost-effective for adolescents (ages 11–15 years) than for children (ages 5–10 years) because of differences in prevalence and enrollment. Screening at broad age intervals was more cost-effective than screening at single age intervals.

Sustainability and other constraints can be challenging. Eyeglasses need to be replaced regularly, especially in children. Supply constraints relate to lack of trained personnel and poor eye care infrastructure. Demand constraints include lack of awareness of need and societal views that eyewear is unattractive (Kodjebacheva, Maliski, and Coleman 2015). In China, take-up was 65 percent, while in the United States it was 75 percent. The main impediment in all studies was failure to gain parental permission for the exam.

In summary, school-based approaches provide an economically attractive intervention to correct visual impediments that hinder child development.

Case Study 2. Childhood Disability, Education, and Poverty in Vietnam

Daniel Mont contributed this case study.

The WG is the international standard setter for measuring disability at the national level. It identifies the likelihood of disability using the ICF. The questionnaire identifies difficulties that people have in undertaking basic activities (box 17.1). It is also useful for disaggregating socioeconomic indicators by disability status (Loeb 2016).

In 2006, Vietnam based disability questions on the WG questionnaire and included them in the Vietnam Household Living Standards Survey, which was administered to a nationally representative sample of households. The result was a high-quality dataset on both disability and socioeconomic indicators (Mont and Nguyen 2013b).

The poverty rate in Vietnam was 22 percent for people with disabilities and 15 percent for people without disabilities (Mont and Cuong 2011). The poverty gap was even higher for younger people. Poverty was nearly twice as high for children with disabilities, after adjusting for the extra costs of living with a disability, as for other children (table 17.3).

Having a childhood disability was also associated with having less education. Children with disabilities were 41 percent less likely to attend school; excluding children with mild disabilities, that figure rose to 47 percent. Overall, having a disability in childhood was found to significantly reduce the chances of completing school for older children and adolescents regardless of the definition of disability or type of school. Having a childhood disability also lowered the level of completed education. Moreover, having a parent with a disability reduced the chances that children without disabilities would attend school (Mont and Nguyen 2013a).

Including the WG questions on both the census and household survey allowed for small-area estimation of the relationship between poverty and disability. The poverty gap between households with and without a disabled member varied significantly and was lower in areas with better infrastructure and health care services (Mont and Nguyen 2013b).

This dataset from Vietnam adds weight to the relationship between disability and poverty. As the questionnaires are administered more widely, policy makers can better determine where the link between disability and poverty is strongest and what the most promising and appropriate avenues are for designing interventions to weaken that link.

Case Study 3. Disability-Inclusive School Health and Nutrition Programs

Sergio Meresman and Cai Heath contributed this case study.

School health and nutrition programs have increasingly been recognized for their educational impact on the most vulnerable learners (PCD 2015). Inclusive education encompasses children who have difficulty seeing or hearing, limited mobility, or difficulty learning in classrooms designed for children without disabilities. *Disability-inclusive school health and nutrition* refers to educational approaches designed to meet the needs of all children who are vulnerable to dropping out or being excluded from education,

Box 17.1

Washington Group Short Set of Questions on Disability

The next questions ask about difficulties you may have doing certain activities because of a HEALTH PROBLEM.

1. Do you have difficulty seeing, even if wearing glasses?
2. Do you have difficulty hearing, even if using a hearing aid?
3. Do you have difficulty walking or climbing steps?
4. Do you have difficulty remembering or concentrating?
5. Do you have difficulty (with self-care such as) washing all over or dressing?
6. Using your usual (customary) language, do you have difficulty communicating, for example, understanding or being understood?

Possible responses for all questions are no difficulty, some difficulty, a lot of difficulty, and cannot do at all.

Table 17.3 Poverty Rates for People in Vietnam, with and without Disabilities, 2006

percent

Current age (years)	People without disabilities	People with disabilities	People with disabilities after accounting for extra costs of living with a disability
5–18	19.3	31.1	36.2
19–40	15.1	24.7	31.4
41–62	9.2	11.9	15.3
Older than 62	14.5	17.0	22.8

Source: Mont and Cuong 2011.

Table 17.4 Pillars of the FRESH Framework

FRESH pillar	Key concepts for inclusion	Practical implications
Equitable school health policies	Inclusive development; universal design	Gather and disaggregate data on children with disabilities; require adequate and sustainable funding; make policy makers aware and trained
A safe learning environment	Physical access; stigma-free environment	Follow accessibility standards; promote human rights, equity, and diversity to remove attitudinal barriers
Skills-based health education	Curriculum adaptations; information, education, and communication materials in accessible formats (Braille, sign language, easy reading)	Adapt methodologies and content to the learning needs of all children; provide accessible learning materials
School-based health and nutrition services	Inclusive delivery of health and nutrition services; cross-sector collaboration; integrated approaches to programming	Train teachers and health workers in inclusive school health and nutrition; provide health screening and appropriate assistive devices; conduct high-quality context analysis; support inclusive homegrown school feeding programs; provide inclusive water, sanitation, and hygiene programming; engage families and organizations to support outreach and delivery of services

Source: Meresman and others 2015.
Note: FRESH = Focusing Resources on Effective School Health.

including children with disabilities, orphans, migrants, those affected by human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS), those who do not speak the language used in the classroom or who belong to a different religion or caste, and those who are sick, hungry, or not excelling academically.

In 2000, the Education for All goals and Focusing Resources on Effective School Health (FRESH) framework were launched at the World Education Forum in Dakar (FRESH Initiative 2000). The framework outlines approaches that support effective school health programming (table 17.4).

The FRESH framework is helpful for designing and implementing disability-inclusive school programs because it addresses the needs of the learners from multiple angles. For more information on FRESH, see chapter 20 in this volume on school as a platform for addressing health (Bundy, Schultz, and others 2017).

Although a disability-inclusive approach to school health and nutrition programming is a recent concept, the need for these strategies in education sector planning has long been apparent. Kenya's 2005–10 Education Sector Plan identified two key gaps: a lack of clear guidelines on the implementation of an all-inclusive education policy and a lack of reliable data on children with special needs (Republic of Kenya 2005). Zanzibar's 2008–16 Education Sector Plan noted, "Enrollment of children with special needs is low [and] this results in insufficient support to people with special needs." Key strategies included designing all education interventions in a disability-inclusive manner, collecting more accurate data, and improving training for teachers (Government of Zanzibar 2007).

School health and nutrition programs are becoming more disability inclusive. In Kenya the government's homegrown school feeding program (discussed in chapter 12 in this volume, Drake and others 2017) sought to

improve targeting and data collection for all vulnerable children, sensitize teachers and parents, and provide vocational training to improve economic outcomes (PCD 2013).

Case Study 4. Early Childhood Monitoring to Screen for Disability in the Lao People's Democratic Republic

Sally Brinkman contributed this case study.

The Lao People's Democratic Republic is a predominantly rural low-income country. More than two-thirds of the country's 6.5 million people live in rural areas, where the poverty rate is almost 30 percent (Lao Population and Housing Census 2015; Lao Statistics Bureau 2014). Most rural children have never seen a doctor, and less than one-fifth of the population lives in villages with health centers; three in four villages have primary schools (Lao Population and Housing Census 2015). Little is known about the situation of children with disabilities (Evans and others 2014).

In April 2014, the Early Childhood Education Program received funding to improve child development and school readiness and establish a monitoring system to measure child development. The program includes a two-phase process. First-phase screening is part of a population-wide system for monitoring childhood development. Second-phase screening is provided to children who were identified in the first phase as having a disability or impairment (World Bank 2014).

The project is collecting baseline data using the WG short set of questions on disability, with data to be collected on an estimated 6,500 children across five provinces. The results will demonstrate the questionnaire's effectiveness in Lao PDR and determine the prevalence of childhood disability—both important steps in filling the current knowledge gap regarding children with disabilities.

The most likely impediment to scale-up of the program will be the expense and service capacity needs associated with second-phase screening, which must be covered by the health care system, nongovernment agencies, or families. Analyzing the results of first-phase screening against the diagnostic tests to assess the costs of scaling up to the national level will be important.

Case Study 5. Autism Spectrum Disorders: Providing Inclusive Education in Kilifi, Kenya

Amina Abubakar, Andy Shih, Joseph Gona, and Amy Daniels contributed this case study.

The prevalence of autism spectrum disorders has grown considerably in recent decades. Today an estimated 1 in 68 children in the United States has autism (CDC 2014), and estimated prevalence is comparable in other regions (Elsabbagh and others 2012). Autism is typically a lifelong condition characterized by impaired social interaction and communication and the presence of restrictive or repetitive behavior. Children with autism are significantly more likely to have intellectual disabilities and other mental and physical conditions than other children. Autism can severely affect the quality of life of autistic persons and their caregivers.

In the United States, autism was estimated to cost US$1.4 million for individuals over a lifetime and US$137 billion for society per year (Buescher and others 2014). Less is known about the costs of autism in LMICs (Wang and others 2012; Xiong and others 2011).

In Kenya, inclusive education has been a major government policy for many years, but most children with disabilities continue to receive their education in special schools and units (Adoyo 2007; Kenya Ministry of Education 2009). To investigate some of the factors that have hindered the success of inclusive education, Autism Speaks conducted a small qualitative survey of stakeholders, including teachers, placement officers, and representatives of a community-based organization, in Kilifi, Kenya. The discussions centered on the challenges facing the mainstreaming agenda and the steps that could be taken to facilitate inclusive education. Questions were asked about children with autism, although the interview also touched on other forms of disability.

The survey revealed that inclusive education in Kilifi faces four principal challenges: teacher-related problems (lack of training; poor attitude toward inclusion), family obstacles (preference for separate education; tendency to delay the start of school for children with disability), inadequate resources (inadequate facilities; large class sizes), and government policies (motivation allowances for teachers in special units but not for teachers with disabled students in regular schools; former practice of basing school resources on test results). Teachers in mainstream schools identified lack of adequate training for handling children with disabilities as the major hindrance to inclusive education.

What needs to be done to facilitate inclusive education in Kenya and other low-resource settings? Participants from the study highlighted four areas that have the potential to be scaled up in Kenya and other countries:

- Train and provide teachers in mainstream schools with the skills required to handle students with special needs

- Ensure that children with limited mobility can move around the school comfortably
- Initiate parent-based interventions aimed at raising awareness and encouraging them to time school matriculation properly, reinforce skill-building techniques at home, and become engaged in inclusive education efforts
- Make special needs education mandatory for all teacher trainees and critically evaluate the current teacher education curriculum in colleges and universities to ensure an all-inclusive curriculum.

Taking steps to implement the policy and provide adequate infrastructural support for learners with special needs will contribute toward a more inclusive educational setting in Kilifi, Kenya, specifically, and in other low-resource settings more generally.

Case Study 6. Targeting HIV Prevention and Sexual Health Education for Young People with Hearing Loss in Brazil and Uruguay

Sergio Meresman contributed this case study.

Persons with disabilities are at high risk of HIV/AIDS exposure and are disproportionately affected by the epidemic in communities worldwide (World Bank 2003). The main drivers of the epidemic are strongly associated with disability, including a high prevalence of poverty (Inclusion International 2006; Watermeyer 2006), lack of education (Helander 1999; Muthukrishna 2006; World Bank 2003), and lack of access to sexual and reproductive health education or services (DenBoer 2008; Katoda 1993; WHO and UNFPA 2009). Once persons with disabilities become infected, many structural and social factors linked with disability significantly decrease the likelihood that they will receive the treatment, care, and support available to other people living with HIV/AIDS (World Bank 2004).

Because of the misconception that individuals with disability are not exposed to sexual violence and abuse and not at risk of contracting sexually transmitted infections (Berman Bieler and Meresman 2010), prevention campaigns and educational programs frequently overlook this population, making it more vulnerable to the risks of transmission (Groce 2003). A long chain of barriers and taboos—combined with the poverty and exclusion that disproportionately affect persons with disabilities and their families—deprives disabled persons of access to sexuality education suited to their age and needs, to HIV/AIDS programs, and to health services in general.

In South America, the deaf and hard-of-hearing population is one of the largest groups omitted from HIV/AIDS education. In Uruguay, a country with more than 30,000 people who have severe hearing impairments or are deaf (MIDES 2011), most children and adolescents with disabilities attend school but are not involved in health and sexuality education programs (Meresman and others 2015). In Brazil, a country with more than 5 million people who have impaired hearing (CONADIS 2010), HIV/AIDS education has involved marginalized communities for many years, but materials in sign language and inclusive programming have yet to be developed.

Since 2010, the Inter-American Institute on Disability and Inclusive Development, the Center for Health Promotion, and the Partnership for Child Development have been working with deaf organizations in Brazil and Uruguay to promote inclusive approaches to HIV/AIDS education and information on reproductive health. This partnership established the Everyone's School (Escola de Todos) Program, which is administered in collaboration with the national education and health authorities and the national HIV/AIDS programs in both countries. Everyone's School provides access to reproductive health and HIV/AIDS education in sign language for deaf youth. Educational resources were prepared by deaf participants and distributed throughout the deaf community in Brazil and Uruguay. The set included posters, postcards, and quick response (QR) code messages—a digital media platform that is increasingly being used in inclusive school health and nutrition projects—aimed at deaf people. Two workshops were conducted. In each, about 20 participants adapted and translated key messages on health, prevention, and effective condom use into Brazilian and Uruguayan sign language.

As a result of the positive outcomes of the Everyone's School Program, task forces were created with the goal of improving accessibility to programs and services. Such interest spawned new initiatives, including an inclusive prevention grant made available by the National Prevention Program of Uruguay to support training and to design accessible campaigns around sexually transmitted diseases and unwanted pregnancies. A group of deaf youth trained in the initial program is preparing to implement the new initiative.

CONCLUSIONS

The definition of disability has changed over the years and is now commonly used to describe the interaction between impairments and the physical, cultural, and institutional environments. Progress on defining disability has not been matched by efforts to provide standardized estimates of the prevalence of disability. The differing nuances used by statistical agencies, legislative,

and political bodies has made it difficult to collect comparable data on prevalence and severity of disability in both LMICs and in HICs, alike.

Education is the gateway into society, but that gateway is not fully open to children with disabilities. Developing polices that equalize the opportunity to receive a quality education requires a deeper understanding of the scope and nature of children with disabilities' exclusion and the barriers they face. Recent development in how we conceptualize and measure disability are beginning to make a difference in our ability to do that.

Introducing inclusive education is the start of a process to increase the ability of individuals with disabilities to participate in their communities. The path to implementing and achieving inclusive education is complex and is likely to be country specific. However, meaningful steps can be taken at all stages of development.

Establishing inclusive education may be slow, but cross-sectoral collaborations will be critical to achieving progress and to documenting and disseminating successes. The impacts of disability are cross-sectoral, and an approach that focuses on a single sector will be less successful than an approach that takes into account the full range of challenges facing a disabled child. Policies that promote access to education will be more fruitful if school-to-work transition programs are in place to promote employment and inclusion for people with disabilities.

Several publications and reports have outlined key actions that governments can take to support children with disabilities (Thomas and Burnett 2013; UNICEF 2013, 2015). The following actions, which are in line with the recommendations of these publications and those outlined in the *World Report on Disability* (WHO and World Bank 2011) and in the *State of the World's Children 2013* (UNICEF 2013), should form part of a successful platform designed to meet the needs of all learners:

- Undertake situational analyses to better understand the nature and scope of the barriers children with disabilities face when it comes to attending school. These studies should rely on the bio-psychosocial model of disability that conceptualizes disability as arising from the interaction between a children's impairments and the environmental barriers they face.
- Promote inclusive education for children with disabilities at all levels, including early childhood education, and review national policies in relevant sectors—health, education, and social—to ensure that they are aligned with international conventions and commitments and inclusive of children with disabilities
- Collect high-quality data about disability and the school environment via administrative data systems consistent with international standards to fill gaps and monitor progress on the education of children with disabilities.
- Analyze sector-wide strategies, programs, and budgets to determine whether they include concrete actions to support children with disabilities and their families
- Develop, implement, and monitor a comprehensive multisector national strategy and plan of action for children with disabilities that addresses family support, community awareness and mobilization, human resources capacity, coordination, and service provision
- Establish clear lines of responsibility and mechanisms for coordination, monitoring, and reporting across sectors
- Ensure that an inclusive education strategy and action plan are part of the education sector plan, including building or retrofitting schools that are accessible for children with disabilities; creating accessible curricula and learning materials, processes, and assessments; and training teachers to foster a commitment to inclusion in schools and communities
- Evaluate and identify gaps in service delivery, advocate for and seek sustainable financial and technical support to address the gaps identified, and link the collection of disability data with service provision

NOTES

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. In the Convention on the Rights of Persons with Disabilities, "Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others."
2. The authors wish to thank Hasan Minto, Vilay Pillay, and David Wilson of the Brien Holden Vision Institute for information regarding the cost of glasses.

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Chapter 20

The School as a Platform for Addressing Health in Middle Childhood and Adolescence

Donald A. P. Bundy, Linda Schultz, Bachir Sarr,
Louise Banham, Peter Colenso, and Lesley Drake

INTRODUCTION

Health and nutrition programs targeted at school-age children are among the most ubiquitous of all public health programs worldwide. Since the inclusion of school health and nutrition (SHN) in the launch of the call for Education for All (EFA) in 2000, it has been difficult to find a country that is not attempting at some level to provide SHN services (Sarr and others 2017). It is estimated that more than 368 million schoolchildren are provided with school meals every day (World Food Programme 2016), and according to the World Health Organization (WHO) statistics (WHO 2015), 416 million school-age children were dewormed in 2015, which equals 63.2 percent of the target population of children in endemic areas; see chapter 29 in this volume (Ahuja and others 2017). These largely public efforts are variable in quality, and coverage is greatest in the richer countries, but the scale indicates public recognition of the willingness to invest in middle childhood and adolescence.

Health status affects cognitive ability, educational attainment, quality of life, and the ability to contribute to society. Some of the most common health conditions of childhood have consequences for education. SHN interventions can support vulnerable children throughout key stages of their development in middle childhood and adolescence. A set of priority school-based interventions, selected on the basis of cost-effectiveness, benefit-cost analysis, and rate of return, is described in chapter 25 in this volume (Fernandes and Aurino 2017).

Schools are a cost-effective platform for providing simple, safe, and effective health interventions to school-age children and adolescents (Horton and others 2017). Many of the health conditions that are most prevalent among poor students have important effects on education—causing absenteeism, leading to grade repetition or dropout, and adversely affecting student achievement—and yet are easily preventable or treatable. With gains in enrollment achieved by the Millennium Development Goals, SHN interventions are important cross-sectoral collaborations between Ministries of Health and Education to promote health, cognition, and physical growth across the life course.

The education system is particularly well situated to promoting health among children and adolescents in poor communities without effective health systems who otherwise might not receive health interventions. There are typically more schools than health facilities in all income settings, and rural and poor areas are significantly more likely to have schools than health centers. The economies of scale, coupled with the efficiencies of using existing infrastructure and the potential to administer additional interventions through the same delivery mechanism, make SHN interventions

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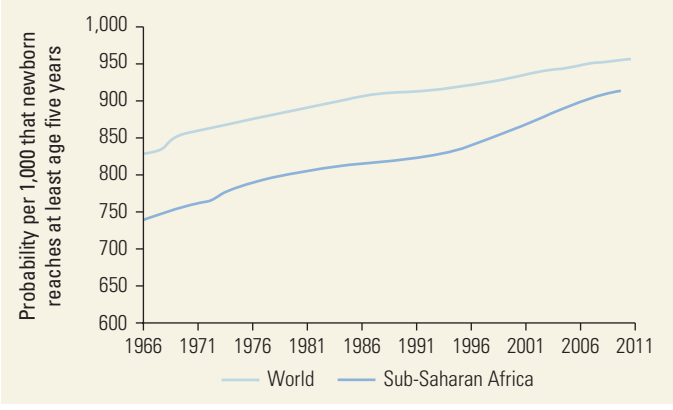
particularly cost-effective. As a result, schools can reach an unprecedented number of children and adolescents and play a key role in national development efforts by improving both child health and education. Because schools are at the heart of all communities, we have an opportunity to use the school as a sustainable, scalable option for simple health service delivery.

This chapter explores the developmental rationale for improving the health of school-age children and the economic rationale for administering health interventions to school-age children (typically from ages 5 to 14 years) through existing educational systems as compared with the health system. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017).

SCHOOL HEALTH AND NUTRITION

SHN describes a wide range of interventions delivered through schools to improve education and health outcomes by enhancing nutrition, alleviating hunger, and preventing disease. SHN interventions can target the most common local health conditions that affect school-age children and can be delivered by teachers and other proxies for the health system. Delivery of health interventions through schools enables children to take advantage of investments made in the education sector and improves country competitiveness, given that each increased year of schooling is associated with greater earning capacity and lower levels of mortality, illness, and health risks. As more children survive and thrive (figure 20.1), the role of schools becomes increasingly important.

Figure 20.1 Rate of Survival beyond Age Five Years

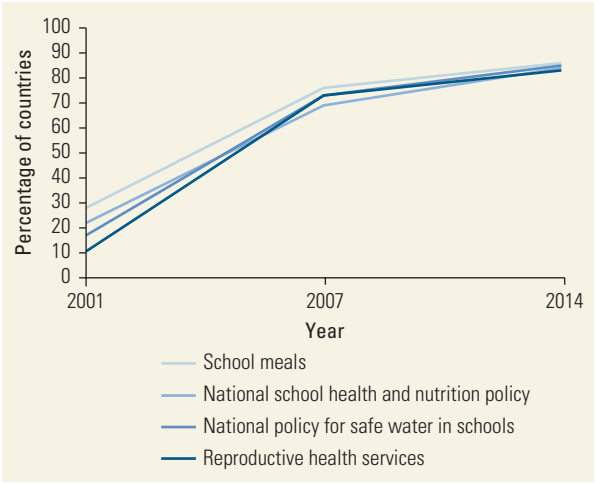


Source: World Bank 2016.
Note: Survival rate is the inverse of the under-five year mortality rate, which is the probability per 1,000 that a newborn will die before reaching age five years, subject to age-specific mortality rates for the specified year.

These programs have a long history. At the turn of the twentieth century, school feeding[1] initiatives were among the first social welfare programs to emerge in high-income countries (Atkins 2007). Recognition that SHN benefits learning had been clear from the 1920s, when school-based deworming programs were instituted across the southern United States specifically to promote education and reduce poverty (Ettling 1981). By the 1980s, SHN programs had become ubiquitous in upper-middle-income countries and high-income countries. Change also began in the 1980s in low- and middle-income countries (LMICs) with a shift away from the traditional complex, medical-based approach, usually targeted to elite urban or boarding schools, and toward interventions targeted to the poorest schools.

Both the health and education communities have championed SHN in LMICs. The WHO's Ottawa Charter for Health Promotion, launched in 1986, provided momentum for global recognition of the importance of addressing health in the educational context (WHO 1986). This recognition was further propelled by the work of the WHO Expert Committee on Comprehensive School Health and Nutrition Education and Promotion in the mid-1990s. The WHO's Information Series on School Health and Nutrition, together with the United Nations Educational, Scientific and Cultural Organization (UNESCO) and Education Development Center, commenced in the late 1990s (WHO 1997). There was also an attempt to promote thinking around SHN at the 1990 World Education Forum in Jomtien, Thailand, but it was not until 10 years later that the concept gained traction in the global commitment to achieve EFA launched at the World Education Forum in Dakar, Senegal, in 2000. To strengthen the focus on SHN, several organizations, including UNESCO, the United Nations Children's Fund (UNICEF), the WHO, and the World Bank, used the Dakar Forum to launch an organizing framework entitled Focusing Resources on Effective School Health and Nutrition (FRESH). Since then, an increasing number of low- and lower-middle-income countries have adopted more comprehensive SHN policies with the specific aims of achieving EFA along with the education-specific Millennium Development Goals of universal basic education and gender equality in educational access (Bundy 2011). In Sub-Saharan Africa, the percentage of countries implementing programs that meet the minimum WHO Health Promoting School criteria of equity and effectiveness rose from 10 percent in 2000 to more than 80 percent in 2014 (Drake, Maier, and de Lind van Wijngaarden 2007) (figure 20.2). In Sub-Saharan Africa, the percentage of reproductive health service–supported programs rose from 10 percent to more than 70 percent, with an estimate of 80 percent in 2014.

Figure 20.2 Expansion of School Health and Nutrition in Sub-Saharan Africa



Source: Adapted from Drake, Maier, and de Lind van Wijngaarden 2007.

HEALTHY CHILDREN, BETTER LEARNING

SHN programming is increasingly recognized as a critical element for achieving universal access to education. Access to a school, provision of quality teaching and learning materials, and availability of trained teachers are necessary, but insufficient, to achieve good learning outcomes. Children also need to be healthy and regularly attending school to be able to benefit fully from the learning opportunities. Ill health can be the catalyst for extended absence or dropping out of school completely; malaria and worm infections can reduce enrollment; anemia can affect cognition, attention span, and learning; and the pain associated with tooth decay can affect both attendance and learning (chapters 11–16 of this volume; Benzian and others 2017; Brooker and others 2017; Bundy, Appleby, and others 2017; Drake, Fernandes, and others 2017; LaMontagne and others 2017; Lassi, Moin, and Bhutta 2017). The potential for school health interventions to shape physical and psychosocial health as well as education outcomes for youth has been explored to a greater extent in high-income countries, especially in the United States (Durlak, Weissberg, and Dymnicki 2011; Murray and others 2007; Shackleton and others 2016).

Some of the most prevalent health conditions of school-age children affect children's education participation and learning outcomes significantly (table 20.1). Typical interventions and their target conditions include the following: deworming and worm infection; bednets and malaria; handwashing and bacterial infections; toothbrushing and dental caries; spectacles and refractive error; micronutrients and micronutrient deficiency; and food and hunger. Research has shown that the average IQ loss for children with these conditions can range from 3.7 IQ points per child with untreated worm infections to 6.0 IQ points for children with anemia. Together, these prevalent conditions are estimated to translate into the equivalent of between 200 million and 500 million years of school lost due to ill health in LMICs each year (Bundy 2011).

Interventions for these common health conditions can have long-term economic benefits. Estimates show that poor students in areas where these conditions are prevalent would gain the equivalent of 0.5–2.5 extra years of schooling if their health benefited from appropriate interventions. Sustaining the benefits across multiple years of schooling could improve cognitive abilities by 0.25 standard deviations, on average; extrapolating the benefits of improved accumulation in human capital could translate to roughly a 5 percent increase in earning capacity over the life course; see chapter 29 in this volume (Ahuja and others 2017).

SHN interventions can enhance equity by supporting student participation and contributing to a reduction in the education achievement gap between well-performing and underperforming students. A study in South Africa found that children who score 0.25 standard deviations above the mean on grade 2 examinations were significantly more likely to complete grade 7 (figure 20.3). If schools that delivered health and nutrition interventions could raise examination scores, they may experience higher student retention, compared with schools without health programs.

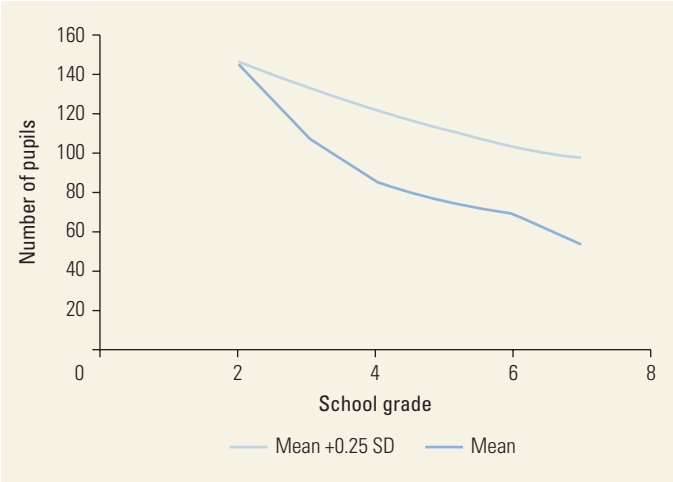
Although better health alone cannot compensate for missed learning opportunities, it can provide children with the potential to take advantage of learning

Table 20.1 Estimates of the Global Cognitive Impact of Common Diseases of School-Age Children in LMICs

Common diseases	Prevalence (%)	Total cases (millions)	IQ points lost per child	Additional cases of IQ <70 (millions)	Lost years of schooling (millions)
Worms	30	169	3.75	15.8	201
Stunting	52	292	3	21.6	284
Anemia	53	298	6	45.6	524

Source: Bundy 2011.
Note: IQ = intelligence quotient; LMICs = low- and middle-income countries.

Figure 20.3 Estimated School Dropout Rates, with and without School Health and Nutrition Interventions, in South Africa



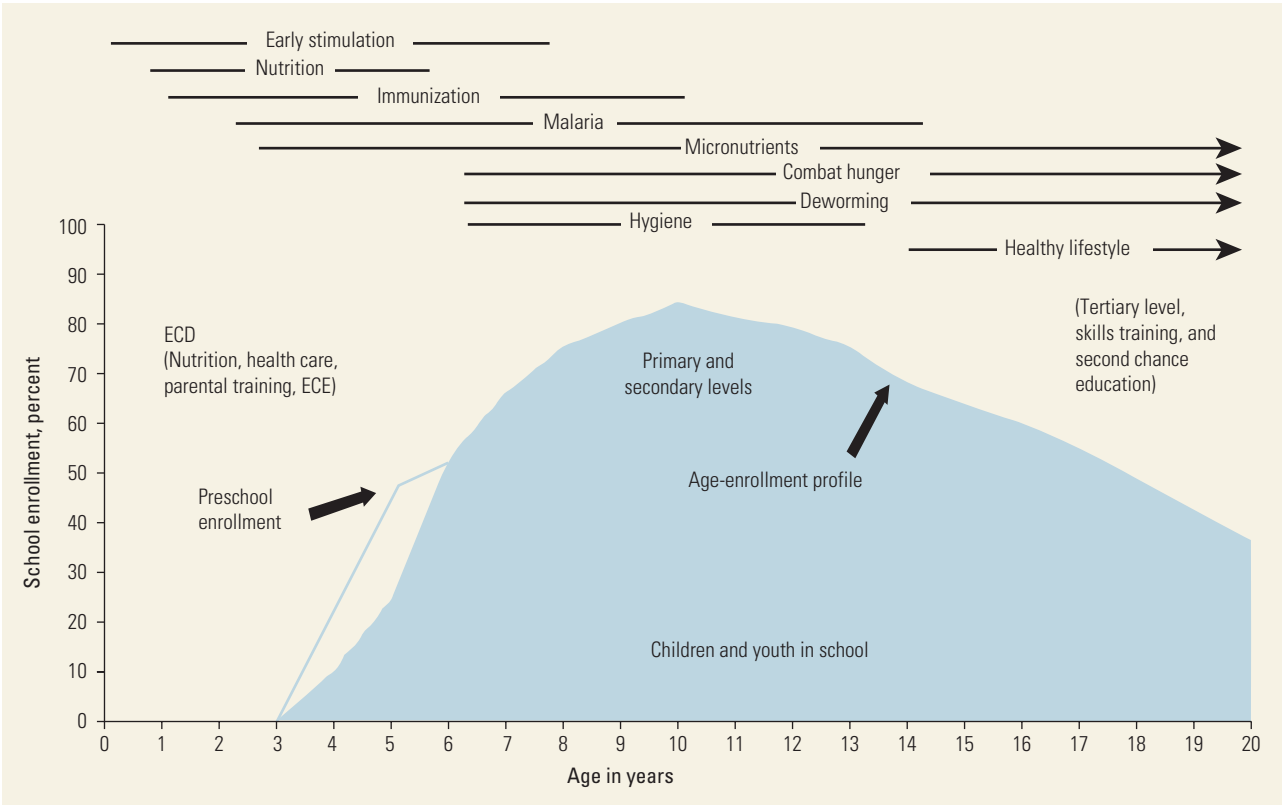
Source: Liddell and Rae 2001.
Note: SD = standard deviation. Students who score 0.25 SD higher on exams in grade 2 are more likely to complete grade 7. If schools that delivered health and nutrition interventions could raise examination scores, they may experience higher student retention compared with schools without health programs.

opportunities (Grigorenko and others 2006). Children are more ready to learn after treatment; they may be able to catch up with better-off peers if their improved learning potential can be used effectively in the classroom. The education sector is responsible for the quality of education delivered and for leveraging the investment it has already made.

A key message of this volume is that different types of health interventions are required at different stages in child and adolescent development. The accumulating evidence on the benefits of targeted interventions from middle childhood to late adolescence is summarized in chapter 6 in this volume (Bundy and Horton 2017); the potential impact of targeted intervention in school-age children is discussed in chapter 8 of this volume (Watkins and others 2017).

SHN and school feeding interventions build on the foundation of early child development interventions and exploit the accessibility of children in schools. Figure 20.4 demonstrates how the World Bank characterized the varied opportunities for health interventions at different life

Figure 20.4 Learning as a Lifelong Process



Source: Adapted from World Bank 2011, updated to include preschool enrollment; World Bank 2016.
Note: ECD = early child development; ECE = early childhood education. Rates of preschool enrollment by country group: 18.05 (low income), 49.56 (lower-middle income; reflects reported rate from 2012), 58.39 (middle income). The rates indicate the total enrollment in preprimary education, regardless of age, expressed as a percentage of the total population of official preprimary education age.

stages as part of an education strategy. The figure indicates schematically when interventions might be particularly helpful. For example, early stimulation can help ensure school readiness; malaria prevention and education on bednet use, school feeding, and deworming treatments can help keep children in school by enhancing attendance and reducing dropout rates; and vision correction and skills-based health education, along with school feeding, might help improve learning by enhancing cognition and educational achievement (World Bank 2012).

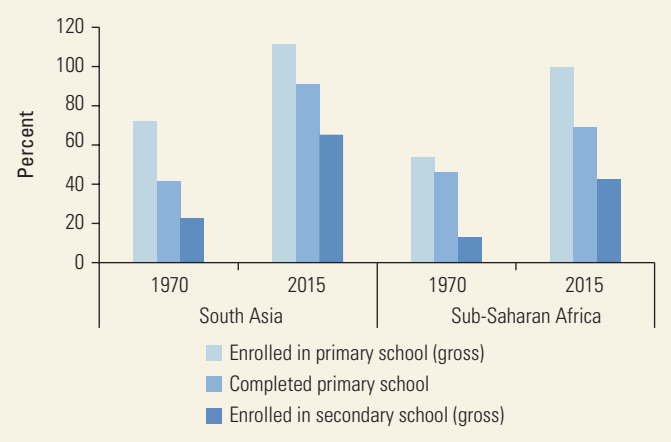
SCHOOLS AS ENTRY POINTS FOR HEALTH INTERVENTIONS

Schools are one of the few institutions in poor communities that provide access to trained human resources. In contrast, the health systems in many LMICs experience multiple barriers, especially in costs and human resources, that limit their ability to reach beyond health facilities. Schools cannot replace health systems, which remain the formal avenue for health delivery, but education systems can complement health delivery mechanisms by providing outreach opportunities through schools. Even in LMICs, school-based interventions can be widely implemented by the education sector, with the health sector ensuring proper oversight and training of school staff (Bundy 2011).

School-based health programs have the potential to reach an estimated 575 million school-age children in low-income countries (UNESCO 2008). This opportunity is particularly relevant to Sub-Saharan Africa. Young people constitute the greatest proportion of the population, and this is the only region in which the number of young people continues to grow substantially (UNFPA 2012). It is also important that this is now a region in which most children attend school. As shown in figure 20.5, the percentage of the population that has enrolled in school, completed primary education, and moved on to secondary school has increased considerably during the past four decades, so that the proportion of school-going children and adolescents in Sub-Saharan Africa today approaches that of South Asia. Despite the increasing number of children in school, Sub-Saharan Africa has low enrollment rates compared with the rest of the world. Looking ahead, an unprecedented number of children are anticipated to be in school in this region as enrollment rates improve. Because most countries have SHN programs, opportunities exist to scale up the scope of services and tailor specific types of programs to local contexts. It is important to note that the high pupil-to-teacher ratio in many schools may discourage educators and the education sector from adding extra responsibilities that accompany SHN programming. Preservice sensitization and training can help educators recognize that healthy children learn better.

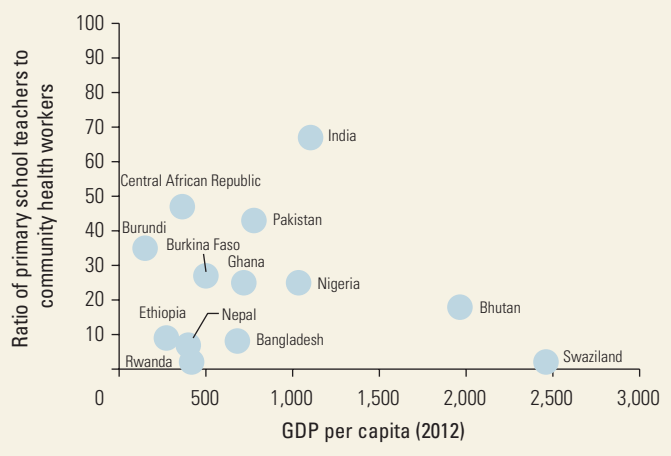
SHN systems build on existing infrastructure, curriculum opportunities, and teacher networks to accelerate implementation and reduce costs. There are more teachers than nurses and more schools than clinics, often by

Figure 20.5 Percentage of Population Enrolled in Primary School and Who Move on to Secondary School in South Asia and Sub-Saharan Africa, 1970 and 2015



Source: World Bank 2016.
Note: Total enrollment, regardless of age, expressed as a percentage of the population of official primary or secondary education age. Gross enrollment rate can exceed 100 percent as a result of the inclusion of over-age and under-age students because of early or late school entrance and grade repetition.

Figure 20.6 Ratio of Primary School Teachers to Community Health Workers in 13 Low- and Lower-Middle-Income Countries, by GDP per Capita



Sources: Data on the number of primary school teachers are from UNESCO Institute for Statistics (http://stats.uis.unesco.org); data on the number of community health workers are from the WHO Global Health Observatory Data Repository (http://apps.who.int/ghodata/); and GDP data are from World Bank 2016.
Note: GDP = gross domestic product.

an order of magnitude. Figure 20.6 shows that the ratio of primary teachers to community health workers in several countries is in the range of 20:1 to 65:1; this relationship is only loosely related to gross domestic product (GDP). Including teachers—as the largest segment of the workforce and often community leaders—in public health activities can also broaden awareness of, and community commitment to, public health interventions.

SCHOOL HEALTH AND NUTRITION PROGRAMS: PRO-POOR AND PRO-GIRL INTERVENTIONS

SHN programs can help level the playing field for the most vulnerable students: the poor, the sick, and the malnourished. These are the children who require the greatest support throughout their schooling to minimize the risk of absenteeism and dropping out, but who generally have the least access to care and support (World Bank 2012). SHN and nutrition programs are pro-poor because the greatest benefits accrue to those children who are most affected at the outset (Bundy 2011). This pro-poor focus has also been increasingly emphasized in WHO SHN policies and practices (Tang and others 2009).

Poverty is a key consideration in the design of SHN and school feeding programs. The negative correlations between ill health, malnutrition, and income level are clearly demonstrated in both cross-country comparisons and individual country analyses (de Silva and others 2003), partly because low income and poverty promote disease and inadequate diets. Paradoxically, SHN programs are often most equitable when they are universal; mass delivery can help ensure that the interventions reach those poorest children who are more often systematically overlooked, especially by intervention programs that operate through diagnoses at health facilities.

However, the equity value of universal access within schools does not imply that there is no value in targeting poor communities. With few exceptions, the diseases that affect children and their education are most prevalent in poor countries, particularly in the poorest communities within those countries. As a result, targeting interventions to those communities most likely to benefit is cost-effective and a common characteristic of strong SHN programs. The benefits of targeting school feeding interventions is discussed in depth in chapter 12 in this volume (Drake, Fernandes, and others 2017). Lessons gleaned from country case studies can illustrate the strengths of different school feeding approaches in both program design and service delivery (Drake, Woolnough, and others 2016).

Girls and young women benefit particularly from SHN and school feeding programs because some of the most common health conditions affecting education are more prevalent in girls, and because gender-based vulnerability and exclusion can place girls at greater risk of ill health, neglect, and hunger (Bundy 2011). Deworming and iron supplementation offer particular benefits to girls because women and girls are, for physiological reasons, more likely to experience high rates of anemia. SHN programs draw children—especially girls—into schools and encourage them to stay (Gelli, Meir, and Espejo 2007). This dynamic is particularly relevant to achieving EFA; marginalized children, among whom girls are overrepresented, account for the majority of out-of-school children (UNESCO 2011). Moreover, improved health and increased educational attainment for young women can help delay age at first birth, which is associated with improved financial risk protection and enhanced intergenerational health outcomes; see chapter 28 in this volume (Verguet and others 2017).

Girls can benefit greatly from health promotion and life-skills lessons offered in schools. This benefit is exemplified with human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) education, particularly because young women in Sub-Saharan Africa are estimated to be two to seven times more likely to be infected with HIV than young men (MacPhail, Williams, and Campbell 2002). Health responses are more sustainable and have a greater reach when integrated into an existing framework, such as through a wider curriculum of health promotion (Jukes, Simmons, and Bundy 2008). Research shows that the most trusted source for young people to learn about HIV/AIDS is through schools and teachers (Boler 2003). A wide range of life skills and health promotion curriculum design, content, and implementation is available (Hargreaves and Boler 2006). Relatively simple lessons on skills-based health education can usefully address stigma and discrimination, and an integrated curriculum at a higher level of complexity can usefully influence protective health behaviors. Data show that for every extra year children remain in school HIV/AIDS rates are reduced (World Bank 2002). The years of school attended may not equate to greater attainment of skills-based health education because curriculum quality and extent of integration into the larger school framework vary widely (Hargreaves and others 2008; Jukes, Simmons, and Bundy 2008).

SHN programs may also work synergistically with conditional and unconditional social transfer programs; see chapter 7 in this volume (Alderman and

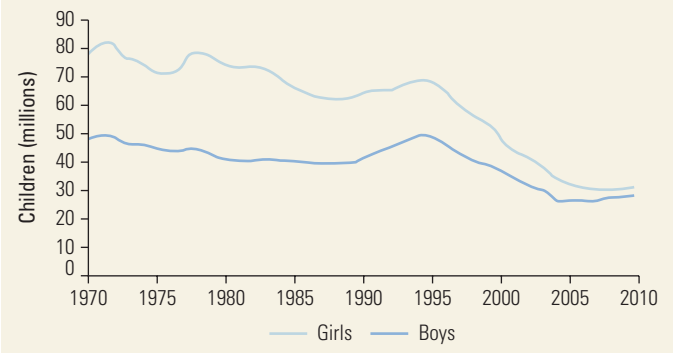
others 2017) and chapter 12 in this volume (Drake, Fernandes, and others 2017). Take-home rations and conditional cash transfers can encourage girls to go to school; bursaries, which give rations directly to girl students, can encourage girls to stay in school (Chapman 2006). The broader value of these programs is discussed in chapter 23 in this volume (de Walque and others 2017).

Schools are an increasingly attractive and effective platform for reaching girls given that the gender gap in enrollment is closing in most countries. Figure 20.7 illustrates decreasing out-of-school rates between 1970 and 2010. The trend for girls is especially clear: between 1970 and 2010 the significant gap in enrollment of boys and girls was dramatically reduced, although a substantial number of children—more or less equally boys and girls—never enroll in school. Figures 20.8 and 20.9 provide a more nuanced look at the narrowing gender disparities in out-of-school children in South Asia and Sub-Saharan Africa, showing that greater change in enrollment among girls has occurred in South Asia.

Significant cross-country differences exist in gender disparities in enrollment rates based on historical experience and government policies. Data from five Sub-Saharan African countries are presented in figure 20.10. In Mozambique, the number of out-of-school children decreased significantly from 2000 to 2014, while gender gaps remained substantial. In contrast, the gender gap remained small in Ghana, while the trend was downward; in Niger, the number of out-of-school children remained relatively constant over the period, while the gender gap widened.

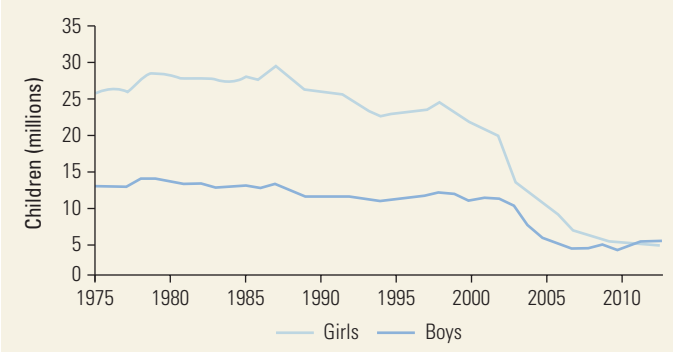
In some Sub-Saharan African countries, the numbers of out-of-school children have proved difficult to reduce; as a result, the observation that SHN programs can benefit out-of-school children becomes increasingly important. As documented in Guinea and Madagascar, many out-of-school children will take advantage of simple health services provided in schools, for example, deworming and micronutrient supplements; school feeding programs, especially take-home rations, have been shown to benefit siblings at home (Adelman and others 2008; Bundy and others 2009; Del Rosso and Marek 1996). Deworming programs in schools have been found to reach out-of-school children at scale (Drake and others 2015) and reduce disease transmission in the community as a whole (Bundy and others 1990; Miguel and Kremer 2004). Although the benefits of SHN programs can extend beyond those who attend school, SHN programs are best considered in conjunction with other approaches to encouraging enrollment and attendance.

Figure 20.7 Global Out-of-School Children of Primary School Age, by Gender, 1970–2010



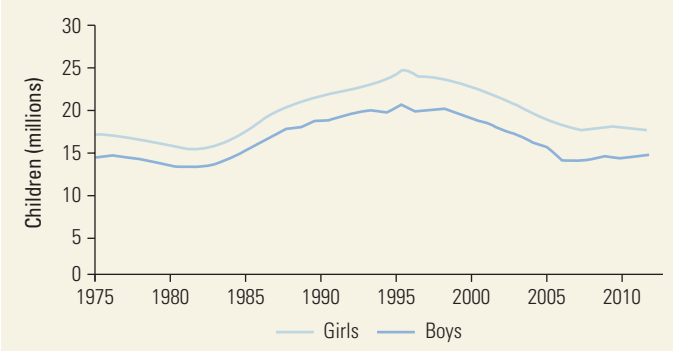
Source: World Bank 2016.
Note: The total number of boys and girls of primary school age who are not enrolled in either primary or secondary schools.

Figure 20.8 Out-of-School Children of Primary School Age in South Asia, 1975–2013



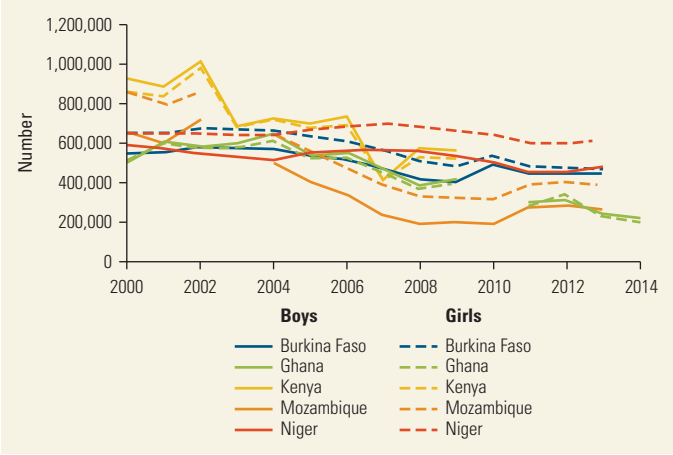
Source: World Bank 2016.
Note: The total number of boys and girls of primary school age who are not enrolled in either primary or secondary schools.

Figure 20.9 Out-of-School Children of Primary School Age in Sub-Saharan Africa, 1975–2013



Source: World Bank 2016.
Note: The total number of boys and girls of primary school age who are not enrolled in either primary or secondary schools.

Figure 20.10 Out-of-School Children of Primary School Age, in Five Countries, by Gender, 2000–14



Source: World Bank 2016.
Note: Out-of-school children of primary school age for specific countries. Figure shows the total number of boys and girls of primary school age who are not enrolled in primary or secondary schools. Gaps in the graphs are due to lack of data for those years.

It is important that out-of-school children have access to skills-based health education and life-skills development to prevent illnesses such as HIV/AIDS (Hargreaves and others 2008).

DEFINING SECTOR ROLES

The implementation, funding, and oversight of SHN programs do not fall squarely within either the education or the health sector. Rather, many approaches, stakeholders, and collaborations are involved in the delivery of health and nutrition services in schools. Diverse experiences suggest that existing programs highlight certain consistent roles played by government and nongovernmental agencies and other partners and stakeholders. It is clear that program success depends on the effective participation and support of strategic partnerships, especially with the beneficiaries and their parents or guardians (table 20.2).

In nearly every national SHN program, the Ministry of Education is the lead implementing agency, reflecting both the goal of SHN programs to improve educational achievement and the fact that the education system often provides the most complete existing infrastructure to reach school-age children. In successful programs this responsibility has been shared between the Ministry of Education and the Ministry of Health, particularly since the latter has the ultimate responsibility for the health of all children. However, collaboration across sectors is not easy, particularly given different institutional structures, operational mechanisms, and working cultures between different line ministries. Each sector needs to identify its respective role and responsibilities and present a coordinated plan of action to improve the health and education outcomes of children. Beyond the education and health ministries and nonstate actors, intersectoral collaboration is more complex. The starting point is usually the establishment of cross-sectoral working groups or steering committees at national, district, and local levels to coordinate actions and decision making (FRESH 2014). The understanding and recognition by the education and health sectors of each other's core business and priorities are also essential; the stronger and more explicit focus that the WHO places on achieving both health and education outcomes can facilitate collaboration between health promotion practitioners and teachers.

Successful multisector school-based health service delivery includes referral and treatment opportunities that extend beyond the school platform. School-based responses to the various diseases affecting school-age children vary depending on the nature of the treatment required. For example, there is a clear policy context for integrating the identification and referral of refractive error into wider SHN programs. It is essential that school-based vision screening programs include screening and referral at the primary level; refraction and optical dispensing at the district level; and supported advanced care, including pediatric and contact lens services, at the tertiary health care level, although the costs increase and feasibility decreases with each step away from the primary level (World Bank 2012). See chapter 17 in this volume (Graham and others 2017) for a more detailed look at school-based vision programming.

SHN programs offer a compelling case for public sector investment and interventions. First, these interventions may create externalities whereby external benefits accrue to people other than treated individuals. For example, deworming programs reduce the intensity of infection in untreated children in schools, in neighboring schools, and in siblings of those treated at schools (Miguel and Kremer 2004). Second, some health interventions are pure public goods—all school-age children are eligible to access these services and there is typically little private demand for general preventive measures. Accordingly, the private sector is unlikely to compete to deliver these goods and services. SHN programs are most likely to achieve universal coverage and be sustainable when they are under the jurisdiction of the public sector and integrated into national education sector plans (ESPs).

Table 20.2 Comparison of Roles Played by Government Agencies, Partners, and Stakeholders in School Health and Nutrition Programs

Partner	Roles	Comments
Ministry of Education	• Lead implementing agency • Lead financial resource • Education sector policy	• Health and nutrition of schoolchildren is a priority for EFA. • Education policy defines school environment, curriculum, duties of teachers. • Education system has a pervasive infrastructure for reaching teachers and school-age children.
Ministry of Health	• Lead technical agency • Health sector policy	• Health of school-age children has lower priority than clinical services and infant health. • Health policy defines role of teachers in service delivery and how health materials are procured.
Other public sector agencies (for example, ministries of welfare, social affairs, local government, agriculture)	• Support education and health systems • Fund holders	• Ministries of local government are often fund holders for teachers and schools, as well as for clinics and health agents. • Ministries of welfare and social affairs provide mechanisms for the provision of social funds.
Private sector (for example, health services, pharmaceuticals, publications)	• Specialist service delivery • Materials provision	• Major role in drug procurement and production of training materials. • Specialist roles in health diagnostics.
Civil society (for example, NGOs, FBOs, PTAs)	• Training and supervision • Local resource provision	• At the local level, serve as gatekeepers and fund holders; may also target implementation. • Offer additional resource streams, particularly through INGOs.
Teachers associations, local community (for example, children, teachers, parents)	• Define teachers' roles • Partners in implementation • Define acceptability of curriculum • Supplement resources	• School health programs demand an expanded role for teachers. • Gatekeepers for both the content of health education (especially moral and sexual content) and the role of nonhealth agents (especially teachers) in health service delivery. Pupils are active participants in all aspects of the process at the school level. • Communities supplement program finances at the margins.

Source: Jukes, Drake, and Bundy 2008.
Note: EFA = Education for All; FBO = faith-based organization; INGO = international nongovernmental organization; NGO = nongovernmental organization; PTA = parent-teacher association.

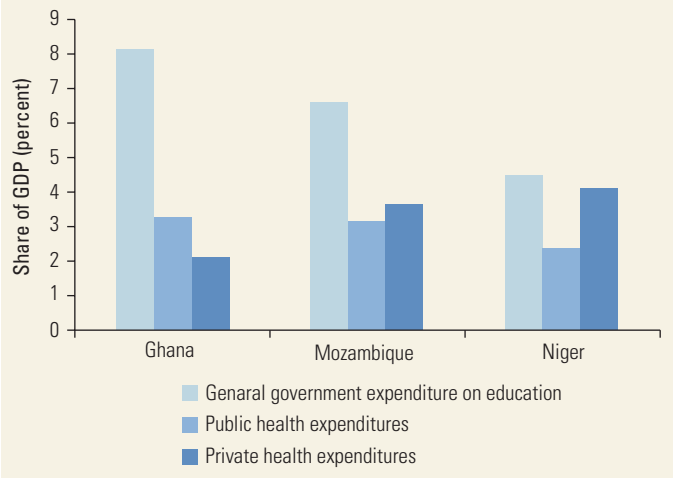
ECONOMIC RATIONALE FOR SCHOOL-BASED HEALTH INTERVENTIONS

In the complex set of conditions required for children to learn well, improved health can be one of the simplest and cheapest conditions to achieve (World Bank 2012). The focus of this economic rationale is on conditions for which there are existing interventions that are sufficiently safe, simple, and well evaluated to be appropriate for education sector implementation through schools, typically with health sector supervision.

Several factors support the economic rationale for schools as a platform for the delivery of health interventions. One of the main factors is the potential savings offered by school systems, rather than health systems, as the delivery mechanism. From this perspective, schools provide a preexisting mechanism, so costs are marginal; they also provide a system that as part of its primary educational purpose aims to be sustainable and pervasive, reach disadvantaged children, and promote social equity. Tailoring and targeting the types of interventions to local contexts lies at the heart of practical success. Targeting reduces costs and facilitates management; it may optimize outcomes.

Education sector spending exceeds public health spending in most LMICs. In Ghana, Mozambique, and Niger, for example, public expenditures for education are more than double those for public health (figure 20.11). The higher investment in the education sector relative to the health sector is reflected in the greater number of schools and teachers versus health centers and health workers in communities (see figure 20.6).

Figure 20.11 Expenditures on Education versus Health as a Proportion of GDP, 2013



Source: World Bank 2016.
Note: GDP = gross domestic product. Total health expenditure is the sum of public and private health expenditure. It covers the provision of preventive and curative health services, family planning activities, nutrition activities, and emergency aid designated for health; it does not include provision of water and sanitation. General government expenditure on education (current, capital, and transfers) is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government. General government usually refers to local, regional, and central governments. Data are more readily available (as are world and regional estimates) for health than for education.

The large share of the population that school-age children represent and the high percentage of children that attend school imply significant economies of scale in the cost of delivering school-based health interventions. The economies of scale can be expected to be larger for interventions with small variable or marginal costs, that is, the cost of treating an additional child. School-based health interventions may also have fixed costs for establishing infrastructure, staffing, government capacity, intersectoral policies, and monitoring systems.

The rationale for school-based health interventions is also stronger for interventions that address prevalent conditions in populations (see table 20.1). In this case, the expected benefits are higher per dollar invested. Targeting school-based health interventions to children at greater risk may lead to greater benefits, but it may also lead to higher costs, depending on how the targeting is achieved.

COMPARATIVE COST-EFFECTIVENESS OF DELIVERING HEALTH INTERVENTIONS THROUGH SCHOOLS

Schools offer advantages over community and primary health center platforms. Chapter 25 in this volume presents an essential package of low-cost health interventions that can be delivered effectively in LMICs through schools (Fernandes and Aurino 2017). The analysis suggests that the economic benefits as measured by the returns to health and education outweigh the costs, while remaining affordable within government budget constraints. The essential package includes targeted school meals with micronutrient fortification, education on malaria prevention and oral hygiene, deworming treatment, screening for refractive error, and appropriate immunization.

The cost savings of delivering simple and safe interventions through schools can be illustrated in deworming and screening for refractive error. For example, delivery of mass administration of deworming treatment through schools (not including the cost of treatment because it is currently donated for schoolchildren) is estimated to cost US$0.03–US$0.04 per child per year, compared with US$0.21–US$0.51 through mobile health teams coordinated by primary health centers (Guyatt 2003). Screening costs for refractive error and provision of glasses through area hospitals were estimated to be US$8.17, but the cost drops to US$2–US$3 if the screening is provided by mobile teams dispatched to schools following screening by teachers (Baltussen, Naus, and Limburg 2009; Graham and others 2017) (table 20.3). With minimal training combined with access to periodic supervision and support, school teachers can safely administer pills or screen children for health conditions of interest, limiting the time requirement and cost of access to skilled health personnel.

The presence of children at school obviates the need to draw children to another point of service at regular intervals or for mobile health teams to travel to reach them. Furthermore, the implementation of multiple interventions through the same delivery system allows for shared costs and efficiencies, for example, for teacher training. The effectiveness of primary health centers is contingent on the target population coming to clinics to receive the interventions, which can be a significant time

Table 20.3 Essential Package of School-Based Health Interventions, 2012 U.S. dollars

	Annual cost per child per year ($)
School meals	44
MNP supplementation	3
Malaria	2–3
Refractive error screening	2–3
Toothbrush provision	0.50
HPV vaccine	2
Tetanus toxoid vaccine	0.40

Source: Fernandes and Aurino 2017.
Note: HPV = human papillomavirus; MNP = micronutrient powder.

and cost burden on poorer families and especially challenging for interventions with multiple dosages, such as the human papillomavirus (HPV) vaccine, and for the school-age population; see chapter 15 in this volume (LaMontagne and others 2017). The economic analysis of the effect of health interventions on improved education attainment is discussed in chapter 22 in this volume (Plaut and others 2017).

CONTEXT FRAMING AND POLICY FRAMEWORK

Creating and refining an SHN program involves a series of policy decisions, especially how to work effectively across sectors and how to select interventions to include. Fortunately, two policy tools track some of the decisions that countries made in developing their SHN programs.

- The FRESH framework was introduced at the beginning of LMIC programming in this area and is still widely used. Its primary purpose was to provide a policy framework to support the start-up of new programs or the strengthening of existing programs.
- The Systems Approach for Better Education Results (SABER) was introduced more than a decade later as a mechanism for refining the policy environment of existing programs. The emergence of this tool reflects the need created by the remarkable proliferation of new school health and school feeding programs in LMICs.

FRESH

The use of schools as a platform for delivering SHN interventions was accelerated by the launch of the FRESH framework at the World Education Forum in 2000, by a multi-agency partnership that included UNESCO, UNICEF, the WHO, the World Food Programme, and the World Bank (Sarr and others 2017).

FRESH is a comprehensive, evidence-based framework that promotes better education through health interventions delivered by schools and is supported by an international consensus among partners and stakeholders. The FRESH framework offers strategic guidance to ensure that program implementation is standardized and evidence based (World Bank 2012). It lays the foundation for effective and equitable SHN programs and consists conceptually of four mutually reinforcing pillars (FRESH 2014):

- *Pillar 1: Health-related school policies.* Health- and nutrition-related school policies that are nondiscriminatory, protective, inclusive, and gender sensitive to promote the physical and psychosocial health of children, teachers, and school staff
- *Pillar 2: Safe learning environment.* Access to safe water and provision of separate sanitation facilities for girls, boys, and teachers; a safe, healthy, clean, and emotionally supportive environment that fosters children's ability to attend school, pay attention, and learn
- *Pillar 3: Skill-based health education.* Life-skills education that addresses health, nutrition, and hygiene issues with knowledge, attitudes, and skills to promote positive behaviors
- *Pillar 4: School-based health and nutrition services.* Simple, safe, and familiar health and nutrition services that can be delivered cost-effectively in schools, and increased access to youth-friendly clinics

All four of these components are necessary for a successful program. They can be implemented effectively only if they are supported by strategic partnerships between (1) the health and education sectors, especially teachers and health workers; (2) schools and their respective communities; and (3) pupils' awareness and participation. Figure 20.12 provides an illustrative example of the mutually reinforcing nature of the four FRESH pillars.

Governments that sought EFA outcomes also sought to mainstream programs based on these pillars into their national ESPs. Typically, ESPs reflect both expected budgetary and capacity needs, and are developed in consultation with key external and national stakeholders and partners. Analysis of the country ESPs provides insight into the relevance and prioritization of specific SHN issues by national governments. A comparison between the content of ESPs that were developed immediately following the launch of FRESH and those developed 15 years later provides an indication of how SHN programs have been mainstreamed into education systems. Figure 20.13 illustrates the proportion of countries seeking financing for each of the four pillars of FRESH at the two time points for a set of 25 countries in Sub-Saharan Africa. Countries include Benin, Burkina Faso, Burundi, Cameroon, the Central African Republic, Chad, Eritrea, Ethiopia, The Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Liberia, Madagascar, Mali, Mauritania, Mozambique, the Democratic Republic of Congo, Rwanda, Senegal, Togo, Uganda, Zambia, and Zimbabwe.

The share of ESPs seeking financing for policy pillar 1 is low at both times, reflecting the long-term nature of the policy planning cycle and the typically fixed, nonrecurrent cost of implementing policy change.

Figure 20.12 FRESH Components Supported by the Strategic Partnerships

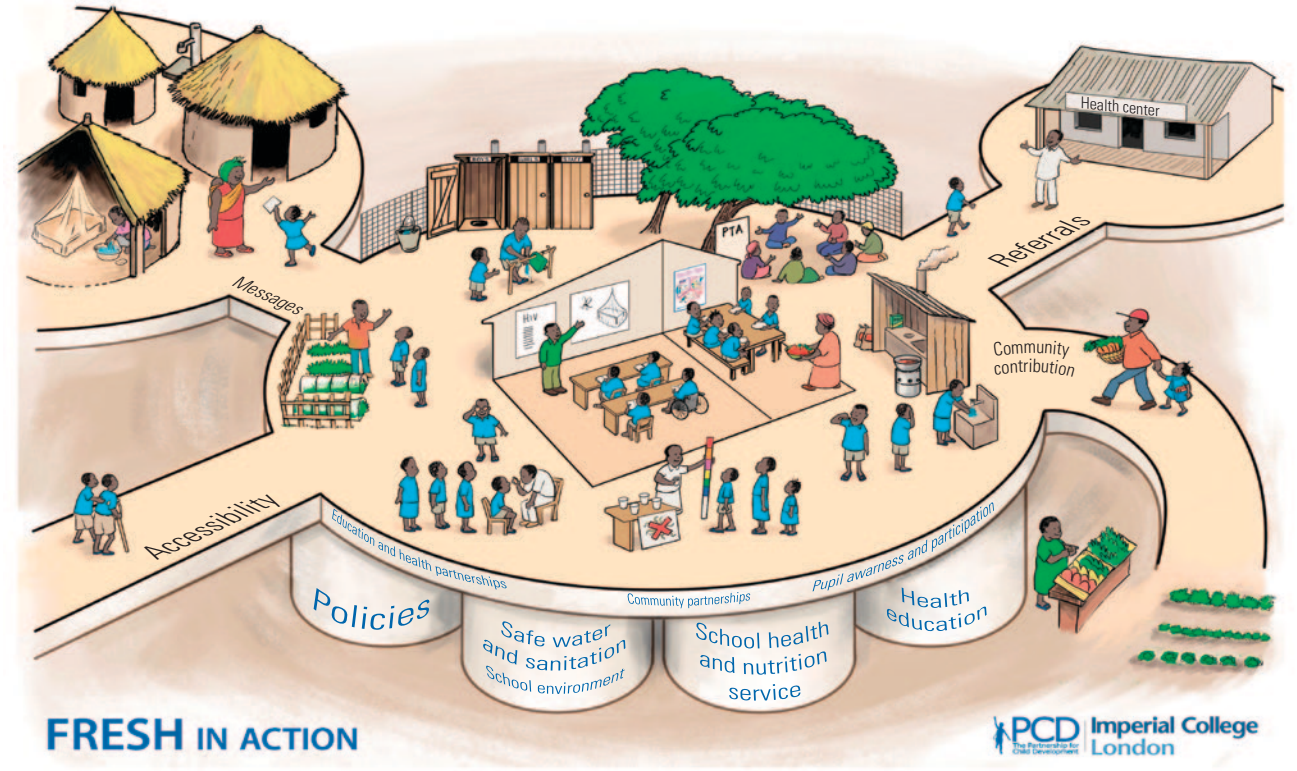


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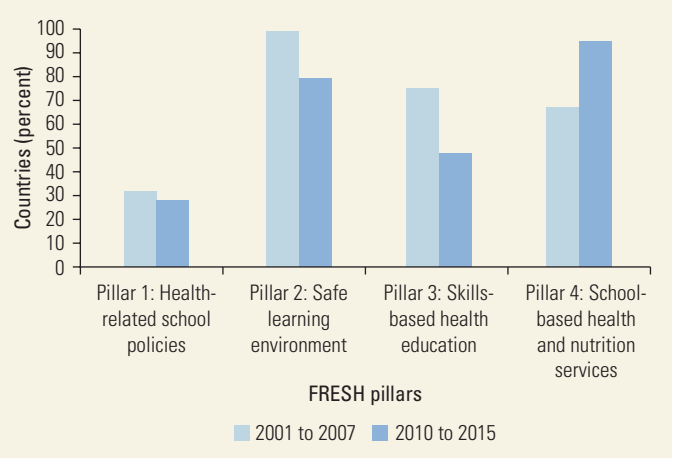
Figure 20.13 Reflection of Funding Prioritized for FRESH Pillars in Education Sector Plans from 25 Countries in Sub-Saharan Africa, 2001–15



Source: Sarr and others 2017.

Note: FRESH = Focusing Resources on Effective School Health; UNESCO = United Nations Educational, Scientific and Cultural Organization. The dates for each period correspond to the date when the education sector plan (ESP) was published. ESPs set country priorities for the sector and typically reflect funding needs for 5 to 10 years. They are developed by governments in consultation with relevant stakeholders. ESPs from the earlier period were obtained from the UNESCO Planipolis portal, while ESPs from the later period were obtained from the Global Partnership for Education website.

In contrast, infrastructure and service costs, reflected under pillars 2 and 4, respectively, have a substantial recurrent component, which is reflected in the large proportion of countries seeking financing for these pillars at both times. Pillar 2 also reflects the focus on building new schools to support EFA, hence its inclusion in the ESPs for all countries in the earlier period and to a lesser degree in the later period, perhaps reflecting investment in additional water and sanitation facilities and a new focus on menstrual hygiene management. Pillar 3 in the 2000s in Sub-Saharan Africa was focused on HIV/AIDS prevention education. In the early period, this intervention was given special emphasis by the regional Accelerate initiative, in which most countries participated. As the HIV/AIDS epidemic waned, financing for pillar 3 declined (Sarr and others 2017).

Perhaps the most important consequence of FRESH has been to offer a common point of entry for new efforts to improve health in schools. This is important because over time SHN programs can address issues that both the education and health sectors are unfamiliar with and that are intrinsically multisectoral.

The FRESH framework remains a driver of new SHN programming and has provided a common platform upon which to build agency-specific programs. Chapter 17 in this volume (Graham and others 2017) discusses how countries have used the FRESH framework to guide education that is inclusive for children with disabilities.

SABER

The degree to which SHN in practice is embedded in the education sector can be benchmarked with the SABER tool. The SABER tool was developed by a partnership led by the World Bank (2012) and was based on the FRESH framework. The tool consists of a structured questionnaire whose responses are determined based on consultation with representatives from relevant ministries, including Ministries of Education, Health, and Social Protection. One of the domains developed for SABER is SHN programming, with a large subcomponent for analysis of school feeding programs.

The SABER School Health and Nutrition and School Feeding diagnostic tools provide a snapshot of the development status of their related policies in countries. Specifically, SABER assists governments in assessing the quality of their SHN and school feeding programs and progress in implementing each indicator, and it benchmarks them against other programs and education domains. As such, SABER inspires and supports policy dialogue and reform, and lays the groundwork for a deeper analysis of the implementation of these frameworks. The SABER School Health and Nutrition and School Feeding rubric frameworks help ensure that when possible, schools can serve as entry points for health care for school-age children (World Bank 2012).

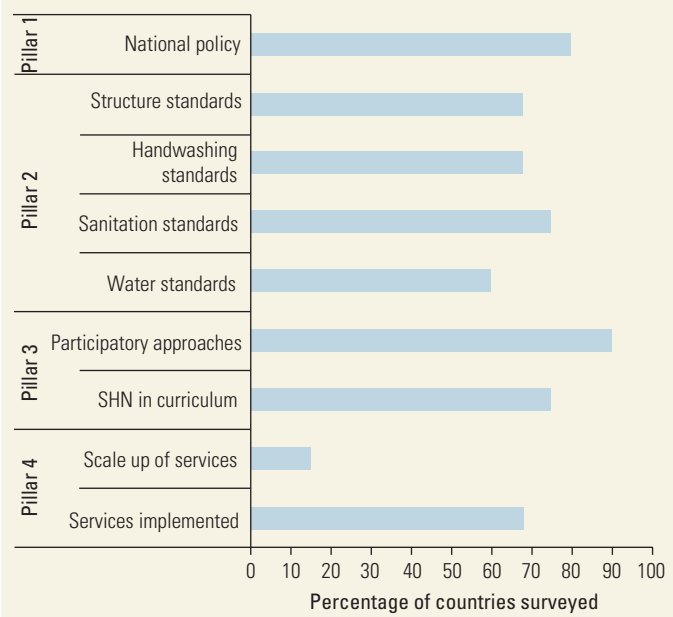
Figure 20.14 presents findings from an analysis of select indicators from SABER SHN reports from 16 LMICs published between 2011 and 2013, using the four pillars of FRESH as the guiding principle.

The results indicate that 13 of the 16 countries have national SHN policies; more than 50 percent have water, sanitation, and handwashing standards in place; 12 of the 16 countries implementing SHN services had specific recurrent budget lines to support delivery. In addition, gender-responsive policies, skills, and services were highlighted in SABER reports from 10 of the 16 countries.

Approaches to school feeding and SHN, as well as different routes to educational success, can be very diverse. No single set of policy options will be relevant to all countries. In developing national and subnational policies—and there are always trade-offs in the choices made—SABER helps identify common policy and institutional threads that run through most of the more successful experiences, such as the following:

- Focus on education outcomes
- Multisectoral policy and a memorandum of understanding between health and education sectors, backed by strong senior leadership from politicians and senior officials
- Information dissemination and consultation with local communities (World Bank 2012)

Figure 20.14 Reflection of FRESH Pillars in School Health and Nutrition Practices in 16 Countries



Source: Sarr and others 2017.
Note: FRESH = Focusing Resources on Effective School Health; SABER = Systems Approach for Better Education Results; SHN = school health and nutrition. Indicators from SABER School Health and Nutrition report from 16 countries conducted between 2011 and 2013. Countries comprise Benin, Cape Verde, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Niger, Nigeria, Rwanda, Senegal, Tanzania, Uganda, and Zanzibar.

Other School Health and Nutrition Policy Tools

Other tools for policy making on SHN programs are available, in addition to FRESH and SABER. The School Health Policies and Practices Survey, the Global School-based Student Health Survey (GSHS), and the Health Behavior in School-aged Children Survey (HBSC) are three such tools.

The School Health Policies and Practices Survey was developed by the WHO in collaboration with the U.S. Centers for Disease Control and Prevention (WHO and

CDC, n.d.). The survey aims to assess the status of school health policies and practices in primary and secondary schools. It is administered through a questionnaire for school principals or head teachers. There are 150 questions divided into six content areas: general school information, healthy and safe school environment, health services, nutrition services, health education, and physical education.

The self-administered GSHS, similarly developed by the WHO and the U.S. CDC, is designed to help countries measure and assess the behavioral risk and protective factors among students ages 13–15 years. The data collected through the survey help set priorities, establish programs, advocate for resources, and allow for comparison across countries. It is a school-based questionnaire survey, managed by a survey coordinator who is appointed through the Ministries of Health and Education. Ten key topics covered include alcohol use, dietary behaviors, drug use, hygiene, mental health, physical activity, protective factors, sexual behaviors, tobacco use, and violence and unintended injury. To date, some 110 countries in all six WHO regions have either implemented the GSHS or are in the process of doing so (WHO 2016a). Of the 110 countries, only 3 are in Europe.

The HBSC is the primary behavioral survey administered in the WHO European Region for this target population. HBSC collects data every four years on the health and well-being, social environments, and health behaviors of boys and girls ages 11, 13, and 15 years through self-administered questionnaires in classrooms. The key content areas covered by the GSHS and HBSC surveys are similar, while the HBSC survey also includes a focus on social and economic determinants. To date, 44 countries and regions across Europe and North America have been involved in the HBSC survey (WHO 2016b).

CONCLUSIONS

The school system offers a number of advantages as a health delivery system in low-income countries. Building on an existing and pervasive infrastructure can reduce start-up costs, accelerate program implementation, and reduce programmatic costs, while optimizing the benefits for education, increasing access to care for the most marginalized, and encouraging girls to attend and stay in school.

Sustainable national school health programs depend on mainstreaming these programs into national policies and plans, as well as increasing national financing for SHN and strengthening cross-sectoral institutional implementation capacity. Existing resources, such as SABER and FRESH, can help the education sector identify policy gaps and opportunities, improve implementation, and scale up. HSBC and GSHS provide similar tools for guiding the school health policy decisions of the health sector.

This approach is most effective if the health sector retains responsibility for the health of children and the education sector retains responsibility for implementation. By working together, Ministries of Education and Health can promote better health and education through multisector SHN interventions.

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NOTES

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. When an intervention involves the provision of food, the term *school feeding* is used. The term includes at least two modalities: in-school feeding, where children are fed in school; and take-home rations, where families are given food if their children attend school regularly. *Nutrition* is properly reserved for when a specific nutrition outcome is sought, such as correcting a micronutrient deficiency.

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Chapter 24

Identifying an Essential Package for Early Child Development: Economic Analysis

Susan Horton and Maureen M. Black

INTRODUCTION

The eight other volumes in this third edition of *Disease Control Priorities* focus on health; this volume complements their focus by examining the synergies between health and education outcomes. Most of the chapters in this volume focus on children ages five years and older and on adolescents. This chapter deals with children younger than age five years, serving as a counterpart to the detailed analysis of young child health in volume 2 (Black and others 2016).

The importance and effectiveness of interventions to enrich early child development (ECD) are discussed in chapter 19 of this volume (Black, Gove, and Merseth 2017). Surveys of the literature for low- and middle-income countries (LMICs) include Engle and others (2007), Engle and others (2011), and Nores and Barnett (2010).

Recent literature has begun to consider the synergies in delivering interventions focusing on nutrition or health in conjunction with child development. Surveys have examined whether codelivery enhances outcomes, reduces costs, and increases cost-effectiveness or benefit-cost ratios (Batura and others 2014; Grantham-McGregor and others 2014).

This chapter examines the costs and benefit-cost ratios of interventions that incorporate responsive stimulation to achieve better child outcomes. The purpose is to develop and cost an essential package of ECD interventions appropriate across LMICs that will complement health and nutritional interventions.

We use the term *responsive stimulation* when discussing ECD interventions that highlight the importance of positive interactions between children and caregivers. Other terms are used in the literature, including *parenting*, *caregiving*, and *psychosocial stimulation*; these terms imply a unidirectional concept, rather than the bidirectional concept that underlies many theories of child development.

The most appropriate interventions vary according to children's ages. Children younger than age three years spend much of their time with parents, family members, or caregivers. Infants and young children need care and adult attention, and the ratio of children per adult needs to be low, making group settings less feasible and more costly. Between age three years and the age of school entry, children are more likely to be in a group setting outside of the home for at least part of the day; 54 percent of this age group worldwide is enrolled in preschool (UNESCO 2015). This practice is dictated in part by economics—the ratio of children per adult supervisor can be higher—and by children's developmental needs as they begin to interact more with peers.

The main public services with which children younger than age three years interact are those for health, nutrition, and social protection. Young children can benefit from community-based interventions (Singla, Kumbakumba, and Aboud 2015), but these interventions do not generally have national coverage. Delivering interventions for responsive stimulation in coordination

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with health and nutrition services for these younger children may be an effective approach in this age group.

After age three years, it is more appropriate to integrate health and nutrition interventions into preschools and schools because children have few regularly scheduled health visits unless they are ill. Accordingly, our discussion of the economics of ECD is divided into the two age groups: children younger than age three years and children ages three to five years.

Factors other than age also affect the best way to deliver interventions. The likelihood that children participate in preschool depends on income. Enrollment in preschool is lower in poorer countries and higher in richer ones; within countries, enrollment is higher in families in the highest wealth quintile compared with other quintiles (UNESCO 2015). Enrollment in group settings is likely to be higher in urban areas than in areas of lower population density. This means that program design has potential impacts on equity—urban and rural areas and countries at different income levels may need different services.

This chapter focuses on responsive stimulation interventions delivered through health and nutrition services for young children when they are usually accompanied by family members and preschool experiences for children ages three to five or six years. We do not discuss day care arrangements for younger children at length because they tend to be more informal and not necessarily of high quality, at least for Latin America and the Caribbean (Berlinski and Schady 2015). Because of the degree of dispersion, high required staff-to-child ratios, and problems in monitoring (Leroy, Gadsden, and Guijarro 2012), day care is not an easy modality by which to deliver interventions to improve responsive stimulation. We also do not cover interventions specifically intended to address the mental health of caregivers; mental health is the subject of volume 4 (Patel and others 2015).

We first briefly discuss the methods used for the literature search and the results on costs per child and benefit-cost ratios of interventions. We use this information to develop and cost an essential package and to derive some brief conclusions. Definitions of age-specific groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017).

METHODS

We began with a systematic search of the published literature. The original searches of the literature for this volume undertaken in July 2014 and January 2015 did not yield any cost-effectiveness or benefit-cost studies for preschool children (Horton and Wu 2016), most likely because the search terms were not specific enough. A second, more specific, search was undertaken in July 2015 with additional search terms (annex 24A) that yielded three relevant articles, two of which contained benefit-cost or unit cost information. Other articles were obtained through consultation with experts, searches of bibliographies of relevant articles, and searches of gray literature.

In all, 11 articles that provide economic estimates were identified. One contained information on benefit-cost ratios only, three on unit cost only, and seven on both. These articles cover a broad range of LMICs, although coverage of Latin America and the Caribbean was the most in-depth (five studies). One study was found for multiple countries in the Middle East, two for Turkey, one for Mozambique, and one for Pakistan, and one covers a broad range of LMICs. Although South-East Asia has large preschool programs and center-based care programs, no articles providing economic estimates were found for that region.

The 11 identified studies of the economics of ECD cover regions similar to those addressed in the larger literature on effectiveness of ECD discussed in chapter 19 in this volume (Black, Gove, and Merseth 2017). A survey and meta-analysis of the effectiveness literature outside Canada and the United States was undertaken by Nores and Barnett (2010). They restricted their coverage to experimental studies and to quasi-experimental studies with stronger designs, identifying 28 studies in 13 countries (4 in Latin America and the Caribbean, 4 in Asia, 3 in Western Europe, and 1 each in Mauritius and Turkey). Four of the programs identified in Nores and Barnett's (2010) survey are also covered in the economic literature—the interventions in Bolivia, Jamaica, Turkey, and Uruguay that are discussed in the next two sections. It is a noticeable omission that no effectiveness and benefit-cost studies are available for Sub-Saharan Africa.

Our survey of cost and benefit-cost is therefore likely to be fairly representative of the larger literature on effectiveness, and there is overlap of actual programs covered. We know quite a lot about the few programs that have been the subject of well-designed research studies. These programs may be more effective than the average, but because they are more intensive, they may cost more. The same would be true for the United States, where the Perry Preschool Project, Head Start, and the Abecedarian Project were intensively studied, with long-term follow-up. Other programs that have not been studied may be less costly, but they may also be less effective and less cost-effective. However, the objective should be to try to replicate good-quality, effective programs.

The literature on both effectiveness and economic aspects also has a regional bias. Studies focus more on

middle-income countries; in particular, we know very little about cost and effectiveness in Sub-Saharan Africa, where coverage is lowest and expansion of coverage is most needed.

BENEFIT-COST RATIOS OF EARLY CHILD DEVELOPMENT INTERVENTIONS

Children Younger than Age Three Years

Recent studies have examined the effectiveness of combined health, nutrition, and early childhood interventions in LMICs for children, typically younger than age three years (Grantham-McGregor and others 2014; Nores and Barnett 2010). Table 24.1 presents our benefit-cost findings based on our literature search.

Two randomized controlled trials for Pakistan and the Caribbean had positive economic evaluations. The benefit-cost ratio for an intervention in Antigua, Jamaica, and St. Lucia that developed videos and showed them to parents waiting in health centers, followed by group discussion, was 5.3 (Walker and others 2015). In Pakistan, a randomized controlled trial compared nutrition alone, responsive stimulation alone, and the two combined against a control receiving usual care (Gowani and others 2014). The combined option had the best outcome and cost less than the other two interventions. The lower costs were unrepresentative of an intervention at scale because they were due to two vacant supervisor positions, and the research study may have helped compensate for the absence of usual levels of supervision.

López Boo, Palloni, and Urzua (2014) estimated a benefit-cost ratio of 1.5 for an intervention in Nicaragua that combined responsive stimulation and a nutrition intervention of multiple micronutrient powders for children younger than age three years. However, the entire benefit is based on reduction of anemia, which is likely to be predominantly due to the nutrition intervention; it does not take into account any cognitive benefits

Table 24.1 Benefit-Cost Ratios of Early Child Development Interventions

Study	Country or region	Comments	Benefit-cost ratio (d = discount rate)
Ages zero to two years			
Berlinski and Schady 2015	Latin America	Home visits; modeled costs and returns, using 3 percent discount rate. Outcomes: child cognitive skills; mother's employment.	3.6 (Guatemala) 2.6 (Colombia) 3.5 (Chile)
Walker and others 2015	Jamaica, St. Lucia, Antigua	Details not yet published; summary results cited in Berlinski and Schady 2015.[a]	5.3
Gowani and others 2014	Pakistan	Parenting intervention took advantage of spare capacity (home visits without intervention were "too short"); combined intervention was less costly because two regular supervisory posts vacant; likely not replicable in nonresearch setting.[a]	Not calculated, but combined nutrition and parenting very favorable
López Boo, Palloni, and Urzua 2014	Nicaragua	Benefit-cost ratio is for combined effect of Sprinkles[b] and early child development, but effect calculated on the basis of anemia (likely to be primarily effect of Sprinkles).[a]	1.5
Ages three to five years: Preschool programs			
Behrman, Cheng, and Todd 2004	Bolivia	Range depends on assumptions about gain in earnings from increased educational attainment, and cost of education.[a]	2.28–3.66 (d = 3%) 1.37–2.48 (d = 5%)
Berlinski and Schady 2015	Latin America	Modeled benefits (child cognitive skills hence future earnings, and mother's employment) compared to preschool costs.	5.1 (Guatemala) 3.4 (Colombia) 4.3 (Chile)
Berlinski, Galiani, and Manacorda 2008	Uruguay	Modeled benefits of increased school grade completion, net of cost of preschool and additional school cost.	19.1 (d = 3%) 3.2 (d = 10%)

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Table 24.1 Benefit-Cost Ratios of Early Child Development Interventions (continued)

Study	Country or region	Comments	Benefit-cost ratio (d = discount rate)
Engle and others 2011	73 low- and middle-income countries	Modeled change in wages due to increased school attainment, associated with increased preschool participation. Includes additional preschool cost but not school cost.	14.3–17.6 (d = 3%) 6.4–7.8 (d = 6%)
Kaytaz 2004	Turkey	Considers cost of preschool education plus forgone earnings of students staying longer in school. Range depends on assumptions on share continuing to tertiary education.[a]	2.18–3.43 (d = 6%) 1.12–1.69 (d = 10%)

Note: For details of interventions, see table 24.2. Berlinski and Schady (2015) also model the benefit-cost ratio of day care provision to children ages zero to five years as 1.2 (Guatemala), 1.1 (Colombia), and 1.5 (Chile), also using a modeling exercise and discount rate of 3 percent. Psacharopoulos (2015) provides benefit-cost estimates of 3:1 for preschool in the Philippines citing Patrinos (2007), and 77:1 in Kenya, citing Orazem, Glewwe, and Patrinos (2009). Patrinos (2007) cites Glewwe, Jacoby, and King (2001), which is a study of the return to nutrition interventions in preschools in the Philippines; and Orazem, Glewwe, and Patrinos (2009) cite Vermeersch and Kremer (2004), which is a study of the return to school meals in Kenya. We have not included these estimates.

a. Measured outcomes are described in table 24.2.

b. Sprinkles is a brand of multiple micronutrient powders.

resulting from responsive stimulation. Finally, one study for Latin America and the Caribbean models the effect of a home visiting program that educates mothers in child development (Berlinski and Schady 2015); however, this program is not combined with a nutrition or health intervention. Benefit-cost ratios for the three countries ranged from 2.6 to 3.6. There may be other benefit-cost studies of home visiting programs in LMICs that we did not survey given that our search focused on combined programs that included health interventions. More economic studies of combined interventions would be helpful.

Children Ages Three to Five Years

There is a larger literature on preschool programs than on programs for younger children (table 24.1). Benefit-cost ratios of preschool for five countries—Bolivia, Chile, Colombia, Turkey, and Uruguay—generally exceeded 3 (using a discount rate of 3 percent or higher); in Uruguay, the benefit-cost ratio was 19.1, using a discount rate of 3 percent. Benefit-cost ratios for preschool ages remained generally greater than 1 for discount rates up to 10 percent. A cross-country study generated a benefit-cost ratio of 14.3–17.6, but it did not incorporate the requisite additional costs of greater school enrollment (Engle and others 2011).

A nutritional add-on to preschool—a breakfast of porridge—generated an extraordinarily high benefit-cost ratio of 77 in Kenya (Psacharopoulos 2015, citing Orazem, Glewwe, and Patrinos 2009, who in turn use Vermeersch and Kramer 2004). However, the underlying empirical study does not appear to have been published, and it is not clear that Psacharopoulos (2015) accounted for the cost of the breakfast in the calculations.

The benefit-cost ratios estimated for LMICs are slightly lower than those estimated for well-known preschool studies in the United States, which ranged from 2.7 to 7.2 for three programs (Temple and Reynolds 2007). One difference is that the type of longitudinal studies available in the United States has not been conducted in LMICs; Gertler and others (2014), one of the first, is a 20-year follow-up to a seminal intervention in Jamaica. For LMICs, there are estimates of the benefits in cognitive achievement, school attainment, and wages. There are few data, however, on some of the substantial costs avoided by quality preschool programs in the United States, such as the costs of crime. LMIC estimates probably underestimate the benefits of ECD interventions; Gertler and others (2014) found large effects on wages for Jamaica that were associated with increases in international migration for the treated group.

Comparing across all programs irrespective of child age, the benefit-cost ratio of integrated programs tends to be higher than that of stand-alone programs. This outcome may be due in part to lower marginal costs of the intervention, as well as possible synergies in outcomes. This inference relies on four studies (Gowani and others 2014; López Boo, Palloni, and Urzua 2014; Walker and others 2015; and a subsequent interpretation by Psacharopoulos 2015 of Vermeersch and Kremer 2004). Because two of these are not or not yet published (Walker and others 2015; Vermeersch and Kremer 2004), and the study designs of the other two have unique features, additional studies are needed to confirm this tendency.

UNIT COST OF INTERVENTIONS

Unit cost data are presented in table 24.2. There are some inconsistencies in the data, for example, Araujo, López Boo, and Puyana (2013) reported financial costs that do not take account of volunteers, donations, and parental contributions. Programs for younger children are more heterogeneous in structure. They vary from day care (Araujo, López Boo, and Puyana 2013; Behrman, Cheng, and Todd 2004), to programs to educate mothers of children ages five and six years in groups (Chang and others 2015; Sirali, Bernal, and Naudeau 2015), to home visits (Gowani and others 2014; van Ravens and Aggio 2008). What is covered in the costs for preschool programs is more uniform because the programs are somewhat more standardized, but preschool programs also vary in intensity, for example, hours per week and ratio of children to teachers.

Costs are updated to 2012 U.S. dollars to permit comparisons, and comparing costs as a percentage of per capita gross national income (GNI) is also useful. Berlinski and Schady (2015) and van Ravens and Aggio (2008) model costs, arguing that the salary of an ECD educator has approximately a constant relation to the salary of a primary teacher; that primary teachers' salaries have a predictable relationship to GNI; and that the educator-to-child ratio is fairly predictable, depending on child age (very high for day care, lower for preschool, and lower still for group education programs for parents and caregivers).

Table 24.2 Unit Costs of Early Child Development Interventions

Study	Country or region	Intervention and outcomes measured	Cost in study	Unit	Currency (year)	Annual cost per child in 2012 US$	Annual cost per child as share of GNI (percent)
Ages zero to two years							
Araujo, López Boo, and Puyana 2013	Latin America and the Caribbean	Financial costs for four parenting programs across Latin America and the Caribbean, ranging from US$13 to US$599 per child; median = Mexico and Ecuador. No outcome measured.	188 (median)	Child per year	US$	220	2.2 for median countries
Walker and others 2015	Antigua, Jamaica, and St. Lucia	Parents were shown a video on responsive stimulation at routine health visits, engaged in group discussion, and received small books and puzzles to use at home. Outcome: parenting scale, Griffith Mental Development Scale, Communicative Development Index.	100	Child over 15-month period	2012 US$	100[a]	2.0
Gowani and others 2014	Pakistan	Lady Health Workers (who provide health and nutrition advice in home visits) were trained to also give responsive stimulation; also monthly group meetings held with mothers; 2x2 factorial design. Outcomes: cognition, motor, language scores.	4	Child per month, birth to 24 months	2012 US$	48	3.8
López Boo, Palloni, and Urzua 2014	Nicaragua	PAININ program provided three-hour care per day in centers (with ECD and Sprinkles[b]) in urban areas; home parenting visits twice a week in rural areas by volunteer mothers. Outcomes: anemia, hemoglobin, verbal and numeric memory.	37	Child per year	2012 US$	37	2.1
van Ravens and Aggio 2008	Middle East	Home visiting: develop formula that cost per child is 16/(total fertility rate), as % of per capita GDP; range of costs US$13–US$1,393 for 19 countries. No outcomes.	85 in median country (Jordan)	Child per year	2006 US$	117	2.3

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Table 24.2 Unit Costs of Early Child Development Interventions (continued)

Study	Country or region	Intervention and outcomes measured	Cost in study	Unit	Currency (year)	Annual cost per child in 2012 US$	Annual cost per child as share of GNI (percent)
Ages three to five years							
Araujo, López Boo, and Puyana 2013	Latin America and the Caribbean	Financial costs from 28 child care programs, ranging from US$257 to US$3,264 per child; median = Mexico and Ecuador. No outcomes measured.	836 median	Child per year	2010 US$	977	10 for median countries
Behrman, Cheng, and Todd 2004	Bolivia	PIDI: provides day care to children ages 6–72 months in poor, largely urban areas; 40 percent of cost is food. Outcomes: motor, language, psychosocial skills; nutritional status.	43	Child per month	1996 US$	600	26.0
Berlinski, Galiani, and Manacorda 2008	Uruguay	Government-provided preschool for ages four to five years. Outcomes: subsequent school attainment.	1,164.80 (US$129.10)	Child per year	1997 Uruguayan pesos	198	1.4
Kaytaz 2004	Turkey	Preschool. Outcomes: subsequent school attainment.	886,424,000 (US$552)	Child per year	2002 Turkish liras	1,245	11.5
Martinez, Naudeau, and Pereira 2012; Sirali, Bernal, and Naudeau 2015	Mozambique	Preschool for three and a quarter hours per day; cost in pilot phase (Martinez, Naudeau, and Pereira 2012) was only half of cost in scale up (Sirali, Bernal, and Naudeau 2015). Outcomes: subsequent enrollment in primary school; scores on various development tests; spillover to older sibling school enrollment and parents' work time.	25 (pilot); 50 scale up	Child per year	2010[c] US$ 2012[c] US$	50 (at scale-up)	9.4
Sirali, Bernal, and Naudeau 2015	Turkey	MOCEP 25-week training program for mothers and children ages five to six years; lectures and discussions once per week, kits for use at home, home visits by trainers. No outcomes discussed.	40	Participant (25 weeks)	2010 US$	90[a]	0.8
van Ravens and Aggio 2008	Middle East	Preschool: develop formula that cost per child is 12.5 percent of per capita GDP; range of costs US$54–US$3,482 for 19 countries. No outcomes discussed.	239 median country Jordan	Child per year	2006 US$	330	6.5 for median country

Note: ECD = early child development; GDP = gross domestic product; GNI = gross national income; MOCEP = Mother and Child Education Program; PAININ = Comprehensive Childcare Program; PIDI = Programa de Atención Integral a la Niñez Nicaragüense, Proyecto Integral de Desarollo Infantil.

a. Cost is for duration of program per child; duration is not exactly one year.

b. Sprinkles are a brand of multiple micronutrient powders.

c. Original authors do not specify dates; these are estimated by current authors.

Berlinski and Schady (2015) explained that the cost of preschool programs varies systematically with process quality. More intensive supervision adds about 10 percent to the cost of preschool programs, while structural quality—quality of buildings, higher pay for teachers, smaller class sizes—can add up to 300 percent to the basic cost of preschool programs. The data are insufficient to examine the benefit-cost ratio variations of basic, improved process quality, and improved structural quality programs, although Berlinski and Schady (2015) argued that the benefit-cost ratio of enhancing process quality is likely higher than that of enhancing structural quality. This is, however, a contested literature, because trained teachers who can improve process quality may not stay long in low-quality school environments, such as those with dilapidated buildings. Vermeer and others (2016) undertook an international meta-analysis and commented on how

different factors affect a measure of program quality that can be measured by observers, and in turn is known to correlate with longer-term outcomes.

Children Younger than Age Three Years

The cost of integrating a component on responsive stimulation with regular visits for nutrition and health is more modest than that of establishing either a day care or a preschool program. Table 24.2 provides unit cost data for five programs for younger children that primarily seek to benefit mothers and children in their homes or in community-based day care with volunteer mothers.

Programs for younger children vary considerably in their format, and annual costs per child range from about 0.8 percent of per capita GNI for financial costs of day care and home visit programs in Latin America and the Caribbean, as well as a mother-child education program in Turkey, to 3.8 percent of per capita GNI for a home visit program in Pakistan. The median share of per capita GNI is 2.2 percent. Programs tend to cost more per child in absolute amount as country income increases because salaries increase, and where the educators are paid rather than serve as volunteers. Home visit programs cost more than programs in which groups of mothers attend centers for parenting education. However, center-based programs may simply transfer the costs of attendance to families rather than trainers, and these programs may reduce participation by those in poorer households or those living in more remote locations.

Children Ages Three to Five Years

Preschool programs are more costly than programs involving educating mothers or caregivers. The annual costs per child range from 1.4 percent of per capita GNI in Uruguay to 26 percent in Bolivia. However, the very lowest and highest costs are probably outliers. The Uruguay program is in an upper-middle-income country and provides a half-day program, which may reduce costs, while the program cost in Bolivia is 16 percent of per capita GNI if cost of food is excluded. The median cost is approximately 10 percent of per capita GNI. This amount is roughly consistent with a formula developed by van Ravens and Aggio (2008), who used salaries and staff-to-child ratios and estimated the cost to be 12.5 percent of gross domestic product (GDP). Preschool programs are consistently more costly than group parenting education because of the higher staff-to-child ratio that is necessary.

Parenting programs are less common in this age group, but one program summarized in the table for children ages three to five years provides group parental education for mothers of older children (Sirali, Bernal, and Naudeau 2015), the Mother and Child Education Program in Turkey. This program has been widely disseminated to other countries.

THE ESSENTIAL PACKAGE AND ITS COST

Assumptions

Parenting programs are more likely to be oriented to children younger than age three years and to entail the participation of mothers. The Mother and Child Education Program delivered to mothers of older children is somewhat unusual in this respect (Sirali, Bernal, and Naudeau 2015). Some parenting programs are delivered to groups of mothers (see table 24.2 for examples for the Caribbean and Turkey); others are delivered primarily through home visits (see table 24.2 for examples from the Middle East and Latin America and the Caribbean); and hybrid programs use both group and home visit components (see table 24.2 for one program in Pakistan). Preschool programs typically focus on ages three to five years, although they may include younger children.

The cost of ECD programs is driven primarily by salary costs. Costs depend on several factors, including the ratio of educators to children, country GNI because salaries tend to increase with country income, and the specific design of individual programs.

Program type has a substantial impact on cost because there are systematic differences in the ratio of staff to children and families. Parenting programs provided to groups can have higher child-to-staff ratios than those involving home visiting; the lowest ratios observed are for preschool programs, where teachers educate children rather than parents. The ratios might be approximately 50 to 1, 25 to 1, and 12 to 1, respectively (estimate based on Araujo, López Boo, and Puyana 2013; Gowani and others 2014; and van Ravens and Aggio 2008). Based on these staffing ratios, we estimate that home visiting programs might cost about twice as much per child as group parenting programs, while preschool programs might cost about four times as much per child as group parenting programs. All three types of programs—parenting programs, home visiting programs, and preschool programs—may vary in effectiveness.

Similarly, we can estimate that the per capita income of lower-middle-income countries is about three times that of low-income countries, and that of upper-middle-income countries is about nine times that of low-income countries, using the World Bank definitions. Table 24.2 includes information from one low-income country, Mozambique.

We developed the following estimates for costs per child per year in 2012 U.S. dollars, based on table 24.2, also using the ratios discussed:

- **Group parenting programs**: US$30–US$35 per child in lower-middle-income countries and US$90–US$100 per child in upper-middle-income countries
- **Home visiting programs**: US$60–US$70 per child in lower-middle-income countries and US$200 per child in upper-middle-income countries
- **Preschool programs**: US$300 per child in lower-middle-income countries and US$600 per child in upper-middle-income countries.

We have no data for low-income countries in Sub-Saharan Africa, other than one preschool program that cost US$50 per child per year for a three hour per day program once the program moved beyond the pilot phase.

These estimates are roughly consistent with the country data (table 24.2) and the staffing ratios presented. Costs for individual countries will vary with per capita GNI and program design. It is always possible to make programs cheaper by, for example, reducing intensity or using volunteers, but doing so can be detrimental to effectiveness. We assume that programs delivered to mothers need to be delivered once per lifetime of children, whereas children may participate in preschool programs for two or three years until they begin formal schooling. The cost of US$30–US$35 for a group parenting program per child born is modest compared with the larger investment in health per child born. Routine immunization alone with six or more vaccines now costs US$46.50 per fully immunized child (Brenzel, Young, and Walker 2015; see Black and others 2016).

Evidence from programs (table 24.1) suggests that the benefit-cost ratio of a well-designed and well-implemented program is in the range of 2–5, using a modest 3 percent to 5 percent social discount rate. Although some benefit-cost estimates are higher than these, they may be from studies that underestimate the full program cost.

Recommendations for an Essential Package

Based on considerations of cost, our subjective assessment of feasibility, and benefit-cost, we recommend the following.

Essential Package

Countries should aim to cover all first-time parents (at a minimum) and all births (preferably) with a group parenting program that is integrated into the provision of health services. This program could be conventional (in person) or could take advantage of innovative methods, such as videos combined with facilitated group discussion. Parenting programs could be integrated into existing home visiting programs that provide health services, in which case the program could be offered instead of or in combination with group delivery. The programs should be provided in one year of the child's first three years, preferably as early as possible to have the greatest impact.

Countries might also choose to implement the program differently in different regions, providing group sessions in more densely populated areas and home visits to more remote households and to poorer households. Costs will increase as the proportion receiving home visits increases, but equity and impact will also increase.

Programs must have a certain intensity to have an impact. In the Caribbean pilot (Walker and others 2015), mothers participated in group discussions five times over approximately 15 months; each session took about 25 minutes of the mother's time (a combination of viewing a video and participating in a group discussion, with one-on-one reinforcement during the visit with the nurse). In Pakistan, mothers received home visits of approximately 30 minutes about once a month, and the pilot program followed children in their first two years of life (Gowani and others 2014). In Latin American programs, parents generally met with community workers for slightly more than an hour a week for 10 months of the year over a two-year period (Araujo, López Boo, and Puyana 2013). A group program in Uganda for both parents that entailed 12 sessions is discussed in chapter 19 in this volume (Black, Gove, and Merseth 2017); the content of the parenting programs is also important. Programs that do not have sufficient quality and intensity will not be effective.

Preschool Programs

Evidence suggests that children are more ready for school cognitively, socially, and emotionally if they have preschool education; this is particularly important for children from more vulnerable households. The estimated cost per child is US$300 per child per year in lower-middle-income countries and US$600 per child per year in upper-middle-income countries. We assume that governments would subsidize or pay the full cost of this education for vulnerable households but require parental contribution or full payment for more affluent households. This approach is more common in upper-middle-income countries.

When estimating preschool costs, van Ravens and Aggio (2008) assume a half-day program and use a ratio of 20 children per teacher. UNICEF (2008) recommends 15 hours per week and a 15:1 maximum ratio, but even

many countries in Europe do not achieve this goal, and this objective would certainly imply higher costs than provided here.

CONCLUSIONS

Codelivery of health, nutrition, and responsive stimulation programs can benefit child development and be cost-effective. For children younger than age three years, codelivery is best achieved by integrating responsive stimulation elements into existing health and nutrition programs. For children ages three to five years, codelivery can be achieved by integrating health and nutrition interventions into preschool programs.

For children younger than age three years, group parenting programs cost about US$30–US$35 per year in lower-middle-income countries, and about twice that if home visiting is included. Some home visiting is likely to be required to reach some populations and improve equity. The benefit-cost ratio for existing programs ranges from about 2:1 to about 5:1. Group parenting programs need facilitators but can also incorporate media, such as videos.

Preschool programs cost about US$300 per child in lower-middle-income countries, and the benefit-cost estimates for existing programs similarly range from about 2:1 to 5:1 (higher benefit-cost ratios have been obtained, but typically where costs are underestimated). Countries can usually afford to subsidize preschool for only selected groups, such as poor households and marginalized groups.

Programs for individual children and families need to be complemented by appropriate national policies for child development. National policies include policies proscribing child abuse and facilitating behavior change communication to support positive parenting behaviors.

Evidence on cost and cost-effectiveness is quite modest, and we rely heavily on a relatively few longitudinal studies of high-quality programs. Some researchers have used innovative methods, such as using national data retrospectively (for example, Berlinski, Galiani, and Manacorda 2008) or linking across national datasets. It would also not be too difficult or costly to augment the cost and cost-effectiveness literature by collecting cost data for existing studies of effectiveness.

Evidence on cost and cost-effectiveness is presently insufficient for low-income countries in Sub-Saharan Africa. Although children in this region likely will benefit from ECD programs, well-evaluated pilot programs are required to identify program designs that will work well in this context and that are scalable.

For all of these interventions, program quality is extremely important. Good training and supervision are critical. If ECD is seen as a low-cost add-on to existing health and nutrition programs, and current staff is overburdened by yet more tasks, the outcomes are likely to be of low quality. Well-designed and well-supervised interventions can affordably improve the likelihood that vulnerable children will be better able to reach their full potential.

ANNEX

The annex to this chapter is as follows. It is available at http://www.dcp-3.org/CAHD.

- Annex 24A. Literature Search Terms and Methods

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NOTE

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.

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Chapter 25

Identifying an Essential Package for School-Age Child Health: Economic Analysis

Meena Fernandes and Elisabetta Aurino

INTRODUCTION

This chapter presents the investment case for providing an integrated package of essential health services for children attending primary schools in low- and middle-income countries (LMICs). In doing so, it builds on chapter 20 in this volume (Bundy, Schultz, and others 2017), which presents a range of relevant health services for the school-age population and the economic rationale for administering them through educational systems. This chapter identifies a package of essential health services that low- and middle-income countries (LMICs) can aspire to implement through the primary and secondary school platforms. In addition, the chapter considers the design of such programs, including targeting strategies. Upper-middle-income countries and high-income countries (HICs) typically aim to implement such interventions on a larger scale and to include and promote additional health services relevant to their populations. Studies have documented the contribution of school health interventions to a range of child health and educational outcomes, particularly in the United States (Durlak and others 2011; Murray and others 2007; Shackleton and others 2016). Health services selected for the essential package are those that have demonstrated benefits and relevance for children in LMICs. The estimated costs of implementation are drawn from the academic literature. The concept of a package of essential school health interventions and its justification through a cost-benefit perspective was pioneered by Jamison and Leslie (1990).

As chapter 20 notes, health services for school-age children can promote educational outcomes, including access, attendance, and academic achievement, by mitigating earlier nutrition and health deprivations and by addressing current infections and nutritional deficiencies (Bundy, Schultz, and others 2017). This age group is particularly at risk for parasitic helminth infections (Jukes, Drake, and Bundy 2008), and malaria has become prevalent in school-age populations as control for younger children delays the acquisition of immunity from early childhood to school age (Brooker and others 2017). Furthermore, school health services are commonly viewed as a means for building and reinforcing healthy habits to lower the risk of noncommunicable disease later in life (Bundy 2011).

This chapter focuses on packages and programs to reach school-age children, while the previous chapter, chapter 24 (Horton and Black 2017), focuses on early childhood interventions, and the next chapter, chapter 26 (Horton and others 2017), focuses on adolescent interventions. These packages are all part of the same continuum of care from age 5 years to early adulthood, as discussed in chapter 1 (Bundy, de Silva, and others 2017). A particular emphasis of the economic rationale for targeting school-age children is to promote their health and education while they are in the process of learning; many of the interventions that are part of the package have been shown to yield substantial benefits in educational outcomes (Bundy 2011; Jukes, Drake, and Bundy 2008). They might be viewed as health interventions that leverage the investment in education.

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Schools are an effective platform through which to deliver the essential package of health and nutrition services (Bundy, Schultz, and others 2017). Primary enrollment and attendance rates increased substantially during the Millennium Development Goals era, making schools a delivery platform with the potential to reach large numbers of children equitably. Furthermore, unlike health centers, almost every community has a primary school, and teachers can be trained to deliver simple health interventions, resulting in the potential for high returns for relatively low costs by using the existing infrastructure.

This chapter identifies a core set of interventions for children ages 5–14 years that can be delivered effectively through schools. It then simulates the returns to health and education and benchmarks them against the costs of the intervention, drawing on published estimates. The investment returns illustrate the scale of returns provided by school-based health interventions, highlighting the value of integrated health services and the parameters driving costs, benefits, and value for money (the ratio of benefits to costs). Countries seeking to introduce such a package need to undertake context-specific analyses of critical needs to ensure that the package responds to the specific local needs.

CONDITIONS AND POSSIBLE INTERVENTIONS

Possible interventions for the essential package were considered from the perspective of four domains of child development. Three of which (physical, nutrition, and psychosocial) pertain primarily to health, and one (cognition) primarily to education. Table 25.1 presents an overview of low-cost interventions in each domain and the possible delivery platforms identified in the literature.

Although interventions promoting psychosocial health may be beneficial for primary-school-age children, most studies focus on secondary school and adolescents. Interventions delivered through population-based mechanisms, such as the media, are likely targeted to decision makers and to adolescents rather than children. For some conditions, such as oral health, identification and prevention may be through one platform (schools or communities), and remedial treatment may be through another (primary health centers).

Most of the interventions have potential impacts on education as a consequence of improvements in health, although the specific pathways vary. Providing meals in schools may help mitigate the energy intake gap for children experiencing low to moderate undernutrition, thereby promoting overall health status and school participation. The regular provision of iron-folate pills or meals fortified with micronutrient powders may reduce the prevalence of anemia and so improve cognitive ability, thereby improving school attendance and learning. Correcting refractive error may have a direct impact on future economic productivity by improving learning and academic achievement.

The benefits of interventions such as oral hygiene and vaccines are related primarily to health. Although most vaccines are delivered in early childhood, primary schools can be optimal delivery platforms for primary doses of the human papillomavirus (HPV) vaccine and booster doses of tetanus vaccine (LaMontagne and

Table 25.1 Platforms for Delivering School-Based Health Interventions

	Platform			
Domain	**Population level**	**Community**	**School**	**Primary health center**
Physical health	Education	Refractive error	**Deworming; insecticide-treated bednets; malaria chemoprevention; tetanus toxoid and HPV vaccination; oral health prevention;** sex education messages; **refractive error**	**Deworming; insecticide-treated bednets; tetanus toxoid and HPV vaccination; oral health and dentistry**
Nutrition	Nutrition education messages	**Micronutrient supplementation; multifortified foods**	**Micronutrient supplementation; multifortified foods; school feeding;** nutrition education messages	**Micronutrient supplementation**
Psychosocial	Mental health messages	n.a.	Mental health education and counseling	Mental health counseling
Cognition	Conditional cash transfers	School promotion	**Vision screening**	**Vision screening**

Note: HPV = human papillomavirus; n.a. = not applicable. Interventions in bold are covered in this chapter.

others 2017), while health centers can target out-of-school children and marginalized girls. In a global survey, 95 of 174 countries used schools to deliver some vaccines, but the prevalence was much lower among LMICs than HICs, 28 percent and 64 percent, respectively (Vandelaer and Olaniran 2015). Effective immunization from tetanus requires several doses in infancy through early childhood, with boosters in middle childhood (around ages 4–7 years) and adolescence (ages 12–15 years). The World Health Organization (WHO) recommends delivering tetanus-diphtheria toxoid combination immunizations rather than a single antigen tetanus toxoid (WHO 2006). At least 80 countries include the tetanus toxoid and booster immunizations in school-based programs, making it the vaccine most commonly delivered through schools (Vandelaer and Olaniran 2015) and part of the essential package.

An estimated 80 percent of the global burden of cervical cancer is concentrated in LMICs, underscoring the relevance of the HPV vaccine as a preventive measure. The essential package promotes the administration of two doses of the HPV vaccine to girls in a given grade in primary school, with the selected grade containing the largest share of the target age group.

The package includes hygiene education, but not the water and sanitation components of WASH. This decision reflects the high cost of intervention, especially the construction of water supply infrastructure and school facility infrastructure and maintenance (Snilstveit and others 2015)-the costs of which would exceed the costs of all other candidate interventions for the essential package.

Table 25.2 estimates the burden of conditions treatable by interventions in the essential package in LMICs, underscoring the potential global impact of school-based health services.

ESTIMATING THE COSTS

Table 25.3 summarizes the evidence on the costs and outcomes of interventions in the essential package. The estimates typically focus on average annual costs incurred in delivering the intervention; they exclude

Table 25.2 Burden of Conditions Affecting the Health and Development of School-Age Children

Domain and condition or infection	Estimated school-age population at risk	Possible interventions
Physical health		
Schistosoma and STHs, including hookworm, roundworm, whipworm	Schistosomiasis: 207 million cases globally STHs: 870 million cases in 2014[a]	Deworming treatment
Malaria	568 million at risk globally; more than 200 million cases of *Plasmodium falciparum* in ages 5–14 years in 2010 in Sub-Saharan Africa alone	ITNs, intermittent preventive screening and administration of malaria chemoprevention, indoor residual spraying
Tetanus	All school-age children	Tetanus toxoid vaccine
HPV	All girls ages 9–14 years	HPV vaccine
Tooth decay	40 percent to 90 percent of children age 12 years in LMICs[b]	Provision of toothbrushes, promotion of oral care, dental screening and referrals
Nutrition		
Micronutrient deficiencies	Anemia: 304.6 million[c]	Micronutrient powders, food fortification, micronutrient-rich foods
Underweight	Girls: 16 percent; boys: 25 percent[d]	School feeding
Cognition		
Uncorrected refractive error	13 million[e]	Vision screening and provision of inexpensive eyeglasses

Note: HPV = human papillomavirus; ITNs = insecticide-treated bednets; LMICs = low- and middle-income countries; STHs = soil-transmitted helminths.
a. Fenwick 2012.
b. Bagramian, Garcia-Godoy, and Volpe 2009.
c. McLean and others 2009.
d. Manyanga and others 2014. Seven African countries (Benin, Djibouti, the Arab Republic of Egypt, Ghana, Malawi, Mauritania, and Morocco) reported prevalence for students ages 11–17 years.
e. Resnikoff and others 2008.

Table 25.3 Costs of Potential Interventions

Costs per year (2012 US$ unless otherwise noted)

Domain	Intervention	Cost per child	Cost per case averted	Cost per death averted	Cost per DALY averted
Nutrition	School meals[a]	41 (2008)	100 kilocalorie gain: 10.22	—	n.a.
	Micronutrient powder supplementation[b]	2.92 (2014)	Anemia: 8.59	—	n.a.
Infectious disease	Deworming: Mass drug administration[c]	0.35	Helminth infection: 0.93–5.28	n.a.	3.36–6.92
	Malaria: Intermittent parasite clearance[d]	1.88–4.03 (2009) (White and others 2011)	Infection: 5.36–9 (Horton and Wu 2015); 1.45–33 (2009) (White and others 2011); anemia: 29.84–50 (Horton and Wu 2015)	110–4,961 (2009)	24 (2009)
	Malaria: Insecticide treated bednets[d]	0.40	Infection: 10–48	950–2,500 (2009)	20–48 (2009)
Vision screening	Refractive error screening and provision of corrective glasses[e]	Ready-made glasses: 2–3; Screening kit: 9 each	Poor vision: 0.71–1.07	—	84
Oral health	Toothbrush provision and education[f]	0.60	Caries reduction: 40 percent, 1.25 per child	—	n.a.
Vaccines	Tetanus toxoid vaccine[g]	0.40 (2003)	—	117 (2003)	3.61 (2003)
	HPV bivalent vaccine[h]	Vaccine cost: 0.55–2.00 per dose for Gavi-eligible countries; Delivery: 4.88–6.73 per fully vaccinated girl (2009)		2,161–2,608	QALY gained for reduced cervical cancer risk: 4,500–8,890 (2011 international $)

Note: — = not available; n.a. = not applicable; DALY = disability-adjusted life year; HPV = human papillomavirus; LMICs = low- and middle-income countries; QALY = quality-adjusted life year.

a. Standardized cost of school meals in LMICs in 2008 US$ (Kristjanssen and others 2015). Cost is standardized to 401 kilocalories. School meals should contribute at least 30 percent to international recommendations, or 555 kilocalories.

b. Cost estimate from Stopford and others, forthcoming. Cost per case averted was calculated assuming that micronutrient powders reduce anemia by 34 percent, based on a review of the evidence (Salam and others 2013).

c. Cost per case averted from Horton and Wu 2015.

d. Cost per death and DALY averted from Horton and Wu 2015; White and others 2011.

e. Cost per DALY for ages 5–10 years from Baltussen, Naus, and Limburg 2009. Cost per case averted assumes that eyeglasses have a useful lifespan of four years, one teacher has one kit for 165 schoolchildren, and compliance is 70 percent, similar to Baltussen, Naus, and Limburg 2009.

f. Monse and others 2013.

g. Griffiths and others 2004.

h. Change in recommendation from a three-dose to a two-dose schedule is likely to improve cost-effectiveness. Gavi eligibility is based on average gross national income. At least 54 LMICs qualify for support (http://www.gavi.org/support/apply/countries-eligible-for-support/). Estimate of cost per death averted from Levin and others 2015.

teacher training, policy development, and monitoring and evaluation. The estimates are drawn from existing studies; therefore the components of each cost estimate are not presented or standardized.

Training Costs

Regular training and refresher courses are needed for teachers delivering the interventions. Training could cover all interventions in the essential package and be integrated with other teacher training courses. Refresher courses are particularly critical in contexts with high teacher turnover. Appropriate monitoring and evaluation are also strongly recommended to ensure appropriate implementation.

Nutrition Costs

School meals can contribute to the recommended energy intake for undernourished children (Drake and

others 2017). The three possible modalities include meals, biscuits or snacks, and take-home rations. Almost every country in the world offers school feeding in some form, and meals are the most common modality. The essential package includes the provision of meals or alternatively of snacks in contexts where meals are not possible. Snacks such as packaged biscuits or milk may be more appropriate in emergency contexts or where schools do not have the infrastructure to prepare or serve meals. The inclusion of micronutrients may increase costs, but also benefits. Various studies assess the value of iron-folate pills for girls, especially those entering adolescence. The intervention in the essential package focuses on addressing micronutrient deficiencies.

Infectious Disease Treatment Costs

The cost-effectiveness estimates for infectious diseases—in particular, malaria and helminth infection—may vary with the transmission setting and level of treatment coverage. Deworming treatment is included in the essential package, given the prevalence of soil-transmitted helminths (STHs) and *Schistosoma* infection in this age group (Bundy, Appleby, and others 2017). The pills are free to public health systems because they are donated by the global pharmaceutical industry via the WHO, and costs are related primarily to delivery. In some contexts, one oral treatment provided to each child annually is sufficient; in contexts with higher prevalence, two treatments may be needed. The cost of delivering schistosomiasis treatment in addition to STH treatment is marginal and assumed to be absorbed almost fully in the modeling of costs. The alternative of screening for worm infections, for example by using the Kato-Katz test, and treating only those who are infected is significantly more expensive and is not included in the package (Speich and others 2010).

For malaria, three school-based interventions were considered for inclusion in the essential package. The alternative of intermittent preventive treatment (Stuckey and others 2014)—that is, the distribution of antimalarials to all children at specific times, for example, when malaria is seasonally epidemic—was also ruled out because there is no affordable treatment available that is recommended by the WHO for this use in school-age children.

The evidence clearly demonstrates the cost-effectiveness of ITNs to lower the risk of malaria (Lim and others 2011), as well as the low usage rate among school-age children (Noor and others 2009). The essential package includes malaria education in schools for endemic countries because it is deemed to be the most effective way to promote use of ITNs (Nankabirwa, Wandera, and others 2014).

Vision and the Correction of Refractive Error

Refractive error can be detected through basic screening and can be corrected by the provision of inexpensive corrective lenses (Graham and others 2017). Schools are important in this context as a focus for identifying children with poor vision: children are typically unaware of their impairment and health systems in LMICs rarely have community outreach. The prevalence of refractive error is low, and the costs of corrective lenses can be spread across the target population, reducing the cost per child and increasing the affordability of the intervention. Studies suggest that uncorrected refractive error affects 2.34 per 1,000 people in Africa and 6.59 per 1,000 people in South-East Asia (Baltussen, Naus, and Limburg 2009); however, the proportion in Africa will likely rise as more children have access to schools and books. Studies suggest that the corrective lenses affordable in LMICs are likely to be ready-made.

Oral Health Costs

Two options for oral health are dental services and prevention through skills-based oral health education (Benzian and others 2017). In LMICs, oral health services are typically provided in clinics and hospitals, and are limited by the availability of qualified personnel; the ratio of dentists to population is roughly 1 to 2,000 in HICs, compared with 1 to 150,000 in Sub-Saharan Africa. Oral disease is an expensive condition to treat and is poorly integrated in primary health systems in LMICs (Kandelman and others 2012).

Dental screening at schools and referrals to mobile health teams with dental expertise may be possible in some settings but was not considered affordable and generalizable to be included in the essential package. In contrast, oral health promotion through schools is low cost and has the potential to shape long-term oral hygiene behaviors and is included. Oral health promotion can take place through information provided in health education classes regarding the benefits of using a toothbrush and fluorination; it may involve daily group brushing with fluoride toothpaste at school. The essential package proposes the inclusion of the Fit for School integrated oral health intervention, which has been tested in Cambodia, Indonesia, the Lao People's Democratic Republic, and the Philippines. The program, which cost US$0.60 per child per year for supplies in the Philippines, reduced school absences

as well as caries by one-third after one year (Monse and others 2013).

Vaccine Costs

Evidence on the costs of administering the tetanus toxoid vaccine in schools is lacking for LMICs, hence the estimates are based on studies of the cost of antenatal vaccination in primary health clinics. The share of children reached through schools is likely to be higher, depending on attendance rates. School-based delivery is unlikely to have significant economies of scale compared with interventions such as school feeding that reach all children on a daily basis. The tetanus toxoid booster vaccine is typically administered once a year to all children at the beginning and end of primary school, in accordance with the national immunization schedule.

Vaccination to prevent HPV includes two doses administered to girls between ages 9 and 13 years. The costing exercise reflects the administration of two doses to girls in one grade in primary school. The cost of the vaccine is highly dependent on the price of the vaccine itself, which may be subsidized through GAVI, the Vaccine Alliance. On average, the cost of administering HPV immunizations in LMICS is greater than for other routine immunizations, which range from US$0.75 to US$1.40 per dose. However, the cost has dropped in recent years, enabling HPV vaccination to be delivered in low-resource settings. Some studies have found that delivering HPV vaccines through schools costs more than delivering them through health facilities and integrated school-health centers (Hutubessy and others 2012; Levin and others 2014), but coverage may also be higher. School-based delivery is likely to reach a larger share of the population, including children from disadvantaged households.

ESTIMATING THE BENEFITS

Each intervention in the essential package is justified by its low costs of delivery and high ratio of benefits to costs, making it a sound and affordable investment for LMIC governments. Improved education and health outcomes translate into improved productivity and higher national gross domestic product (GDP). To permit comparisons with costs, these benefits must be quantified in financial terms.

This section summarizes the economic benefits of each intervention and the pathways through which they are achieved, based on the literature. Estimates for the benefits of school feeding are based on evidence on specific pathways leading to health and educational outcomes.

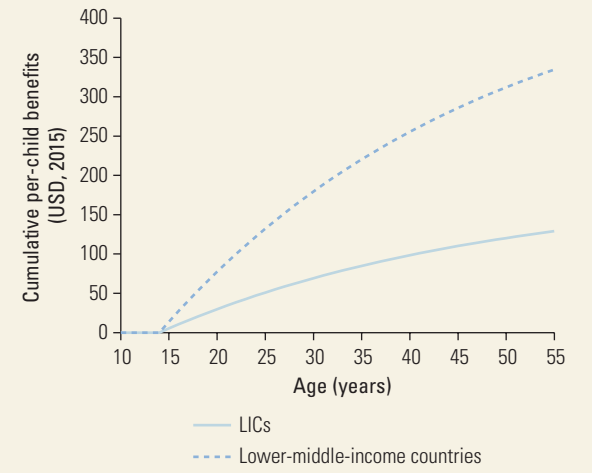
Nutrition and Food

School feeding has at least three objectives: social protection, education, and health (Drake and others 2017). School meals transfer a significant amount of noncash income to households, which can cushion shocks such as high food prices. School meals can draw children to school, support learning, and support physical growth by reducing energy deficits. Meals enhanced with micronutrients can also support child nutrition and enhance cognition. Iron-deficiency anemia is one of the top five causes of years lost to disability, contributing nearly 50 percent of the total for ages 10–19 years (Murray and others 2013). While these multiple benefits support the case for school feeding, they are difficult to quantify and aggregate (see chapter 12 in this volume, Drake and others 2017 for more discussion on school feeding).

A recent systematic review (Snilstveit and others 2015) synthesizes the findings from 16 studies (15 unique programs) published in 21 papers, of the effects of school feeding (where feeding occurs in school, that is, does not include take-home rations). The review examines three access outcomes (enrollment, drop-out, and attendance), as well as four measures of schooling outcomes (cognitive scores, math scores, language arts scores, and composite achievement scores). A meta-analysis indicated that although in many cases the point estimate of the effect of school feeding was in the expected direction (improving enrollment, reducing drop-out, and improving scores), none of the effects was statistically significant, other than an increase in attendance.

We use the effect on enrollment (a 9 percent increase, equivalent to 8 extra days in school [Snilstveit and others 2015]), the cost per school meal of $41 per child (table 25.4), and mean per capita GDP in 2015 of $620 in low-income countries and $2035 in lower-middle income countries in 2015 (World Bank 2016a). We assume that the average child eating school meals for one year is 10 years old, enters the labor force at age 15, and continues working until age 55. Annual wage income per person of working age was therefore about $574 in low-income countries and about $1,489 in lower-middle-income countries in 2015 (based on the proportion of the population of working age, 15–64 years, being 54 percent in low-income countries and 64 percent in lower-middle-income countries [World Bank 2016b], and labor income being approximately half of GDP). The returns to an extra year of education are 12 percent per annum in Sub-Saharan Africa (Montenegro and Patrinos 2014;

Figure 25.1 Estimated Cumulative Per-Child Benefits from Receipt of One Year of School Feeding in LICs and lower-middle-income countries



Note: LICs = low-income countries.

Pradhan and others 2017, chapter 30, estimate somewhat lower but still substantial returns to education across low- and middle-income countries).

With these assumptions, we can calculate that eight days of increased attendance increases future wages by 1.08 percent (12 percent multiplied by 0.09). A stream of future wages of $W per year (starting 5 years in the future and continuing for 40 years) is worth about 20W currently, when discounted at 3 percent. Figure 25.1 presents the estimated trajectory of benefits that accrue due to the delivery of school feeding for one year based on the calculation described.

Combining these assumptions implies that the benefit-cost of school meals is around 3 in low-income countries and exceeds 7 for lower-middle income countries. With more optimistic assumptions (for example, that there are additional benefits from improved cognitive scores), the benefit-cost ratio would be even higher.

Infectious Disease

Children infected with intestinal worms are often too sick or tired to attend school or to concentrate in school when they do attend. Persistent worm infections are associated with impaired cognitive development and lower educational achievement (Mendez and Adair 1999; Simeon, Grantham-McGregor, and Wong 1995). A study from Kenya found that after a deworming program, enrollment increased 7 percent and school absenteeism decreased 25 percent (Miguel and Kremer 2004). However, these effects mask heterogeneity; children who are worse off to begin with are likely to gain more. Simeon, Grantham-McGregor, and Wong (1995) found significant impacts on attendance for children who had heavy *Trichuris* infection or were stunted. Two studies have calculated the economic and social returns to deworming in the United States and Kenya, respectively, through long-term follow-ups (Baird and others 2015; Bleakley 2007). In the United States, hookworm eradication led to gains in income and returns to schooling. In Kenya, deworming increased labor and educational outcomes among men and women, respectively. The authors estimated a conservative internal rate of return to deworming of 32 percent.

Schools can provide significant economies of scale for deworming treatment. The cost for delivery through schools was US$0.03 (Tanzania) and US$0.04 (Ghana) per child per year, compared with delivery through mobile health teams coordinated by primary health centers of US$0.21 in Tanzania and US$0.51 in Montserrat (Guyatt 2003). See also chapters 13 (Bundy, Appleby, and others 2017) and 29 (Ahuja and others 2017) in this volume for discussion of these issues.

Malaria places a significant burden on health care systems and productivity in endemic countries. In Sub-Saharan Africa, malaria is responsible for at least 15 percent of disability-adjusted life years (DALYs) (WHO 2001). Furthermore, mortality from malaria is concentrated among the poor. An estimated 60 percent of malaria-related deaths occur in the poorest 20 percent of the global population, a higher share than other common infectious diseases and conditions. Various studies have estimated the impact of malaria with regard to nutritional, cognitive and educational impairments among school-age children, such as anemia, diminished cognitive function and motor and language skills, and school absenteeism (Boivin and others 2007; Clarke and others 2004; John and others 2008; Nankabirwa, Brooker, and others 2014; Nankabirwa, Wandera, and others 2014). Malaria is associated with GDP losses of 1 percent to 20 percent, averaging 10 percent in Sub-Saharan Africa (Gallup and Sachs 2001). The regional loss in economic output is about US$12 billion a year (WHO 2001).

Several strategies are in place to control and eradicate malaria. Ultimately, effectiveness varies with the intensity of transmission and other factors contributing to anemia, such as undernutrition and helminth infection. Global policy efforts have focused on pregnant women and children younger than age five years because of strong evidence on the effectiveness of interventions such as ITNs (White and others 2011). Recent efforts have shifted to providing ITNs to everyone, not only the most vulnerable. Less attention has been given to school-age children, although the prevalence of malaria in the school-age population is often high and can explain approximately one-half of mortality occurring in this age group (Nankabirwa, Brooker, and others 2014).

For the school-age population, strategies to control and eradicate malaria can provide benefits, such as averted cases of malaria and anemia; reduced absenteeism; enhanced attention span and cognitive function; and lowered risk of cerebral malaria, which may alter speech, language, and motor skills.

ITNs are a cost-effective intervention for reducing malaria and anemia among asymptomatic cases (White and others 2011). School-age children are the least likely to use ITNs, although studies generally find positive evidence that they face a lower risk when they do (chapter 14 in this volume, Brooker and others 2017). Based on data from 18 Sub-Saharan African countries, about 40 percent of school-age children are not protected (Noor and others 2009).

As demonstrated in studies from Ghana, Kenya, Lao PDR, and Thailand, skills-based health education in schools can increase knowledge about malaria and the correct use of ITNs and decrease parasite prevalence (Ayi and others 2010; Nonaka and others 2008; Okabayashi and others 2006; Onyango-Ouma, Aagaard-Hansen, and Jensen 2005). In Ghana, school-based education regarding ITN use was associated with a decline in malaria prevalence to 10 percent from 30 percent over the course of one year (Ayi and others 2010). Averting even a single episode of malaria may bring substantial benefits, such as increased participation in higher education and improved cognitive development over the life of the child.

Vision and the Correction of Refractive Error

The benefits of correcting poor vision are related primarily to education pathways and gains in labor market outcomes. An estimated 153 million people globally suffer from poor vision, including 13 million school-age children (Resnikoff and others 2008; Smith and others 2009). Economic losses due to impaired vision exceed an estimated US$200 billion a year globally (Fricke and others 2012). Although little is known about the prevalence of uncorrected refractive error among school-age children, an estimated 9 percent of children in Ethiopia (Yared and others 2012) and 13 percent in China (Glewwe, Park, and Zhao 2012) have undiagnosed or untreated vision problems. In Brazil, poor vision resulted in a 10 percentage point higher probability of dropping out and an 18 percentage point higher probability of repeating a grade (Gomes-Neto and others 1997). In China, poor vision decreased students' academic performance, as measured by test scores, by 0.2–0.3 standard deviations, equivalent to a loss of 0.3 years of schooling (Glewwe, Park, and Zhao 2012).

Providing eye care screening and free glasses in schools can overcome the barriers of cost and lack of skilled eye care personnel (Limburg, Kansara, and d'Souza 1999; Sharma and others 2008; Wedner and others 2000). Training teachers to assess whether children should be examined and potentially receive glasses has been tested in various contexts; in a rural region in Cambodia, fewer than 100 teachers in less than four weeks screened 13,175 students and referred 44 to a team of refractionists to be assessed for eyeglasses (Keeffe 2012).

The essential package recommends periodic screening of children in a specific grade for refractive error and provision of glasses, with the aim of screening all children at risk over time (Baltussen and Smith 2012).

Oral Health

The burden of poor oral health and hygiene is concentrated in upper-middle-income countries and HICs, although the share of the population that is untreated is highest in LMICs. Tooth decay can affect psychosocial well-being and lead to school absenteeism (Kakoei and others 2013; Krisdapong and others 2013; Naidoo, Chikte, and Sheiham 2001). Prevention of cavities may also reduce undernutrition because of the pain associated with severe tooth decay (Benzian and others 2011). The risk of poor oral health is expected to rise as diets in LMICs shift to greater consumption of processed foods and sugars (Viswanath and others 2014). Between 1990 and 2012, the average increase in DALYs due to dental caries was between 42 percent and 78 percent in most countries in Sub-Saharan Africa (Dye and others 2013; Kassebaum and others 2015). Building healthy habits in childhood may provide benefits over the life course. Group activities in school may be an effective means for establishing these norms (Claessen and others 2008).

Vaccines

Although the HPV vaccine is substantially more expensive than the tetanus toxoid vaccine, both are cost-effective. At the global level, cervical cancer caused 6.9 million DALYs in 2013, with more than 80 percent of cases occurring in LMICs (Fitzmaurice and others 2015). Country- and region-specific studies have been conducted on the benefits of HPV vaccination, with a focus on health benefits. The overwhelming majority of these studies indicate that HPV vaccination of preadolescent girls (usually ages 8–14 years, depending on the specific country) has the potential to substantially reduce the morbidity and mortality associated with cervical cancer. Assuming coverage of 70 percent, effective over a lifetime, HPV vaccination could avert more than 670,000

cervical cancer cases in Sub-Saharan Africa over five consecutive birth cohorts of girls vaccinated as young adolescents (Kim and others 2013).

The HPV vaccination is now part of the recommended national schedule in more than 60 countries or territories, but only 8 of these are LMICs (WHO and UNICEF 2013). However, more than 25 LMICs, about one-third in Africa, have piloted the vaccine in one or more urban and rural districts. Recommendations to replace the three-dose schedule with a two-dose schedule, with a minimum interval of six months between doses, would increase the benefits in relation to the costs (WHO 2014). More information on the HPV vaccine can be found in volume 3, chapter 4 (Denny and others 2015).

Delivery of the tetanus toxoid vaccine lowers the risk of contracting tetanus, both for recipients and for their children who have not yet been vaccinated, providing an intergenerational benefit. In Africa, tetanus has caused 3 million DALYs (Ehreth 2003). For the essential package, countries need to administer the tetanus toxoid vaccine to children in the grade that captures the largest proportion of children ages 4–7 or 12–15 years.

COMPARING COSTS AND BENEFITS OF THE ESSENTIAL PACKAGE

Figure 25.2 provides an illustrative mapping of the benefits and costs for all of the interventions in the essential package. Some interventions should be delivered to all children, while others should be targeted geographically or by age to limit overall costs.

Table 25.4 presents the essential package of school health interventions for LMICs, based on costs and benefits. Differences between LICs and lower-middle-income countries are due to differences in resources. Upper-middle-income countries can augment the essential package with additional interventions or expand coverage of targeted interventions to a wider age group or to more schools. All countries may tailor the package to the context and add additional components.

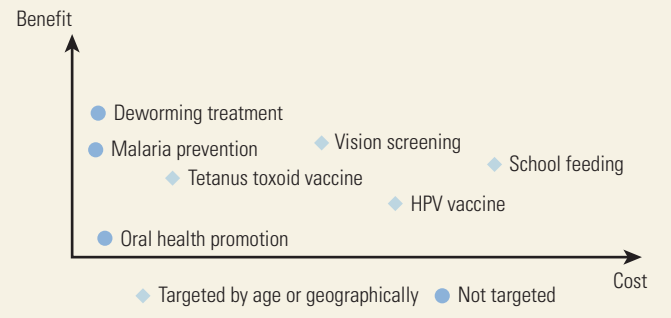
The essential package addresses a variety of health risks facing school-age children. Some are tackled directly; others seek to change behaviors associated with poor health outcomes, including the use of ITNs and promotion of oral health. The frequency of delivery is also noteworthy. Some interventions are delivered just once over the course of primary school (HPV vaccination), while others recur daily (school feeding) or annually (deworming and vision screening). All costs are standardized to one calendar year.

In total, the essential package costs an estimated US$10.30 per child per year in LICs. The average cost per child of each intervention draws on the cost per treated child in table 25.3. For targeted interventions, the cost per treated child exceeds the average cost per child. Some efficiencies can be expected. In this exercise, a 20 percent reduction in costs for the integrated delivery of malaria and oral health education was assumed (figure 25.3).

The delivery of some interventions is recommended for all children (oral hygiene). For other interventions, screening of all children and treatment for an identified subset of children is recommended (eyeglass screening). For some interventions, the economic returns are greater when targeted to a subset of the population, such as school feeding for food-insecure areas or for children at risk of dropping out.

These estimates exclude start-up costs, which could include the costs of establishing policies or guidelines or undertaking mapping exercises. For example, a national mapping exercise of helminth worms would indicate where deworming treatment is needed, and mapping of poverty and food security would support

Figure 25.2 Indicative Mapping of Benefits and Costs of Essential Package Interventions



Note: HPV = human papillomavirus.

Figure 25.3 Cost Shares of the Essential Package, by Country Income Level

U.S. dollars

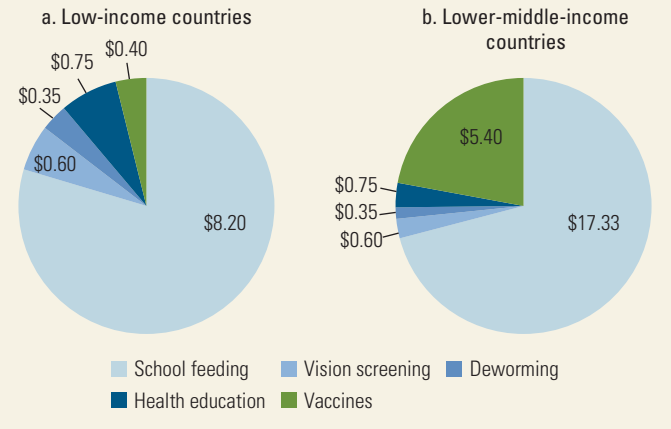


Table 25.4 Costs of the Essential Package of Health Interventions for School-Age Children

	Low-Income Countries			Lower-Middle-Income Countries		
Domain	Intervention	Target	Average annual cost per child (US$)	Intervention	Target	Average annual cost per child (US$)
School feeding	Daily snacks or meals with micronutrient fortification	All children in at least 20% of schools in regions with the highest levels of poverty and food insecurity	8.20	Daily meals with micronutrient fortification	All children in at least 40% of schools in regions with the highest level of poverty and food insecurity	16.40
Deworming	Deworming treatment	All children attending schools in areas endemic for STHs and schistosomiasis[a]	0.35	Deworming treatment	All children attending schools in areas endemic for STHs and schistosomiasis[a]	0.35
Vision screening	Screening and provision of ready-made glasses	All children in a select grade	0.60	Screening and provision of custom or ready-made glasses	All children in a select grade	0.60
Oral health and malaria	Health education about prevention of tooth decay and usage of ITNs	All children for oral health promotion and all children attending schools in endemic areas for malaria[a]	0.75	Health education about prevention of tooth decay and usage of ITNs	All children for oral health promotion and all children attending schools in endemic areas for malaria[a]	0.75
Vaccines	Tetanus toxoid vaccine	Children in a select grade in all schools	0.40	Tetanus toxoid vaccine	Children in a select grade in all schools	0.40
	HPV vaccine			HPV vaccine	Girls from a select grade in all schools (two doses)	5

Note: HPV = human papillomavirus; ITNs = insecticide-treated bednets; STHs = soil transmitted helminths.
a. Assuming 50 percent of child population at risk.

the targeting of school feeding to the most disadvantaged households. Costs of the total package are aggregated by size of population in low-income and lower-middle income countries in chapter 1 (Bundy, de Silva, and others 2017).

CONCLUSIONS

Several low-cost health interventions to support the development of children can be delivered through schools. The health and education benefits for each intervention are significant, but there is comparatively less evidence on the combined benefits of providing several interventions jointly. The provision of a set of integrated basic interventions may create cost efficiencies and increase the benefit-cost ratio. For example, health education classes can include material on both oral hygiene and malaria prevention.

This chapter defines an affordable package of school-based health interventions for LMICs and estimates the costs and potential benefits. The interventions can improve the quality and the quantity of schooling, generating a high benefit-cost ratio. The returns to education are highest in LICs, but this finding is due, in part, to higher per capita income in lower-middle-income countries. More research is needed on how to support countries in financing the essential package as well as evaluating the benefits over the life course.

Interventions for school-age children can have significant impacts on schooling, earnings, health status, and productivity in LMICs. The estimated benefit-cost ratios for such interventions consistently exceed one, suggesting that the discounted value of gains exceeds the costs. These results support the case for placing school health high on the policy agenda and for promoting coherence with early childhood health intervention programs to maximize benefit gains. Causal estimates of the impacts of interventions stem mostly from small-scale local interventions and are likely to be sensitive to population heterogeneity (social, economic, and cultural differences), differences in program implementation (administrative

capacity and trust), and differences in the wider political economy of reform. As a result, available impact estimates may have limited external validity. In addition, benefit-cost ratios based on these impact estimates are sensitive to the choice of rates of return and discount rates applied in evaluating future impacts against costs.

If benefit-cost ratios associated with interventions for the school-age child are so attractive, why have governments not implemented them at scale? Benefits may not scale up, despite scale economies, and the benefit-cost ratio for nationwide implementation may be lower. Moreover, governments may not be sufficiently aware of the benefits of the interventions; indeed, the documents guiding national and international policy tend to evaluate immediate reductions in clinical morbidity and mortality and to give low priority to the long-term socioeconomic benefits. Furthermore, the health and development of school-age children has historically been given low priority in health system planning, so even where governments recognize the net benefits of interventions for the school-age child, they may face budgetary constraints and conflicting priorities, especially given the strong vested interests in existing programs for other age groups.

NOTE

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.

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Chapter 26

Identifying an Essential Package for Adolescent Health: Economic Analysis

Susan Horton, Elia De la Cruz Toledo, Jacqueline Mahon, John Santelli, and Jane Waldfogel

INTRODUCTION

Adolescents form a large proportion of the population in many low- and middle-income countries (LMICs)—more than 20 percent in the countries with the fastest-growing populations (WHO 2014). The adolescent period, defined as ages 10 through 19 years, is key to future health because it is during these years that health decisions and habits are formed that have long-term impacts. Adolescents who are enabled to make healthy eating and exercise choices, to adopt healthy sexual behaviors, and to avoid addictive substances and excessive risks have the best opportunities for health in later life. Equally important, some mental health issues are manifested in late adolescence, and early detection is important.

Despite the pivotal nature of this age, adolescents until recently have been relatively neglected in international donor strategies for maternal, newborn, and child health. Specific areas where funding is lacking include preventing unsafe abortion and coerced sex, and providing antenatal, childbirth, and postnatal care (iERG 2013). Many adolescents are entitled to appropriate health care under the Convention on the Rights of the Child, but those ages 18 and 19 years are not specifically included.

Recent reports and studies seek to bring greater attention to adolescent health needs (Gorna and others 2015; Laski and others 2015; Patton and others 2016; UNICEF 2011, 2012; WHO 2014). Groups such as the International Health Partnership (http://www.internationalhealthpartnership.net) have begun to modify the well-known term *RMNCH* (Reproductive, Maternal, Newborn, and Child Health) to *RMNCAH* to include adolescents. The Every Woman Every Child (2015) strategy is titled "The Global Strategy for Women's, Children's and Adolescents' Health 2016–2030" and signals a positive change. It highlights research indicating that the health of women, children, and adolescents is central to the Sustainable Development Goals for 2030. The term *youth* is mentioned 10 times in the Outcome Declaration of the Sustainable Development Agenda (UN 2015), and the term *adolescent* is mentioned once in reference to adolescent girls.

This chapter provides an overview of methods and examines the economic case for investment in adolescent health by surveying what is known on cost, cost-effectiveness, and cost-benefit ratios of interventions. We then use these economic data to examine the cost of an essential package of health and behavioral interventions that all countries need to provide. The essential package draws on packages developed elsewhere (Every Woman Every Child 2015; Patton and others 2016; WHO 2013). Useful information also comes from costing studies of related packages (Deogan, Ferguson, and Stenberg 2012; Temin and Levine 2009). Countries can modify this package depending on their specific needs and resource availability. Finally, we estimate what such a package might cost in 2012 U.S. dollars and provide brief conclusions. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017).

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METHODS

Our focus is on the costs and cost-effectiveness of certain areas of health of particular concern in adolescence. Topics we do not address are discussed in other volumes in this series:

- Human papillomavirus (HPV) (volume 3, Gelband and others 2015; volume 6, Holmes and others 2017)
- Reproductive health more generally (volume 2, Black and others 2016)
- Interventions in nonhealth areas, such as education and child marriage, that have strong impacts on health
- Conditional cash transfers (chapter 23 in this volume, de Walque and others 2017)
- Cost-effectiveness results from the second edition of *Disease Control Priorities* (*DCP2*), which included substantial modeling of interventions for smoking (Jha and others 2006), alcohol (Rehm and others 2006), obesity (Willett and others 2006), injury (Norton and others 2006), and mental health (Hyman and others 2006); these are all health issues for which adolescence is a particularly vulnerable age. *DCP2* included a chapter on adolescent health (Lule and others 2006) that reviewed the economic literature before 2000.
- Interventions covered in the chapter on school-age children (chapter 25 in this volume, Fernandes and Aurino 2017) are more appropriate with younger age groups, although some overlap occurs between school age and adolescence. Table 26.1 shows how the discussion is divided between this chapter and the preceding chapter on school-age children.

We searched the literature on the economics of interventions that were aimed specifically at adolescents or that would primarily benefit adolescents. The main areas where we anticipated finding studies included nutrition, sexual and reproductive health, mental health, alcohol, injury, and smoking and other addictive substances.

There are relatively few cost and cost-effectiveness studies on these topics in the peer-reviewed literature in English for LMICs. We drew first on systematic reviews of cost and cost-effectiveness for high-income countries (HICs), which were identified using a search in PubMed (see details in annex 26A). We identified seven such systematic reviews published since 2000.

We then undertook a systematic review of the literature in English for LMICs (see annex 26A for details) to identify individual studies since 2000. We augmented this review with an expert search and identified seven studies.

Table 26.1 Platforms for Delivering Different Interventions for Adolescents, Compared with School-Age Children

Health area	Population level	Community	School	Primary health center
Physical health	Healthy lifestyle messages: tobacco, alcohol, injury Sexual health messages	*Deworming* *Malaria prevention and treatment* *Tetanus toxoid and HPV vaccination* *Oral health promotion* Adolescent-friendly health services	*Deworming* *Malaria prevention and treatment* *Tetanus toxoid and HPV vaccination* *Oral health promotion* Sexual health education Healthy lifestyle education Adolescent-friendly health services	*Deworming* *Malaria prevention and treatment* *Tetanus toxoid and HPV vaccination* *Oral health promotion and treatment* Adolescent-friendly health services
Nutrition	Nutrition education messages	*Micronutrient supplementation* *Multifortified foods*	*Micronutrient supplementation* *Multifortified foods* *School feeding* Nutrition education	
Mental health	Mental health messages		Mental health education and counseling	Mental health treatment
Cognitive development		School promotion	*Vision screening*	*Vision screening*

Note: HPV = human papillomavirus. Blue colored interventions are covered in chapter 25 in this volume, Fernandes and Aurino 2017, on school-age children.

Costs and cost-effectiveness are expressed in the original currency units; for LMICs they are also converted to 2012 U.S. dollars, first by adjusting using the consumer price index in the currency of the studied country, and then using the 2012 market exchange rate to the U.S. dollar. The WHO (2001) benchmark for cost-effectiveness is the point at which an intervention's cost per disability-adjusted life year (DALY) averted is less than three times a country's per capita gross national income (GNI), and an intervention is very cost-effective if the cost per DALY averted is less than per capita GNI.

We did not convert the cost-effectiveness numbers for HICs. The benchmark for acceptability for public financing would be about US$50,000 per quality-adjusted life year (QALY) saved in the United States or £30,000 per QALY saved in the United Kingdom; we simply specify in the text whether the interventions are or are not cost-effective. All figures refer to 2012 U.S. dollars, unless otherwise noted.

Cost and cost-effectiveness studies do not cover all the areas of interest for adolescent health interventions. It is particularly difficult to find costs and cost-effectiveness of interventions at the national level (for example, for policy change or mass media campaigns), given that there is no easy way to identify the effectiveness of interventions in the absence of a control group. Clearly, however, interventions at the national level can be important. We also did not find studies of the cost and cost-effectiveness of social media, which may be an effective way to reach adolescents. These interventions are relatively new, and the literature may not yet have caught up.

UNIT COST, COST-EFFECTIVENESS, AND BENEFIT-COST RATIOS OF INTERVENTIONS

Given the relative neglect of adolescent health in LMICs, the paucity of economic analysis is not surprising. Even evidence of effectiveness of interventions is scanty. More pilot programs using innovative methods are needed, and existing successful pilot interventions need to be brought to scale.

Adolescents are also a diverse group, and interventions that succeed in some contexts may not do so in others. Some adolescents are in school, but others are not, and there are generally fewer cost-effective ways to reach those not in school. Some adolescents are married and face very different health challenges from those who are not. Adolescents living in rural areas face different circumstances than those in cities; there are also big differences across world regions, for example, in the experience of violence by adolescents.

Table 26.1 categorizes interventions by the type of delivery platform, as well as the broad program outcome; the four groupings are physical health, nutrition, mental health, and cognitive development. Many programs delivered in person need to be supplemented by national-level policy changes as well as by supportive messages in the media. Most programming for adolescents will be delivered either in the community or in school (for those in school).

Neuroscience has given us new insights into the difficulties in effecting behavior change in adolescents. In this age range, the brain develops in ways that stimulate innovation and risk-taking. Peer influence becomes increasingly important, and input from parents and adults less salient (see discussion in chapter 6 in this volume, Bundy and Horton 2017, and chapter 10 in this volume, Grigorenko 2017). Risk-taking may have evolutionary benefits, in that this is the period in which adolescents have traditionally been expected to leave the parental home and set up a new, independent household. Risk-taking also has a downside, in that executive control functions are still developing and can be overridden in the heat of the moment, particularly in the company of peers. Steinberg (2007) suggests that interventions limiting the scope of potential damage may work better than education alone. For example, graduated driving licenses may more successfully reduce automobile injuries than educational programs about safe driving behavior. At the same time, adolescence is such a crucial time for establishing habits and behaviors with lifelong consequences that it would seem impossible not to include educational interventions.

Two methodological issues affect the economic evaluation of school-based interventions. First, the same intervention can vary substantially in quality depending on the context in which it is implemented, and hence also in effectiveness. Second, very few school-based programs track outcomes longitudinally. This shortcoming is particularly an issue for the myriad studies of obesity; short-term weight gain outcomes may be a very poor guide to long-term outcomes. Lack of longitudinal studies may be less of an issue in the areas of smoking and early pregnancy. In both cases, avoiding the risky behavior for three or four years may suffice to avoid the undesired outcomes. Adolescents who reach early adulthood without becoming smokers are substantially less likely to become lifelong smokers. Similarly, postponing first pregnancy until the end of the teenage years can have a significant effect on schooling attainment for young women as well as health benefits for both the young women and their babies.

Findings for High-Income Countries

Our literature search identified six systematic reviews for HICs (Guo and others 2010; Korber 2014; Romeo, Byford, and Knapp 2005; Shepherd and others 2010; Vos and others 2010; Wu and others 2011). We also draw on nonsystematic reviews by De la Cruz and others (2015) and McDaid and others (2014). Given the amount that is spent on, for example, educational programs, it is surprising that the cost-effectiveness literature is relatively spotty.

Obesity

For HICs, we identified two systematic reviews of cost-effectiveness of physical activity as a way to address obesity (see table 26.2) (Korber 2014; Wu and others 2011); McDaid and others (2014) also reference studies on obesity. These three reviews identify some interventions that are cost-effective and others that are not. In some cases, interventions that are cost-effective are costly and may not be affordable (Wu and others 2011). De la Cruz and others (2015) surveyed individual studies

Table 26.2 Summary of Reviews of Cost-Benefit and Cost-Effectiveness of Interventions for Adolescent Health, High-Income Countries

Study	Scope of review or study	Study findings
Guo and others 2010	Study of school-based **health care** in four school districts in the United States	• School-based health care could have saved Medicare US$35 per student per year; cost of intervention US$180 per student per year for children and adolescents ages 5–14 years. • School-based care also narrowed gap between disadvantaged groups (African American) and other students.
Korber 2014	Systematic review of 13 economic evaluations of interventions to promote **physical activity**	5 studies of United States, 4 Australia, 2 Germany, 1 United Kingdom, 1 New Zealand • Cost per DALY averted for Australia ranged from $A 20,227 to $A 760,000 per DALY (Walking School Bus). • Cost per QALY saved for United States ranged from US$900 to US$4,305. • Cost per QALY saved for United Kingdom was £94–£103.
McDaid and others 2014	**Alcohol**: Review of 2 studies	• Education sessions with 11–12-year-olds and parents (one study) have a benefit-cost ratio of 9:1; various interventions (other study) have benefit-cost ratios ranging from 5:1 to 100:1 in United States.
McDaid and others 2014	**Smoking:** Review of 7 studies, largely school based (2 include mass media as well)	• The Netherlands: Cost US$25,174 per QALY saved • Germany: 3.6:1 benefit-cost ratio • United States: (4 studies) US$5,860–US$405,277 per QALY saved; US$7,333–US$24,271 per QALY saved; highly cost-effective; and cost-effective or cost saving, respectively • Canada: Results similar to United States
McDaid and others 2014	**Sexual health:** 1 study	• Net savings for a program to prevent early pregnancy among adolescents in low-income areas in United States is US$11,262 per participant.
McDaid and others 2014	**Mental well-being:** 5 studies	• US$3,500 per DALY for program to screen Australian teenagers with depressive symptoms and treat with psychiatrist • US$9,725 per DALY for program in United States to offer 15 sessions of CBT to at-risk teens ages 13–18 years with one parent with depressive disorder • Three interventions to promote well-being in schools in United States had benefits of 28:1, 5:1–10:1, and 25:1 for reduced drug dependency, smoking, and delinquency, respectively.
McDaid and others 2014	**Obesity prevention:** 3 studies	• Various programs in Australia were cost saving over lifetime; others (Walking School Bus, gastric banding, and drug therapy) were not. • Program in United States to reduce TV watching, improve physical activity, and improve diet effective in girls at cost of US$5,076 per QALY saved. • Study in United Kingdom found lifestyle interventions effective at cost of US$20,589 per QALY saved.

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Table 26.2 Summary of Reviews of Cost-Benefit and Cost-Effectiveness of Interventions for Adolescent Health, High-Income Countries (continued)

Study	Scope of review or study	Study findings
Romeo, Byford, and Knapp 2005	Systematic review of **mental health interventions** for children and adolescents	21 studies: 10 United States, 4 United Kingdom, 3 Canada, 1 Australia, 1 Sweden, 1 Norway, and 1 the Netherlands • Programs heterogeneous in design and in outcome measures, not readily converted to a common health outcome metric.
Shepherd and others 2010	Systematic review of school-based interventions for prevention of transmission of **sexually transmitted infections**; modeled for economic cost-effectiveness	• Examined 15 RCTs: 13 for United States, 2 for United Kingdom • Review found significant changes in knowledge and in some measures of self-efficacy but few significant differences in behavior (only short follow-up). • Estimated cost of teacher-led programs at £4.30/pupil; peer-led £15/pupil; incremental cost-effectiveness ratio £20,223 per QALY saved for teacher led; £80,782 per QALY saved for peer led
Vos and others 2010	Modeling of cost-effectiveness of broad range of interventions for Australia (costs in $A); **drugs and mental well-being**	• School-based program for illicit drug education cost $A 59,000 per DALY averted. • Screen and treat with a psychologist in school for child and adolescent depression cost $A 5,400 per DALY averted. • Screen and treat with bibliotherapy in school for child and adolescent depression cost $A 180 per DALY averted, but evidence of effectiveness limited.
Wu and others 2011	Systematic review and cost-effectiveness of programs to promote **physical activity**	91 studies (141 interventions) of which 48 RCTs; predominantly for United States, almost all for HICs. Of these, the cost per MET per person per year varied considerably: • Point-of-decision prompts had the lowest cost per MET but very small effect on overall physical activity levels. • School and community-based programs had middle cost per MET and middle effect on physical activity levels. • Individually adapted behavior change and social support programs had highest cost per MET but highest effect on physical activity levels.

Source: Horton 2015.
Note: Costs are in year of original study. CBT = cognitive behavioral therapy; DALY = disability-adjusted life year; HICs = high-income countries; MET = Metabolic Equivalent of Task; QALY = quality-adjusted life year; RCTs = randomized controlled trials.

for HICs and identified two studies for obesity: Haynes and others (2010) suggesting that reducing consumption of carbonated drinks can be very cost-effective; and Carter and others (2009), indicating that physical activity promotion is cost-effective, although barely.

Smoking, Alcohol Use, and Illicit Drug Use

No systematic reviews were identified for smoking, alcohol use, or illicit drug use. Individual studies may not include keywords related to adolescence, although it is well understood that adolescence is a key period for experimentation with (and in some cases becoming addicted to) these substances. For the United States, there are examples of cost-effective, as well as cost-ineffective, smoking prevention interventions for adolescents (surveyed in McDaid and others 2014). De la Cruz and others (2015) highlight one study for smoking, in which increased cigarette taxation combined with subsidies for quitting aids has attractive cost-effectiveness ratios in the Netherlands (Over and others 2014). Vos and others (2010) survey examples of programs to prevent or reduce use of illicit substances, some of which are cost-effective.

Reproductive and Sexual Health

Two systematic reviews (Guo and others 2010; Shepherd and others 2010) cover school-based health care, which often has a focus on sexual and reproductive health, and at times, on mental health. Some school-based programs are cost-effective in preventing sexually transmitted infections (Shepherd and others 2010). Some school-based interventions on reproductive health are even cost saving (Guo and others 2010), as was one program aimed at preventing early pregnancy among adolescents living in a low-income area (McDaid and others 2014).

Mental Health

School-based programs can also be effective for mental health (Romeo, Byford, and Knapp 2005), although cost may make them difficult to afford. De la Cruz and others (2015) identify a study combining cognitive behavioral therapy with a change in medication that improves mental health, but this intervention is not quite cost-effective (Lynch and others 2011).

Overall Findings

In each of the reviewed health areas in HICs, it is possible to find some interventions for adolescents that are cost-effective, using the country's own threshold, and others that are not. Lack of cost-effectiveness has several causes, among them, poor implementation, poor monitoring, and poor design. Monitoring behavior change interventions is more challenging than, for example, monitoring vaccinations. Poor design may arise when modeling or communicating behavior changes in ways that do not appeal to adolescents. Some interventions may be effective but relatively high cost, so that even if they are cost-effective, they are not affordable.

The lessons from HICs are that schools are an appropriate venue for interventions since adolescence is a key age at which interventions should occur; however, it is crucial to have programs that are well conceptualized, well targeted, and well implemented. Programs need to be evidence based. In the United States, the Department of Health and Human Services (2014) funds evaluations for pilot programs and lists the types of evidence required for a program to be eligible for evaluation. As outlined in the methodology section, implications have to be drawn cautiously. The context of HICs differs from that of LMICs; and even in HICs, the number of studies with long-term follow-up is limited.

Findings for Low- and Middle-Income Countries

We identified seven studies in LMICs, most of a single country, but one has results for six middle-income countries (MICs). Two are of obesity; four are of sexual and reproductive health; and one is of smoking prevention (table 26.3). Most of the studies were conducted in MICs.

Obesity

For MICs, school-based interventions to reduce obesity are affordable at less than US$1 or US$1.50 per person in the overall population; however, they are not cost-effective, according to Cecchini and others' (2010) comprehensive modeling study of interventions in MICs. In comparison, restrictions on the advertising of food to children cost about one-tenth as much per person in the population; although only marginally cost-effective over a 20-year horizon, these restrictions become cost saving or cost-effective or very cost-effective in all the countries over a 50-year horizon. Cecchini and others (2010) also model five other interventions aimed at adults that are not discussed here.

A large trial of school-based interventions in China (Meng and others 2013) finds that nutritional or physical activity interventions alone are not effective, but a combined program is effective, albeit not significantly so. This observation that comprehensive interventions are required is consistent with the general literature on obesity prevention that is not restricted to children and adolescents or to LMICs. Meng and others (2013) do not calculate cost-effectiveness per DALY or QALY. Accordingly, it is not possible to infer whether the intervention is cost-effective; however, it is not inexpensive at US$4.41 per participant over two years, and at US$31.10 if teachers' time is included. In comparison, per capita annual health expenditure from the public budget in 2013 was, on average, US$15.36 for low-income countries, US$30.67 for lower-middle-income countries, and US$260.96 for upper-middle-income countries (World Bank 2016).

Smoking

Findings from a study of a school-based intervention for smoking in India (Brown and others 2012) are similar. Although the program is cost-effective per QALY saved, the cost of US$45.81 per student is not inexpensive; removing the cost of teachers' time reduces the cost of this particular intervention by only 5 percent. This was a large-scale pilot; it is possible that costs could be reduced by embedding the training involved into the regular teacher training curriculum rather than delivering it via special workshops that require travel and per diem expenses.

Reproductive and Sexual Health

Of the four studies of interventions for sexual and reproductive health, only one (Duflo and others 2006) provides cost-effectiveness estimates. Their findings suggest that providing adolescent girls with information they can use to make more informed decisions (advising them of the age profile of human immunodeficiency virus/acquired immune deficiency syndrome [HIV/AIDS] status in men) is the most cost-effective at US$253 per DALY averted. More general educational interventions regarding HIV/AIDS, and subsidies designed to help girls stay in school also fall into the very cost-effective zone for Kenya at less than one times per capita GNI (WHO 2001). Unit costs are modest; Duflo and others (2006) do not present unit costs for the curriculum-based

Table 26.3 Cost And Cost-Effectiveness of Interventions Relevant for Adolescent Health in Low- and Middle-Income Countries, from Systematic Review

Study	Country/region	Intervention/condition	Cost per unit as presented in article	Unit	Currency (year)	Cost per unit in 2012 US$
Obesity						
Cecchini and others 2010	Brazil, China, India, Mexico, Russian Federation, South Africa	Modeling effects of two interventions aimed at obesity at school age, and five others aimed at adults:				
		• School-based interventions	0.82 (Brazil)	Per head of population	2005 US$	1.44
			0.53 (China)			0.86
			0.73 (India)			1.09
			1.22 (Mexico)			1.35
			0.51 (Russian Federation)			0.87
			0.99 (South Africa)			1.19
		• Food advertising regulations for children	0.04 (Brazil)	Per head of population	2005 US$	0.07
			0 (China)			0
			0 (India)			0
			0.09 (Mexico)			0.10
			0.13 (Russian Federation)			0.22
			0.08 (South Africa)			0.10
		• School-based interventions (20-year horizon)	> 1 million (except Russian Federation)	Per DALY averted	2005 US$	> 1 million in all countries
			830,177 (Russian Federation)			
		• Food advertising regulations for children (20-year horizon)	CS (Brazil)	Per DALY averted	2005 US$	CS
			556 (China)			902
			3,186 (India)			4,753
			11,151 (Mexico)			12,340
			5,718 (Russian Federation)			9,725
			13,241 (South Africa)			15,892

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Table 26.3 Cost And Cost-Effectiveness of Interventions Relevant for Adolescent Health in Low- and Middle-Income Countries, from Systematic Review (continued)

Study	Country/region	Intervention/condition	Cost per unit as presented in article	Unit	Currency (year)	Cost per unit in 2012 US$
		• School-based interventions (50-year horizon)	93,350 (Brazil)	Per DALY averted	2005 US$	174,918
			35,174 (China)			57,031
			59,665 (India)			89,009
			235,957 (Mexico)			261,123
			261,114 (Russian Federation)			444,098
			153,233 (South Africa)			183,911
		• Food advertising regulations for children (50-year horizon)	CS (Brazil)	Per DALY averted	2005 US$	CS
			CS (China)			CS
			752 (India)			1,122
			658 (Mexico)			728
			4,823 (Russian Federation)			8,209
			3,352 (South Africa)			4,023
Meng and others 2013	China	Combined nutrition and physical education intervention in schools (also reports nutrition alone, physical education alone; no significant effect)	26.80	Per student	US$ (year not given; likely 2009–10)	31.10
			3.80 excluding cost of time of teachers			4.41 excluding cost of time of teachers
			1,308.90	Per case of overweight or obesity averted	US$ (year not given; likely 2009–10)	1,519
Sexual and reproductive health						
Duflo and others 2006	Kenya	• Education of school students on HIV/AIDS (cost $9 per student in a specific grade in 2003, estimated by authors of this chapter)	575	Per pregnancy averted (proxy for unprotected sex)	US$ (year not given; likely 2003)	1,600
		• Informing girls in school of age profile of HIV in men	91	Per pregnancy averted	US$ (year not given; likely 2003)	253
		• Free school uniforms once in each of two years for grade 6 students (uniform cost $6 in 2003)	749 (full cost)	Per pregnancy averted	US$ (year not given; likely 2003)	2,084

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Table 26.3 Cost And Cost-Effectiveness of Interventions Relevant for Adolescent Health in Low- and Middle-Income Countries, from Systematic Review (continued)

Study	Country/region	Intervention/condition	Cost per unit as presented in article	Unit	Currency (year)	Cost per unit in 2012 US$
Kempers, Ketting, and Lesco 2014	Moldova	Adolescent-friendly sexual and reproductive health services	2.55	Per person in population covered	2011 US$	2.59
			12.10	Per user		12.58
Kivela, Ketting, and Baltussen 2013	Nigeria	School-based intervention for sexuality education (costs for pilot programs also for India, Indonesia, and Kenya)	7 (Nigeria)	Per student	2009 US$	9.40
Terris-Prestholt and others 2006	Tanzania	An adolescent sexual health program, with school-based education component plus condom distribution	13.46	Per student	2001 US$	17.92
			1.54	Per condom distributed		2.05
Smoking						
Brown and others 2012	India	School-based education intervention against smoking (MYTRI)	31.73 per student for 2-year program	Per student	2006 US$	45.81
			2,492	Per QALY	2006 US$	3,598
			(2,769 if students' time included)			(3,998 if students' time included)

Note: CS = cost saving; HIV/AIDS = human immunodeficiency virus/acquired immune deficiency syndrome; MYTRI = Mobilizing Youth for Tobacco-Related Initiatives in India.

interventions, but calculations using their data suggest these cost approximately US$25 per student in one grade. Duflo and others (2006) present figures for a subsidy to keep students in school of 2012 US$16.69 per student (cost of a uniform) per year, and US$33.38 for the intervention that provided uniforms in two different years.

Two other studies provide costs per student for educational interventions on sexual and reproductive health. Kivela, Ketting, and Baltussen (2013) examine costs in four LMICs; for a program at scale in Nigeria; and pilot programs in India, Indonesia, and Kenya. The two extracurricular programs in Indonesia and Kenya cost significantly more than the intracurricular ones. Costs were US$85 and US$205 per student, respectively, compared with US$9.40 in Nigeria, and US$16.30 in India. The budgetary outlays were a quarter or less of the total cost for the three countries with intracurricular programs because governments are already paying teachers' salaries. International standards recommend that there should be 12–20 lessons of 45–60 minutes each, spread over more than one year, for such interventions to be effective.

Kivela, Ketting, and Baltussen (2013) point out some of the issues of including sexuality education in the curriculum. Their study notes that opposition to the programs in India and Nigeria caused implementation delays of several years, with attendant increased costs.

A study for Tanzania (Terris-Prestholt and others 2006) estimated that an adolescent sexual health intervention cost US$17.92 for the school-based education component. Other components included adolescent-friendly health services, peer distribution of condoms, and community mobilization efforts; the educational component accounted for 70 percent of the costs. Information about the net budgetary cost was not presented, including how much of the educational program cost was allotted to teacher's salaries when presenting the program, as opposed to the additional costs for teacher training.

The last study of sexual and reproductive health (Kempers, Ketting, and Lesco 2014) presents the cost of an adolescent-friendly sexual and reproductive health service in Moldova. Four well-performing centers were picked for study out of 38. The centers provide services for sexually transmitted infection, early pregnancy and contraception, and HIV/AIDS. Costs were US$6.14 per visit; assuming each participant required on average two visits, the cost was US$12.58 per user per year. Slightly less than 20 percent of the covered youth population used the services, such that the cost per young person in the population covered was US$2.59.

Although the youth-friendly health services in Moldova were potentially cost saving for potential numbers of sexually transmitted infections averted, unwanted pregnancies averted, and cases of HIV/AIDS averted, funding the services was difficult. A little more than 50 percent of the cost came from the National Health Insurance Company; services also relied on contributions from donors, nongovernmental organizations, and local authorities, as well as substantial amounts of volunteer time.

Implications for Program Development

This review of evidence from HICs and LMICs provides some guidance for the economics of an essential package of interventions. At the same time, we must recognize that evidence on what works is still being amassed.

First, data are simply insufficient in a number of areas, including national media campaigns, national policy making, and social media, which are likely all important ways to support any intervention delivered to individual adolescents. The modeling results on restrictions on food advertising to young people (Cecchini and others 2010) are promising, but the estimated effectiveness of advertising interventions relies on very limited evidence.

Second, programs delivered through schools are a mainstay (Bundy, Schultz, and others 2017). Their unit costs are not inexpensive, but school-based programs may be less costly than community-based ones. Costs of educational programs in schools can be reduced by providing intracurricular programs at scale and incorporating training into the teacher education curriculum. Teacher involvement in educational interventions is crucial, and effective training can reduce costs and improve affordability in the long term. At the same time, neuroscience suggests that education programs alone are insufficient in areas in which adolescents make "hot" decisions. Education may need to be complemented with risk reduction efforts based on behavioral theory and skill development. The likelihood of success for simply preventing an undesirable outcome for a few years may be higher than that for establishing lifelong healthy habits.

One limitation of the evidence is that education programs are very heterogeneous. Program design, context, and intensity of effort in implementation all matter. Another limitation is that the duration of follow-up studies of school-based interventions is usually short. Thus, evidence on long-term impact is lacking. This differs from the literature on early childhood development and preschool interventions, where there are a modest number of high-quality research studies with long-term follow-up, both for HICs and LMICs (see chapter 19 in this volume, Black and others 2017, and chapter 24 in this volume, Horton and Black 2017).

Finally, youth-friendly health services may be important and cost-effective, but they are time intensive to deliver, and issues of affordability in LMICs may arise.

COSTING AN ESSENTIAL PACKAGE

Promoting adolescent health requires a broad range of actions across several sectors. Education is key and affects skills and employment opportunities; for girls, education helps delay marriage and early childbearing. Policies and laws that allow flexibility in adolescents' access to health services without necessarily requiring parental authorization are vital, as are policies and laws controlling their exposure to unhealthy products and activities (Laski and others 2015). Empowerment and involvement of adolescents in decision making concerning their well-being is essential. Although ministries of health will be involved in promoting adolescent health in all of these areas, they will not necessarily lead the efforts.

The focus of this chapter is on the more narrowly defined interventions to promote adolescent health in which ministries of health have the primary responsibility. The adolescent package costed here draws on several other sources. The WHO (2013) provides policy advice on programs for preconception care, which overlaps substantially with the initiatives discussed in the previous section. Patton and others (2016) include recommendations for adolescent health as well as other supportive nonhealth services. The Global Strategy for Women's, Children's and Adolescents' Health (Every Woman Every Child 2015) includes recommendations in five priority areas for adolescent health interventions (Laski and others 2015).

Two other studies provide cost estimates. The Centre for Global Development's *Start with a Girl* discusses an agenda for adolescent girl health that was also costed (Temin and Levine 2009). Deogan, Ferguson, and Stenberg (2012) provide estimates for a package of adolescent-friendly health services, as well as the cost of providing this package in 74 LMICs. These services are one component of a desirable package for promoting adolescent health.

The WHO's (2013) guidelines on preconception care recommend interventions in 13 areas. These areas are primarily directed at women but apply to older adolescent girls, given the younger age at first birth in many LMICs. The areas comprise the following:

- Nutritional conditions
- Vaccine-preventable diseases
- Genetic conditions
- Environmental health
- Infertility and subfertility
- Female genital mutilation
- Too early, unwanted, and rapid-succession pregnancies
- Sexually transmitted infections
- HIV/AIDS
- Interpersonal violence
- Mental health
- Psychoactive substance use
- Tobacco use.

Nutritional conditions and vaccine-preventable diseases are discussed in the package for school-age children (Fernandes and Aurino 2017); others are consistent with topics discussed in this chapter.

Priority actions for adolescent health in the Global Strategy for Women's, Children's and Adolescents' Health are summarized by Laski and others (2015) as follows:

- Health education, including comprehensive sexuality education
- Access to and use of integrated health services
- Immunization
- Nutrition, including healthy eating and exercise, and supplementation of key micronutrients
- Psychosocial support for detection and management of mental health problems.

Start with a Girl is an ambitious agenda with eight components recommended for adolescent girls in LMICs (Temin and Levine 2009). The total package is US$359.31 per girl per year. (We have not updated their cost estimates to 2012 since doing so is not straightforward for a multicountry estimate). The eight components specific to girls, with associated costs per girl per year, are youth-friendly health services (US$8.50), iron supplements (US$2.00), HPV vaccination (US$17.50), reducing harmful traditional practices (US$80.85), male engagement (US$113.85), obesity reduction (US$0.11), edutainment programs (US$0.57), safe spaces (US$130.51), and comprehensive sexuality education (US$6.02). The edutainment intervention, which combines computer games with educational elements, is directed at issues of sexual and reproductive health, gender-based violence, and other health challenges facing girls. The ninth component is male engagement for young men ages 15–24 years living on less than US$2 per day (US$113.25). Smoking reduction is not costed because it is expected that revenue from higher taxation would more than cover interventions. This package is somewhat different from what is costed in this chapter. It is, on the one hand, much more comprehensive; on the other hand, it does not consider the health of male adolescents.

Deogan, Ferguson, and Stenberg (2012) have undertaken a comprehensive costing of adolescent-friendly health services for 74 countries. The package includes contraception; maternity care; management of sexually transmitted infections; HIV/AIDS testing and counseling, harm reduction, and care and treatment; safe abortion services; and care of injuries due to intimate partner violence and sexual violence. It also includes costs of activities to improve quality of care and increase uptake of services by adolescents. Once full coverage is achieved, the cost is estimated to be US$4.70 per adolescent, or US$0.82 averaged over the whole population. There is some degree of overlap between costs for adolescent-friendly health services; estimates of expanding contraceptive services are discussed in volume 9, chapter 3 (Watkins and others 2018). The overall cost of US$4.3 billion in aggregate covers 74 countries. We have not converted these figures to 2012 U.S. dollars because their projections are in current U.S. dollars for 2011–15 and the conversion would not be straightforward.

The essential package costed in this chapter draws on the economic assessment of existing interventions and the key interventions outlined in recent strategy documents where ministries of health have a leading or major role. The package that we cost includes the following components:

- Adolescent-friendly health services
- School-based educational programming covering such topics as sexual and reproductive health, mental health, smoking, alcohol, and illicit drugs
- National media and policy efforts to support a healthy lifestyle program to complement school-based programming

These interventions correlate fairly well with the burden of disease in adolescence: the top five causes of death are road injury, HIV/AIDS, suicide, lower respiratory infections, and interpersonal violence; and the top five causes of years lived with disability are depression, road injuries, anemia, HIV, and suicide (WHO 2014). Because road traffic injuries are an important topic in volume 7 of this series (Mock and others 2017), they are not discussed in the present chapter.

We use Deogan, Ferguson, and Stenberg's (2012) estimates for adolescent-friendly health services. We use Ebbeler's (2009) estimates for the national media cost for a sexuality education campaign of US$0.58 per girl or boy reached, and we assume that double this amount could incorporate a more comprehensive campaign against various harms. Ebbeler's (2009) estimates provide the detailed assumptions underpinning the costing in Temin and Levine's (2009) *Start with a Girl*.

Finally, we use estimates from the previous section for the costs of school-based education programs. Three programs (table 26.3) cost US$9, US$18, and US$25, approximately. The Indian antismoking program (Brown and others 2012), at almost US$46, relies heavily on per diem and travel costs as a start-up, and it is unrepresentative of what a mature program might cost. We include a cost of US$18 per adolescent per year and assume that adolescents would participate in such a program each year for three years (ages 14–16 years). Of this cost, 25 percent represents additional budget costs to the government of developing the program, training the trainers, and refreshing the curriculum periodically; the balance is the cost of teachers' time. We specifically exclude obesity from the educational package. The evidence base is weak, and current programs are not unequivocally effective. This is an area where more pilot programs and evaluations are required.

The cost of the recommended package is as follows:

- US$4.70 per adolescent ages 10–19 years for adolescent-friendly health services
- US$1.16 per adolescent ages 10–19 years for national media campaigns and national policy efforts
- US$9.00 per adolescent ages 14–16 years for the net budget cost of a school-based education program, excluding cost of teachers' time; this amount is equivalent to US$3.00 per adolescent ages 10–19 years.

The total package, therefore, costs roughly US$8.90 per year for each adolescent ages 10–19 years.

Deogan, Ferguson, and Stenberg's (2012) estimate for adolescent-friendly health services is carefully constructed using detailed data; the other two items are simply rough estimates and require further refinement. Costs of the total package are aggregated by size of population in low-income and lower-middle income countries in chapter 1 (Bundy, de Silva, and others 2017).

CONCLUSIONS

Adolescent health, overlooked for years, is now achieving much-needed prominence in the international health agenda. Adolescence is a key point in the life course, a point at which important health behaviors are established that determine the path of chronic disease at older ages. It is a key time at which to invest in and benefit the health of the working-age population, older adults, and through new mothers and their babies, the next generation. The relative neglect of adolescents in research and programming means that knowledge of how to design

cost-effective programs is inadequate relative to needs. This is an area in which there may be a payoff to trying innovative approaches and in which pilot programs require rigorous evaluation.

Economic evaluations for HICs suggest that a number of health interventions for adolescents can be cost-effective or very cost-effective, including screening and treating for selected mental health conditions as well as school-based programs on education regarding smoking, alcohol, and sexual health. Whether interventions aimed at obesity are cost-effective is uncertain because data on long-term outcomes are lacking.

For LMICs, we were able to find only two cost-effectiveness studies using QALYs or DALYs as outcomes. One concluded that restrictions on advertising of unhealthy foods was cost-effective (or even cost saving) in preventing obesity across a range of countries, while school-based interventions were not. The other study concluded that a school-based antismoking pilot program in India was cost-effective, although not very cost-effective; it is likely that if it became part of the routine curriculum it could become less costly and therefore likely more cost-effective.

An essential package for adolescent health should include at least three elements: national-level policy combined with communication of social norms, accessible and respectful services, and targeted education. National and subnational governments need to create an appropriate environment through legislation and through social marketing of key messages. Access to services that recognize adolescents' desires for confidentiality and treat them respectfully will facilitate uptake. Education in health and wellness will provide this group with the means to be active participants in their own health and improve outcomes. This education can be provided in schools as well as in other venues where it is cost-effective to reach those who are no longer in school. These elements need to be complemented with broader social policy and initiatives outside the health area that affect adolescent well-being.

The essential package in this chapter costs approximately US$8.90 per adolescent in lower-middle-income countries (in 2012 U.S. dollars). The costs will be somewhat higher in upper-middle-income countries. Compared with per capita annual public health expenditure of US$31 in lower-middle-income countries in 2013 (World Bank 2016), this amount is not unreasonable. Low- and lower-middle-income countries, in particular, face pressing unmet needs for treatment of existing illnesses. The economic evidence summarized in this chapter can help make the case for the substantial returns on preventive investments in adolescent health.

The future research needs are large, given the paucity of existing evidence. Cost-effectiveness studies should be undertaken for promising pilot programs before they are scaled up. It is not too difficult to collect cost information retrospectively to calculate cost-effectiveness or the benefit-cost ratio if a program proves to be effective. Another priority is for longitudinal studies, particularly for the rapidly growing problem of obesity, but there is considerable uncertainty about whether school-based programs have any lasting effect. A third knowledge gap is how to reach adolescents who are not in school. It is possible that social media and mass media can be used innovatively to reach this group, and perhaps the health sector can learn how to design appealing health messages from advertisers of commercial products.

ANNEX

This annex to this chapter is as follows. It is available at http://www.dcp-3.org/CAHD.

- Annex 26A. Methodology and Results of Systematic Search, Cost-Effectiveness Analysis

NOTE

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.

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Chapter 28

Postponing Adolescent Parity in Developing Countries through Education: An Extended Cost-Effectiveness Analysis

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INTRODUCTION

Despite substantial progress in the achievement of Millennium Development Goal 5 to reduce the maternal mortality ratio—the number of maternal deaths per 100,000 live births—by two-thirds between 2000 and 2015, substantial inequalities remain in maternal mortality across countries worldwide (Kassebaum and others 2014; UN 2013; UN MME 2015; Verguet and others 2014). Maternal mortality ratios remain unacceptably high in South Asia and Sub-Saharan Africa, particularly West Africa (Kassebaum and others 2014; UN MME 2015). Together, South Asia and Sub-Saharan Africa account for 86 percent of the world's maternal deaths (WHO and others 2014).

Building on the momentum gathered by the Millennium Development Goals, the post-2015 agenda and its Sustainable Development Goals set the ambitious target of further reducing the maternal mortality ratio, currently about 200 deaths per 100,000 live births globally (UNICEF 2016), to 70 per 100,000 by 2030 (UNW 2016).

Women ages 15–19 years face elevated risks of pregnancy-related mortality and morbidity. In low- and middle-income countries (LMICs), these risks are disproportionately higher (IHME 2013; WHO and others 2014), and the maternal mortality ratios are much larger, on average (Kassebaum and others 2014; UN MME 2015). Furthermore, among girls younger than age 16 years, the relative risk of pregnancy-related mortality is up to five times higher compared with women ages 20–24 years (Huang 2011; Mayor 2004). Although the education of girls has been expanded worldwide (Gakidou and others 2010), early marriages remain common; up to 65 percent and 76 percent of women are married by age 18 years in Bangladesh and Niger, respectively (UNICEF 2016). As a result, the rates of adolescent pregnancies remain very high in many LMICs (Bates, Maselko, and Schuler 2007; Beguy, Ndugwa, and Kabiru 2013; Chloe, Thapa, and Mishra 2004; Dixon-Mueller 2008).

Maternal and adolescent health need to be examined through a wider perspective beyond mortality—notably, morbidity outcomes, such as long-term sequelae for both mothers and their children, and the financial vulnerability of women and adolescents (Ashford 2002; Dale, Stoll, and Lucas 2003; Filippi and others 2006; Langer and others 2015). Pregnant young women present higher chances of school dropout (Lloyd and Mensch 2008; Marteleto, Lam, and Ranchhod 2008; Meekers and Ahmed 1999), and they could face high risks of pregnancy-related impoverishment and

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negative economic consequences (Arsenault and others 2013; Ilboudo, Russell, and D'Exelle 2013; Powell-Jackson and Hoque 2012) if they choose to carry their pregnancy to term. Out-of-pocket (OOP) medical payments in LMICs can lead to impoverishment and related coping strategies, such as borrowing money or selling assets, to pay for health care (Kruk, Goldmann, and Galea 2009; Xu and others 2003).

In the absence of other financing mechanisms, such as private health insurance or fee exemptions, household medical expenditures can be catastrophic (Wagstaff 2010), exceeding a specified percentage of total household expenditures. For example, with increased incidence of complicated deliveries owing to pregnancies at young ages, the OOP costs associated with maternal delivery in facilities are likely to be higher and may subsequently put pregnant adolescents at increased risk of medical impoverishment. In particular, this increased likelihood of financial risk would be expected to be greater among poorer socioeconomic groups; these groups have less disposable income and higher rates of adolescent pregnancies (IIPS 2010; INS and ICF International 2013). This hypothesis is one of several that this chapter examines.

Protection from health care financial risks has become a critical component of national strategies in many countries (Boerma and others 2014; WHO 2010, 2013). Reduction of these financial risks is one objective of public sector policies. For example, public investment in education to increase girls' educational levels could reduce adolescent pregnancies and subsequent risks of both mortality and impoverishment, especially among the poorest women.

Health economic evaluations (cost-effectiveness analyses) have traditionally focused on estimating an intervention's cost per health gain (Jamison and others 2006). Extended cost-effectiveness analysis (ECEA) (Verguet, Gauvreau, and others 2015; Verguet, Kim, and Jamison 2016; Verguet, Laxminarayan, and Jamison 2015; Verguet and others 2013; Verguet, Olson, and others 2015) supplements traditional economic evaluation by incorporating evaluation of financial risk protection (FRP)—prevention of medical impoverishment. ECEA quantifies how much FRP, equity, and health can be purchased for a given expenditure. ECEA can provide answers to help policy makers select the optimal policies for increasing FRP and equity and for improving the distribution of health benefits (WHO 2010, 2013).

Many determinants of adolescent pregnancy and fertility have long been reported in the scientific literature, notably by John Bongaarts (Bongaarts 1978; Bongaarts and Potter 1983). In this chapter, we restrict our analysis to one specific underlying factor of fertility—female educational attainment—and examine its impact on adolescent maternal mortality and medical impoverishment associated with complicated delivery in facility. For this purpose, this chapter uses ECEA to measure the potential mortality, FRP, and equity benefits that could be gained through public financing of increased education of adolescent girls in two illustrative country examples: Niger and India.

METHODS

This chapter examines the potential impact on maternal mortality and impoverishment of the increase in the level of female education by one school year for a cohort of adolescent women. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017).

We consider the population of adolescent women, ages 15–19 years, in Niger and India. Niger has the highest total fertility rate globally (7.6 children per woman of reproductive age) and a high maternal mortality ratio (553 deaths per 100,000 live births), leading to 5,400 maternal deaths annually. India has the largest population in South Asia (1.3 billion), the largest number of maternal deaths worldwide (45,000 deaths), and a high maternal mortality ratio (174 deaths per 100,000 live births) (Alkima and others 2016; UN DESA 2013; UN MME 2015).

General Approach

First, we examine the hypothetical impact of a one-year increase in the education level of adolescent girls. We study the linear relationship between the mean number of years of education among women ages 15–44 years (IHME 2010) and the adolescent pregnancy rate (percentage of women ages 15–19 years who have had children or are currently pregnant) in LMICs with populations greater than 1 million (World Bank 2015). Annex 28A, section 1 provides further details. This approach enables the estimation of the hypothetical impact of increasing education of girls on reducing adolescent pregnancy rates. In these two countries, we assume that the cohort of adolescent women who complete one more year of education would experience a reduction in pregnancy rates in the short term, that is, over the subsequent five years (ages 15, 16, 17, 18, and 19 years).

Second, using this estimated impact of increased education on adolescent pregnancy rates, we use the ECEA framework to estimate the potential reduction in adolescent maternal mortality and impoverishment.

We calculate the number of maternal deaths averted by a decrease in adolescent pregnancies, the amount of out-of-pocket (OOP) costs averted by the prevention of complicated deliveries, and the corresponding number of cases of catastrophic health expenditures averted. The counterfactual scenario corresponds to the case in which female education is maintained at the same level; hence, there would be no change in adolescent pregnancy rates.

ECEA provides a tool for gaining a more complete understanding of the health and financial benefits associated with different health policies and interventions. ECEA combines the traditional health system perspective from cost-effectiveness analysis with the patient perspective, notably by quantifying the benefits associated with avoiding medical impoverishment and assessing the distributional consequences, such as equity, of policies (Verguet, Kim, and Jamison 2016; Verguet, Laxminarayan, and Jamison 2015). This tool helps policy makers make decisions based on the joint benefits and tradeoffs associated with different policies and interventions, specifically in both health gains and FRP and equity benefits. In addition to health benefits, ECEA estimates the impact of policies along three dimensions:

- Household OOP private expenditures averted by the policy
- Financial protection benefits provided
- Distributional consequences, for example, as applied to socioeconomic status or geographical setting

Third, we tentatively assess the costs associated with raising the education level of adolescent girls by one year. To do so, we multiply the entering female adolescent cohort (estimated as the population of women ages 15–19 years divided by five, or about 204,000 per wealth quintile in Niger, for example) by the annual cost of primary education per pupil as estimated by the United Nations Educational, Scientific and Cultural Organization (UNESCO 2015). This approach enables us to quantify the financial resources that may be needed to achieve such an increase in female education. We do not discount the costs and benefits of increased education because the pregnancy events would occur only a few years into the future (annex 28A, section 2).

We rely on secondary data extracted from survey sources, published literature, and estimates from United Nations (UN) agencies. Specifically, we use the following:

- Country maternal mortality ratios and population estimates from the UN
- Percentage of women ages 15–19 years who are pregnant
- Incidence of complicated deliveries
- Skilled birth attendance coverage per income quintile, based on Niger's Demographic and Health Survey and India's District Level Household and Facility Survey, as a proxy for health care utilization

We rely on an estimated increased relative risk of maternal mortality among adolescent women (Huang 2011). In addition, we use data on OOP costs for complicated maternal deliveries and associated transportation costs extracted from the literature for West Africa (Arsenault and others 2013; Storeng and others 2008) and from India's National Sample Survey (NSSO 2004). Finally, we extract adolescent women's incomes from a country income distribution proxied by a gamma distribution supplemented by gross domestic product (GDP) per capita and Gini coefficient (Salem and Mount 1974; World Bank 2015). All of the parameters used in the analysis are shown in table 28.1.

ECEA Outcomes

First, we estimate the number of maternal deaths averted per income quintile owing to a decrease in the adolescent pregnancy rate through increased education. The magnitude of maternal mortality averted depends on the existing burden, the excess relative risk of maternal mortality among adolescent women, the distribution of adolescent pregnancies per income quintile, and the impact of education on reducing adolescent pregnancy rates.

Second, we estimate the amount of OOP expenditures averted related to complicated adolescent maternal deliveries and associated transportation costs. This amount depends on the incidence of complicated maternal deliveries, the relative risk of maternal mortality among adolescent women, the distribution of adolescent pregnancies per income quintile, health care utilization per income quintile, and the impact of education on reducing adolescent pregnancy rates.

Third, we measure FRP by the number of cases of catastrophic health expenditures averted, per income quintile, which depends on individual income, OOP expenditures, and the educational impact. A catastrophic health expenditure for an adolescent woman is defined as OOP expenses higher than 10 percent of income, a commonly used threshold (Pradhan and Rescott 2002; Ranson 2002; Wagstaff and van Doorslaer 2003). Specifically, among adolescent women no longer facing pregnancies, we estimate the number of individuals, per income quintile, for whom the size of OOP expenses

Table 28.1 Parameters Used for the Analysis of Adolescent Maternal Mortality and Impoverishment Averted by Increased Education in India and Niger

Parameter	India	Niger	Sources
Total population (millions)	1,311	20	UN DESA 2015
Population of women ages 15–19 years	58,400,000	1,021,000	UN DESA 2015
Maternal mortality ratio per 100,000 live births	174	553	Alkima and others 2016
Occurrence of complicated maternal delivery among all deliveries (%)	15	15	Authors' assumption based on Prual and others 2000
Relative risk of maternal mortality for women ages 15, 16, 17, 18, and 19 years	4.6, 1.0, 1.0, 1.0, 1.0	4.6, 1.0, 1.0, 1.0, 1.0	Based on Huang 2011
Percentage of women ages 15–19 years who are pregnant, from poorest to richest (income quintiles 1–5)	19; 17; 13; 8; 3	41; 43; 37; 32; 19	INS and ICF International 2013 IIPS 2010
Percentage of women ages 15, 16, 17, 18, and 19 years who are pregnant	1; 3; 5; 9; 12	3; 12; 16; 19; 18	INS and ICF International 2013 IIPS 2010
Health care utilization (percentage of skilled birth attendance coverage), from poorest to richest (income quintiles 1–5)	24; 34; 48; 64; 85	13; 19; 22; 30; 71	INS and ICF International 2013 IIPS 2007
Out-of-pocket direct medical cost (2014 U.S. dollars) of complicated delivery, from poorest to richest (income quintiles 1–5)	58; 62; 70; 81; 108	97; 127; 140; 124; 152	Based on Arsenault and others 2013; NSSO 2004; Storeng and others 2008
Out-of-pocket transportation cost (2014 U.S. dollars), from poorest to richest (income quintiles 1–5)	8; 8; 8; 8; 6	4 for all income quintiles	Based on NSSO 2004; Perkins and others 2009
Gross domestic product per capita (2014 U.S. dollars)	1,596	427	World Bank 2015
Gini index	0.34	0.32	World Bank 2015
Impact of female education on adolescent pregnancy rate	1 additional year of education leads to an 18 percent relative reduction (SE = 2 percent) in adolescent pregnancy rate	1 additional year of education leads to an 18 percent relative reduction (SE = 2 percent) in adolescent pregnancy rate	Annex 28A, section 1 and table S1
Cost of primary education, per pupil per year (2014 U.S. dollars)	258	72	Based on UNESCO 2015

Note: SE = standard error.

(sum of direct medical costs and transportation costs) would have exceeded 10 percent of their income.

The counterfactual scenario corresponds to the situation in which primary education of girls remains at the same level. All costs are expressed in 2014 U.S. dollars. Complete details of the mathematical derivations used for the analysis are given in annex 28A, section 3.

Sensitivity Analysis

Three univariate sensitivity analyses are performed:

- Different thresholds (20 percent and 40 percent of individual income) for the catastrophic health expenditures
- A poverty headcount, estimating the number of individuals falling below the country poverty line because of OOP costs, in lieu of cases of catastrophic health expenditures
- A smaller effect, 11 percent relative reduction (instead of 18 percent) (annex 28A, section 1, table S1), for the impact of a one-year increase in female education on the adolescent pregnancy rate

RESULTS

Costs

The total costs of increasing education of adolescent girls by one school year would be approximately US$15

million in Niger and US$3 billion in India. The number of adolescent women in the two countries, about 1 million in Niger and 58 million in India (table 28.1), is responsible for the large difference in the estimated cost. We observe different orders of magnitude for the size of the maternal deaths averted (160 for Niger and 1,250 for India), OOP payments averted (US$150,000 and US$3 million, respectively), and cases of catastrophic health expenditures averted (1,110 and 5,160, respectively) (tables 28.2 and 28.3).

Adolescent Maternal Deaths Averted

In each country, the extent of adolescent deaths averted, OOP payments averted, and cases of catastrophic health expenditures averted vary significantly across different income quintiles (tables 28.2 and 28.3). In both countries, more adolescent women's lives would be saved in the bottom two quintiles (49 percent in Niger and 61 percent in India), compared with the top two quintiles (30 percent and 20 percent, respectively).

Out-of-Pocket Expenditures Averted

The OOP expenditures averted display a different pattern. In Niger, more OOP expenditures would be averted in the richer income groups; about 54 percent of total OOP expenditures would be averted in the top two quintiles, in contrast to 27 percent in the bottom two quintiles (table 28.2). This finding occurs largely because richer individuals use more health care than do poorer individuals; it is also partly because richer individuals spend more out of pocket than do poorer individuals (table 28.1).

In India, the OOP expenditures averted are more evenly distributed among the different income groups. About 42 percent of total OOP expenditures averted accrue in the top two quintiles, in contrast to 34 percent in the bottom two quintiles (table 28.3).

Catastrophic Health Expenditures Averted

Catastrophic health expenditures results (FRP) reflect a combination of key drivers, including (1) the distributions of health care utilization and OOP costs among income quintiles and (2) individual income. For example, in Niger a larger number of cases of catastrophic health expenditures are averted among the richer (52 percent in the top two quintiles) than among the poorer (30 percent in the bottom two quintiles). Large inequalities exist in health care utilization (71 percent in the richest quintiles, compared with 13 percent in the poorest). Moreover, Nigerians' income is

Table 28.2 Impact of Increasing Mean Years of Female Education by One Year in Niger

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Adolescent maternal deaths averted	164	40 (24%)	40 (25%)	34 (22%)	30 (19%)	20 (11%)
Adolescent OOP expenditures averted (2014 U.S. dollars)	152,000	13,000 (9%)	27,000 (18%)	29,000 (19%)	31,000 (20%)	52,000 (34%)
Adolescent cases of catastrophic health expenditures averted[a]	1,100	130 (12%)	200 (18%)	200 (18%)	240 (22%)	330 (30%)

Note: OOP = out-of-pocket.

a. Cases of catastrophic health expenditures are defined as OOP expenses greater than 10 percent of income.

Table 28.3 Impact of Increasing Mean Years of Female Education by One Year in India

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Adolescent maternal deaths averted	1,260	400 (32%)	360 (29%)	260 (21%)	170 (14%)	70 (6%)
Adolescent OOP expenditures averted (2014 U.S. dollars)	3,050,000	430,000 (14%)	610,000 (20%)	730,000 (24%)	740,000 (24%)	540,000 (18%)
Adolescent cases of catastrophic health expenditures averted[a]	5,160	5,160 (100%)	0	0	0	0

Note: OOP = out-of-pocket.

a. Cases of catastrophic health expenditures are defined as OOP expenses greater than 10 percent of income.

very low, even in the richer socioeconomic groups; GDP per capita is US$427 (table 28.1).

In contrast, in India all the cases of catastrophic health expenditures that are averted are in the poorer quintiles (100 percent in the bottom income quintile); in spite of large inequalities in health care utilization (85 percent in the richest, compared with 24 percent in the poorest), substantial income inequalities remain. GDP per capita is approximately US$1,596, and richer individuals face little risk of catastrophic health expenditures (table 28.1). The difference between India and Niger occurs because the cost of a complicated delivery is higher relative to average income in Niger than in India.

Sensitivity Analyses

When the threshold for estimation of cases of catastrophic health expenditures is raised (to 20 percent or 40 percent), as expected the magnitude of the cases incurred decreases in India and Niger, with a slight alteration of the distribution across quintiles in Niger. Alternatively, when the poverty headcount metric is used, the distribution of induced poverty across quintiles is significantly altered (annex 28A, tables S3 and S4). Finally, when the impact of female education on the adolescent pregnancy rate is reduced (to 11 percent instead of 18 percent), maternal deaths, OOP costs, and induced cases of impoverishment averted were all reduced by 39 percent (annex 28A, tables S5 and S6).

DISCUSSION AND CONCLUSIONS

The use of the ECEA methodology enables the impact of public policies on distributional consequences and their benefits in protecting against impoverishment to be assessed, in addition to the traditional dimension of health benefits. This type of analysis provides critical additional metrics to policy makers inside and outside the health sector when allocating financial resources. We conclude that increased educational attainment for adolescent girls could bring large poverty reduction benefits in addition to significant health benefits by avoiding early pregnancies and maternal deaths. This finding underscores the great economic vulnerability of adolescent women in such settings (Filippi and others 2006; Langer and others 2015).

Our findings align well with a number of expectations. Beyond the large health and financial benefits, the extent of these gains varies significantly across socioeconomic groups. More lives would be saved in the poorer groups because they face higher rates of early pregnancy. However, more OOP expenditures would be averted in the richer groups because they use more health care than do poorer ones. Finally, individual income and broader country wealth—low income versus middle income—also affect the distribution of the FRP benefits.

Advantages of Analysis

Our approach permits FRP to be incorporated into the economic evaluation of public policies. This enables interventions to be selected on the basis of how much FRP and equity can be bought, in addition to how much health can be bought, per dollar expenditure. This methodology helps policy makers consider all of these dimensions when making financing decisions. It facilitates comparison across sectors, which is essential for ministries of finance and development. We show how the FRP and equity benefits of public policies can be substantial and should be taken into account, critically underscoring the multifaceted nature of maternal and adolescent health.

Limitation of Analysis

Our analysis presents several limitations.

First, we have limited data and rely on secondary data and published literature to estimate impact and costs (table 28.1). Accordingly, this analysis is illustrative. A more comprehensive accounting of incurred expenditures for adolescent women could be included, with detailed accounting of medical costs, transportation and housing costs, and time and wages lost. For simplicity, we use average OOP expenses linked to complicated deliveries, even though OOP expenses might significantly rise with the degree of complication and emergency. In particular, we do not include broader pregnancy-related OOP costs or other potential expenditures incurred by adolescent women. While we attempt to examine the impact of ill health on impoverishment, we do not study the impact of poverty on health, that is, the potential increased maternal mortality and morbidity consequences associated with lower socioeconomic status. Similarly, we do not include the potential lifetime economic consequences of adolescent pregnancy, such as its short-term impact on school attendance and its long-term impact on earnings losses, because of the lack of empirical data. We also do not consider the costs to induce girls to stay in school another year beyond the costs of an additional school year to the public sector.

Second, our analysis focuses on only the mortality consequences of adolescent pregnancy, and we do not account for the potential sequelae to the mothers and their children following complicated delivery; neither do we consider abortion. Delaying childbirth is modeled as

a risk displacement to older women; the elevated risk might be a first pregnancy effect or due to an unstable relationship and abortion. Such elevated risk is particularly high at ages younger than 15 years; hence, the deaths averted could be even higher if that age group were considered in the analysis.

Third, we do not pursue a full uncertainty analysis because our purpose is to expose a framework for policy makers, rather than to provide definitive estimates. Similarly, we choose to represent FRP as measured by cases of catastrophic health expenditures averted. Alternatives include a money-metric value of insurance (McClellan and Skinner 2006; Verguet, Laxminarayan, and Jamison 2015), poverty cases averted (Verguet, Olson, and others 2015), and avoided cases of forced borrowing and asset sales. We choose the number of cases of catastrophic expenditures averted metric because of its simplicity. Yet, issues pertain to its use, notably, the choice of a specific threshold—for example, 5 percent, 20 percent, or 40 percent of the capacity to pay (Xu and others 2003)—and the fact that certain individuals may not always be counted in the analysis (Saksena, Hsu, and Evans 2014; Wagstaff 2010).

Fourth, our analysis is narrowly restricted to the impact of education on teenage pregnancy and does not account for the comparative impact of other determinants of fertility (Bongaarts 1978; Bongaarts and Potter 1983) or interventions to reduce unintended pregnancies (DiCenso and others 2002; Hindin and Fatusi 2009). Similarly, we choose a simple modeling approach to examine the impact of one additional school year on teenage pregnancy and do not detail any specific features of education in the two countries studied, including, for example, the quality and impact of educational expenditures or the determinants of educational attainment (Glewwe and Kremer 2006; Heyneman and Loxley 1983).

In summary, our study's primary intent is to demonstrate how increasing levels of female education could potentially decrease rates of adolescent pregnancies and subsequently yield maternal mortality gains, as well as important equity and FRP benefits, to adolescent women.

ANNEX

The annex to this chapter is as follows. It is available at http://www.dcp-3.org/CAHD.

- Annex 28A. Estimation Methods Used in the Extended Cost-Effectiveness Analysis of Postponing Adolescent Parity

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.

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Chapter 29

Economics of Mass Deworming Programs

Amrita Ahuja, Sarah Baird, Joan Hamory Hicks, Michael Kremer, and Edward Miguel

INTRODUCTION

Soil-transmitted helminth (STH) and schistosomiasis infections affect more than 1 billion people, mainly in low- and middle-income countries, particularly school-age children. Although light infections can be fairly asymptomatic, severe infections can have significant health effects, such as malnutrition, listlessness, organ damage, and internal bleeding (Bundy, Appleby, and others 2017).[1]

Low-cost drugs are available and are the standard of medical care for diagnosed infections. Because diagnosis is relatively expensive, and treatment is inexpensive and safe, the World Health Organization (WHO) recommends periodic mass treatments in areas where worm infections are greater than certain thresholds (WHO 2015). A number of organizations, including the Copenhagen Consensus, GiveWell, and the Abdul Latif Jameel Poverty Action Lab, which have reviewed the evidence for, and comparative cost-effectiveness of, a wide range of development interventions, have consistently ranked deworming as a priority for investment.[2] However, Taylor-Robinson and others (2015) challenge this policy, accepting that those known to be infected should be treated but arguing that there is substantial evidence that mass drug administration (MDA) has no impact on a range of outcomes.[3]

This chapter discusses the economics of policy choices surrounding public investments in deworming and considers policy choices under two frameworks:

- *Welfare economics or public finance approach.* Individuals are presumed to make decisions that maximize their own welfare, but government intervention may be justified in cases in which individual actions create externalities for others. These externalities could include health externalities from reductions in the transmission of infectious disease, as well as fiscal externalities if treatment increases long-term earnings and tax payments. Evidence on epidemiological and fiscal externalities from deworming will be important for informing decisions under this perspective.
- *Expected cost-effectiveness approach.* Policy makers should pursue a policy if the statistical expectation of the value of benefits exceeds the cost. Future monetary benefits should be discounted back to the present. Policy makers may also value nonfinancial goals, such as weight gain or school participation; they should pursue a policy if the statistical expectation of the benefit achieved per unit of expenditure exceeds that of other policies that policy makers are considering.

Under either framework, the case for government subsidies will be stronger if demand for deworming is sensitive to price. If everyone would buy deworming medicine on their own, without subsidies, then subsidies would yield no benefits; they would generate a deadweight loss of taxation.

The first perspective focuses on individual goals and assumes that consumers will maximize their own welfare. It treats them as rational and informed, and it

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abstracts from intrahousehold conflicts. The second perspective does not make these assumptions and seeks simply to inform policy makers about expected benefit-cost ratios or cost-effectiveness metrics, rather than making welfare statements.

This chapter summarizes the public finance case for deworming subsidies, given the evidence on epidemiological externalities[4] and high responsiveness of household deworming to price. It reviews the evidence on the cost-effectiveness of mass school-based deworming and associated fiscal externalities. It argues that the expected benefits of following the WHO's recommendation of mass presumptive deworming of children in endemic regions exceed the costs, even given uncertainty about the magnitude and likelihood of impacts in given contexts.[5] This benefit is realized even when only the educational and economic benefits of deworming are considered. Finally, the chapter maintains that between the two leading policy options for treatment in endemic areas—mass treatment versus screening and treatment of those found to be infected—the former is preferred under both public finance and cost-effectiveness approaches. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy, de Silva, and others 2017).

EPIDEMIOLOGICAL EXTERNALITIES

STHs—including hookworm, roundworm, and whipworm—are transmitted via eggs in feces deposited in the local environment, typically through open defecation or lack of proper hygiene after defecating. Schistosomiasis is spread through contact with infected fresh water. School-age children are particularly vulnerable to such infections and prone to transmitting infection (Bundy, Appleby, and others 2017). Treating infected individuals kills the parasites in their bodies and prevents further transmission. Three studies provide evidence on such epidemiological externalities from deworming school-age children and suggest these externalities can be substantial.

Bundy and others (1990) studied a program in the island of Montserrat, West Indies, where all children between ages 2 and 15 years were treated with albendazole, four times over 16 months, to eliminate STH infections. The authors found substantial reductions in infection rates for the targeted individuals (more than 90 percent of whom received treatment), as well as for young adults ages 16–25 years (fewer than 4 percent of whom were treated). These findings suggest large positive epidemiological externalities, although only one geographic unit was examined.

Miguel and Kremer (2004) studied a randomized school-based deworming program in rural western Kenya from 1998 through 1999, where students in treatment schools received albendazole twice a year; in addition, some schools received praziquantel for schistosomiasis infections annually. The authors found large reductions in worm infections among treated individuals, untreated individuals attending treatment schools, and individuals in schools located near treatment schools. The authors estimated an 18 percentage point reduction after one year in the proportion of moderate-to-heavy infections among untreated individuals attending treatment schools, and a 22 percentage point reduction among individuals attending a school within 3 kilometers of a treatment school.[6]

Ozier (2014) studied this same randomized program in Kenya but focused on children who were ages zero to two years and living in catchment areas of participating schools at the time of program launch. These children were not treated, but they could have benefited from positive within-community externalities generated by the mass school-based deworming. Indeed, 10 years after the program, Ozier estimated average test score gains of 0.2 standard deviation units for these individuals. Consistent with the hypothesis that these children benefited primarily through the reduced transmission of worm infections, the effects were twice as large among children with an older sibling in one of the schools that participated in the program.

Bobonis, Miguel, and Puri-Sharma (2006), in contrast, found small and statistically insignificant cross-school externalities of deworming and iron supplementation on nutritional status and school participation of children in India. The authors noted that this finding is unsurprising in this context, given both the lower prevalence and intensity of worm infections and the small fraction of treated individuals.

Together, these studies provide strong evidence for the existence of large, positive epidemiological externality benefits to mass treatment in endemic areas, especially in areas with higher infection loads.[7] Such externality benefits are important to consider in both the public finance and cost-effectiveness decision-making frameworks. Under the first perspective, such benefits cannot be fully internalized by household decision makers and thus provide a potential rationale for government subsidies. Under the second perspective, externalities increase the cost-effectiveness of the intervention by increasing the total benefit achieved for a given amount of expenditure.

IMPACTS OF THE PRICE OF DEWORMING ON TAKE-UP

Assuming that a behavior generates positive externalities—or that under a cost-effectiveness approach, it is valued by policy makers—public finance theory emphasizes that

the attractiveness of a subsidy depends on the ratio of marginal consumers (those who will change their behavior in response to a subsidy) to inframarginal consumers (those who would have engaged in the behavior even in the absence of a subsidy). The higher this ratio, the more attractive the subsidy.

Kremer and Miguel (2007) studied the behavioral response to a change in the price of deworming treatment in the Kenyan deworming program. Starting in 2001, a random subset of participating schools was chosen to pay user fees for treatment, with the average cost of deworming per child set at US$0.30, which was about 20 percent of the cost of drug purchase and delivery through this program. This cost-sharing reduced take-up (the fraction of individuals who received treatment) by 80 percent, to 19 percent from 75 percent.

This result is consistent with findings observed for other products for disease prevention and treatment of non-acute conditions, such as bednets for malaria and water treatment. Figure 29.1 displays how the demand for a range of health care products decreases as price increases.[8] Moreover, Kremer and Miguel (2007) found that user fees did not help target treatment to the sickest students; students with moderate-to-heavy worm infections were not more likely to pay for the medications. These results suggest low costs and large benefits from deworming subsidies, important for both the cost-effectiveness and welfare economics perspectives.

Figure 29.1 Response of Consumer Demand to Increase in the Price of Health Products

Source: Abdul Latif Jameel Poverty Action Lab 2011.

IMPACTS OF DEWORMING ON CHILD WEIGHT

In this and subsequent sections we examine the cost-effectiveness of mass deworming in affecting various outcomes potentially valued by policy makers. We focus primarily on economic outcomes rather than health outcomes because the impact of deworming on health is covered in chapter 13 in this volume (Bundy, Appleby, and others 2017). However, we would like to briefly expand upon that discussion to address the cost-effectiveness of deworming in improving child weight. Bundy, Appleby, and others (2017) discuss recent work of Croke and others (2016), who reviewed the literature on the impact of multiple-dose deworming on child weight. Overall, they estimated that MDA increases weight by an average of 0.13 kilograms, with somewhat larger point estimates among populations in which prevalence is greater than the WHO's 20 percent prevalence threshold for MDA, or the 50 percent threshold for multiple-dose MDA.[9] Assuming that an MDA program with two treatments per year costs US$0.60 per person (Givewell 2016), Croke and others (2016) estimated that the cost of deworming MDA per kilogram of weight gain is US$4.48. For comparison with another policy option, a review of school feeding programs by Galloway and others (2009) found that the average of the range associated with a 1 kilogram weight increase for school feeding from evidence from randomized controlled trials is US$182. This finding implies that per dollar of expenditure, mass deworming produces a weight increase 40.62 times that of school feeding. This finding on weight gain suggests that evidence of education and economic impact should not be rejected out of hand based on concern for lack of evidence about mechanisms by which such impacts could be achieved.

IMPACTS OF DEWORMING ON EDUCATION AND LABOR MARKETS

Evidence on the impact of deworming on education and labor market outcomes directly informs the cost-effectiveness perspective, while the fiscal externalities resulting from labor market impacts are important from a welfare economics perspective.

We review publicly available studies of the impact of mass deworming that do the following:

- Use experimental or quasi-experimental methods to demonstrate causal relationships
- Incorporate a cluster design to take into account the potential for infectious disease externalities
- Minimize attrition that could lead to bias.

Most existing studies on deworming randomize at the individual level; they fail to consider the potential for treatment externalities (Bundy and others 2009) and likely underestimate the impact of treatment. We review evidence from three deworming campaigns in different times and contexts—one in the United States in the early twentieth century and two in East Africa at the turn of the twenty-first century.[10]

The first program was launched by the Rockefeller Sanitary Commission (RSC) in 1910 to eradicate hookworm infections in the U.S. South. With baseline hookworm infection rates at 40 percent among school-age children, traveling dispensaries administered treatment to infected individuals in endemic areas and educated local physicians and the public about prevention. The RSC reported a 30 percentage point decrease in infection rates across affected areas 10 or more years after launch of the program (Bleakley 2007).[11]

The second program was a school-based treatment program sponsored by a nongovernmental organization that was phased into 75 schools in a rural district of western Kenya from 1998 through 2001. Baseline helminth infection rates were greater than 90 percent among school children in this area. The nongovernmental organization provided deworming drugs to treat STHs twice per year and schistosomiasis once per year, as well as educational materials on worm prevention. Schools were phased into the program in three groups over four years; each school was assigned to a group through list-randomization, resulting in a cluster randomized stepped-wedge research design.

The third program was delivered by community -based organizations during 2000–03 across 48 parishes in five districts of eastern Uganda.[12] Baseline infection rates were greater than 60 percent in children ages 5–10 years (Kabatereine and others 2001). Treatment was provided during child health days, in which parents were offered multiple health and nutrition interventions for children ages one to seven years. Using a cluster randomization approach, parishes were randomly assigned to receive either the standard intervention of vitamin A supplementation, vaccines, growth monitoring, and feeding demonstrations, or to deworming treatment in addition to the standard package (Alderman and others 2006; Croke 2014).

School Participation

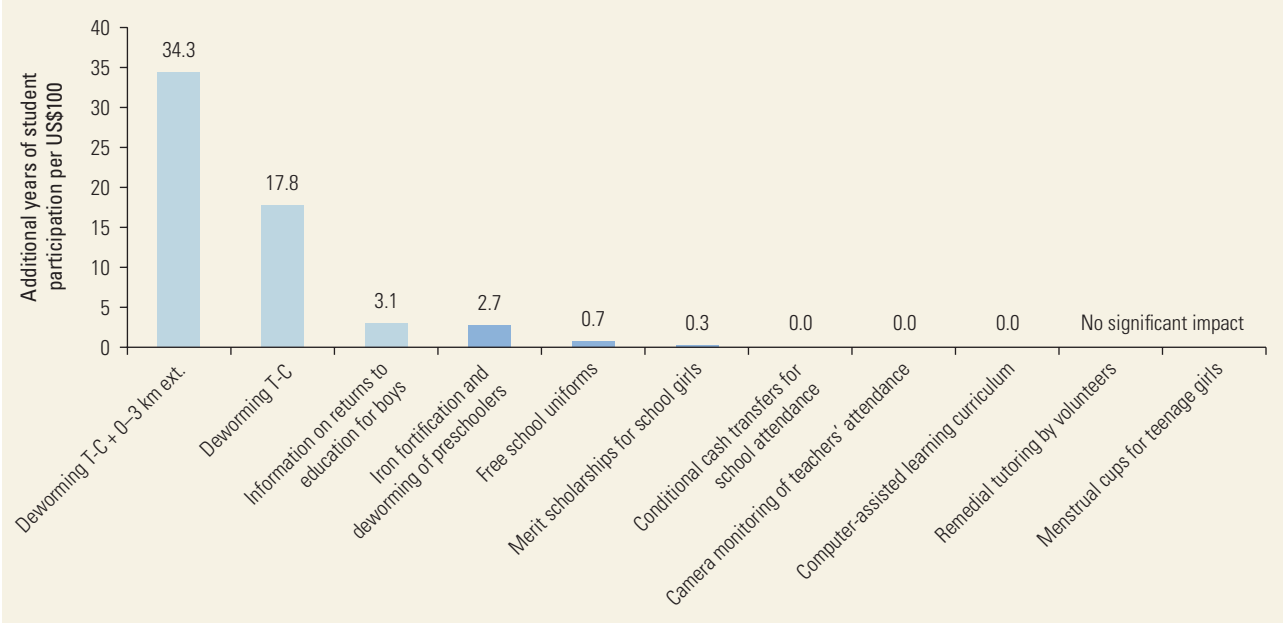
Using a difference-in-difference methodology in his study of the RSC program, Bleakley (2007) compared changes in counties with high baseline worm prevalence to changes in low baseline prevalence counties over the same period. Findings indicate that from 1910 through 1920, counties with higher worm prevalence before the deworming campaign saw substantial increases in school enrollment, both in absolute terms and relative to areas with lower infection rates. A child infected with hookworm was an estimated 20 percentage points less likely to be enrolled in school than a noninfected child and 13 percentage points less likely to be literate. Bleakley's estimates suggest that because of the deworming campaign, a county with a 1910 infection rate of 50 percent would experience an increase in school enrollment of 3 to 5 percentage points and an increase in attendance of 6 to 8 percentage points, relative to a county with no infection problem. This finding remains significant when controlling for a number of potentially confounding factors, such as state-level policy changes and the demographic composition of high- and low-worm load areas. In addition, the author found no significant effects on adult outcomes, which, given the significantly lower infection rates of adults, bolsters the case that deworming was driving these findings.

Miguel and Kremer (2004) provide evidence on the impact of deworming on school participation through their cluster randomized evaluation of the Kenyan school-based deworming program. The authors found substantially greater school participation in schools assigned to receive deworming than in those that had not yet been phased in to the program. Participation increased not only among treated children but also among untreated children in treatment schools and among pupils in schools located near treatment schools. The total increase in school participation, including these externality benefits, was 8.5 percentage points.[13] These results imply that deworming is one of the most cost-effective ways of increasing school participation (Dhaliwal and others 2012). Figure 29.2 shows the cost-effectiveness of deworming in increasing school attendance across a range of development interventions.[14]

Academic Test Scores

In their study of the Kenyan deworming program, Miguel and Kremer (2004) did not find short-term effects on academic test scores.[15] However, the long-term follow-up evaluation of the same intervention (Baird and others 2016) found that among girls, deworming increased the rate of passing the national primary school exit exam by almost 25 percent (9.6 percentage points on

Figure 29.2 Cost-Effectiveness of Development Interventions in Increasing School Attendance



Sources: Hicks, Kremer, and Miguel 2015 based on data from Abdul Latif Jameel Poverty Action Lab.
Note: T–C = the difference between outcomes for those allocated to the deworming treatment group and those allocated to the deworming comparison group; km = kilometers; ext. = externality benefits. Some values are adjusted for inflation but the deworming costs are not. Deworming is costed at US$0.49 per child in Kenya. Some of these programs create benefits beyond school attendance. For example, conditional cash transfers provide income to poor households. The Jameel Poverty Action Lab cost-effectiveness calculations for school participation include conditional cash transfers as program costs.

a base of 41 percent). Ozier (2014) found test-score gains for children younger than age two years at the time of the program.

In the long-term follow-up of the cluster randomized Uganda deworming program, Croke (2014) analyzed English literacy, numeracy, and combined test scores, comparing treatment and control. The study found that children in treatment villages have significantly higher numeracy and combined test scores compared with those in control villages; effect sizes across all three outcomes range from 0.16 to 0.36 standard deviations. The effects were significantly larger for children who were exposed to the program for multiple years.[16]

Labor Market Effects

Bleakley (2007) used data from the 1940 U.S. census to compare adult outcomes among birth cohorts who entered the labor force before and after the deworming campaign in the U.S. South. Adults who had more exposure to deworming as children were significantly more likely to be literate and had higher earnings as adults. The author found a 43 percent increase in adult wages among those exposed to the campaign as children. Given initial infection rates of 30 percent to 40 percent, hookworm eradication would imply a long-term income gain of 17 percent (Bleakley 2010).[17]

Children who were treated for worms in Kenya also had better labor market outcomes later in life. Baird and others (2016) considered women and men separately, given the different set of family and labor market choices they face. They found that Kenyan women who received more deworming treatment are more likely to grow cash crops and reallocate labor time from agriculture to nonagricultural self-employment. Treated men work 17 percent more hours per week, spend more time in entrepreneurial activities, and are more likely to work in higher-wage manufacturing jobs.

Baird and others (2016) estimated the net present value of the long-term educational and economic benefits to be more than 100 times the cost, implying that even policy makers who assume a small subjective probability of realizing these benefits would conclude that the expected benefits of MDA exceed their cost.

Based on these increased earnings, the authors computed an annualized internal rate of return to deworming of 32 percent to 51 percent, depending on whether health spillovers are included. This finding is high relative to other investments, implying that deworming is cost-effective on economic grounds, even without considering health, nutritional, and educational benefits.

Furthermore, because deworming increases the labor supply, it creates a fiscal externality though its impact on

tax revenue. Baird and others (2016) estimated that the net present value of increases in tax revenues likely exceeds the cost of the program. The fiscal externalities are sufficiently strong that a government could potentially reduce tax rates by instituting free mass deworming.

EVIDENCE AND POLICY DECISION RULES

This section argues that available evidence is sufficient to support deworming subsidies in endemic regions, even if the magnitude and likelihood of program impacts realized in a given context are uncertain.

When assessing evidence, there will always be some uncertainty about whether an intervention will have benefits in a given context. First, any body of research risks two types of errors: identifying an impact that does not exist (type 1 error), and missing an impact that does exist (type 2). The risk of making a type 1 error is captured by the confidence level (*P*-value) on estimates of impact. The risk of making a type 2 error is captured by the power of the study. Second, questions about the extent to which a body of research applies to the specific context of interest to policy makers will always arise.

Some (for example, Taylor-Robinson and others 2015) contend that the evidence does not support investments in mass deworming. One area of disagreement is the decision rule used. The decision rule the *Cochrane Review* seems to implicitly apply is that programs should not be implemented unless a meta-analysis (with all its associated assumptions) of randomized controlled trials shows benefits and indicates that the risk of a type 1 error is less than 5 percent. This approach is inconsistent with policy making from both a cost-effectiveness and a public finance perspective.

This decision rule puts no weight on the risk of making a type 2 error, which may be quite important for policy makers who do not want to deny a potentially highly beneficial program to their constituents. Given the statistical tradeoff between type 1 and type 2 errors, the desire to avoid withholding treatment with potentially very high benefits will necessitate being comfortable with less-than-definitive proof about program impact. Note that Taylor-Robinson and others (2015) did not report power, but that Croke and others (2016) found that Taylor-Robinson and others (2015) did not have adequate power to rule out effects that would make deworming cost-effective.

A more reasonable policy rule under uncertainty would be to compare expected costs with expected benefits. Suppose that the costs of the program are known to be *C*. Suppose policy makers are uncertain about the benefits of the program (relative to not implementing the program) in their circumstances. For simplicity, consider an example in which they believe that the total benefits may be B_1 with probability P_1, B_2 with probability P_2, or B_3 with probability P_3. This framework encompasses the case in which policy makers believe that there is some chance of zero impact because B_3 could equal zero. A risk-neutral policy maker will undertake the program if[18]

$$P_1 \times B_1 + P_2 \times B_2 + P_3 \times B_3 - C > 0.$$

With this framework in mind, from a cost-effectiveness perspective, deworming would still be warranted in many settings on educational and economic grounds alone, even if its benefits were only a fraction of those estimated in the studies discussed. Policy makers would be warranted in moving ahead with deworming, even if they thought benefits were likely to be smaller in their own context or had some uncertainty about whether benefits would be realized at all. In particular, even if the policy maker believes the impact of deworming on school participation is only 10 percent of that estimated in Miguel and Kremer (2004), or equivalently, if the policy maker believes there is a 10 percent chance of an impact of the magnitude estimated by Miguel and Kremer (2004), and a 90 percent chance of zero impact, it would still be among the most highly cost-effective ways of boosting school participation (Ahuja and others 2015). If the impact on weight is even 3 percent of that estimated by Croke and others (2016), then deworming is cost-effective relative to school feeding in increasing weight. If the labor market impact were even 1 percent of that found by Baird and others (2016), then the financial benefits of deworming would exceed the cost. Of course, to the extent that deworming may affect multiple outcomes, deworming will be even more cost-effective.

An analogous expected-value approach would be natural in a welfare economics framework. Labor market effects half as large as those estimated in Baird and others (2016) would be sufficient for deworming to generate enough tax revenue to fully cover its costs.[19] Standard welfare economics criteria for programs being welfare improving are much weaker than for the tax revenue fully covering costs.

From either a cost-benefit or a welfare economics perspective, a sophisticated analysis would be explicitly Bayesian, taking into account policy makers' previous assumptions and their best current assessment of their specific context. Under a Bayesian analysis that places even modest weight on evidence discussed here, mass

school-based deworming would be justified in areas with worm prevalence greater than the WHO thresholds.

It is worth noting that a Bayesian policy maker will make current policy decisions based on current information. However, the policy maker would also continue research if the expected benefits outweigh its costs; as new evidence becomes available, it would be systematically combined with the existing best information when making decisions about continuing or modifying the program.

COST OF MASS TREATMENT PROGRAMS VERSUS SCREENED TREATMENT

The WHO recommends mass treatment once or twice a year in regions where worm prevalence is greater than certain thresholds (WHO 2015). Screening, followed by treatment of those testing positive for worms, is far less practical and more costly than mass treatment without diagnostic testing.

School-based mass treatment costs approximately US$0.30 per child per treatment, including delivery costs (GiveWell 2016).[20] Diagnosis of worm infections, in contrast, is far more expensive and complicated. Speich and others (2010) estimate that the cost per child of the Kato-Katz test, the most widely used field test for worm infections, is US$1.88 in 2013 dollars. If the test works perfectly, costs would be more than seven times higher with treatment following screening, compared with mass treatment without screening. Even proponents of the test-and-treat approach acknowledge this huge differential; Taylor-Robinson and others (2015) stated that screening is not recommended by the WHO because screening costs 4–10 times the cost of treatment. Mass treatment is clearly preferred on cost-effectiveness and public finance grounds.

These figures ultimately underestimate the cost of screening, however.[21] First, tests for worms do not identify all infections. Estimates of the specificity for the Kato-Katz method range from approximately 52 percent to 91 percent (Assefa and others 2014; Barda and others 2013). With a specificity of 52 percent, the cost per infection treated would be much higher for screened treatment compared with mass treatment. Second, a large number of infections would remain untreated. With low specificity, many existing infections would be missed; additionally, screened treatment programs need to reach infected children a second time to treat them, and it is unlikely they can reach each child who was tested—making screening even less cost-effective.

In sum, the majority of the 870 million children at risk of worm infections (Uniting to Combat Neglected Tropical Diseases 2014) could be treated each year via mass deworming programs at a cost of less than US$300 million dollars a year, which is feasible given current health budgets. The cost of treating them via screened programs would likely be US$2 billion annually, if not higher, and fewer infections would be treated.

This chapter considers the cost of school-based mass deworming programs, which are particularly inexpensive per person reached. We do not consider the cost-effectiveness of more expensive community-based programs that would include extensive outreach efforts beyond schools. One reasonable hypothesis might be that these more intensive efforts may be most warranted in areas with either high prevalence, and thus likely high intensity, of STHs, or where multiple diseases, such as lymphatic filariasis, onchocerciasis, trachoma, and schistosomiasis, that can be addressed by MDA are endemic (Hotez and others 2007).

CONCLUSIONS

Recent estimates suggest that nearly one-third of children in low- and middle-income countries are treated for worms, many via school- or community-based programs (Uniting to Combat Neglected Tropical Diseases 2014). The most commonly used deworming drugs—albendazole, mebendazole, and praziquantel—have been approved for use by the appropriate regulatory bodies in multiple countries, have been shown to be efficacious against a variety of worm infections, and have minimal side effects (Bundy, Appleby, and others 2017).

The impact of deworming will vary with the local context—including circumstances such as type of worm, worm prevalence and intensity, comorbidity, the extent of school participation in the community, and labor market factors. The decision to expend resources on deworming should be based on a comparison of expected benefits and costs, given the available evidence. Our analysis of evidence from several contexts on the nutritional, educational, and economic impact suggests that the WHO recommendations for mass treatment are justified on both welfare economics and cost-effectiveness grounds. Additional studies will generate further evidence to inform future decisions.

DISCLAIMERS

USAID and the Douglas B. Marshall, Jr. Family Foundation support deworming. Michael Kremer is a former board member of Deworm the World and is currently Scientific Director of Development Innovation Ventures at USAID. Also, Amrita Ahuja is a board

member of Evidence Action, a nonprofit organization that supports governments in scaling mass school-based deworming programs; this is a voluntary position with no associated remuneration. None of these organizations had any influence on this chapter.

NOTES

This chapter draws significantly on Ahuja and others (2015).

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

- 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. For further discussion of biological differences across worms, as well as a broader discussion of deworming, please refer to Bundy, Appleby, and others (2017).
2. See, for example, Hall and Horton (2008), GiveWell (2013), and Abdul Latif Jameel Poverty Action Lab (2012).
3. Bundy, Appleby, and others (2017) provide a discussion of Taylor-Robinson and others (2015).
4. Epidemiological externalities are benefits that accrue to individuals who did not necessarily receive the treatment, for instance, a drug that cures treated individuals, thereby reducing transmission of the disease to others.
5. We do not address the optimality of the WHO prevalence thresholds for MDA.
6. Miguel and Kremer (2014) provide an updated analysis of the data in Miguel and Kremer (2004), correcting some errors in the original paper. Throughout this chapter, we cite Miguel and Kremer (2004) but use the updated numbers, where appropriate.
7. Although they do not explicitly explore externality impacts, several medical studies also show decreases in infection rates among untreated individuals (Miguel and Kremer 2004).
8. See Dupas (2014), Kremer and Glennerster (2011), Kremer and Holla (2009), and Abdul Latif Jameel Poverty Action Lab (2011) for reviews of the literature on the impact of prices on adoption of health interventions.
9. As discussed in more detail in Bundy, Appleby, and others (2017), Croke and others (2016) argued that an influential earlier study (Taylor-Robinson and others 2015) was underpowered to reject the hypothesis that MDA is cost-effective in increasing weight. Croke and others (2016) doubled the sample of 11 estimates of the effect of multiple-dose MDA for worms on weight and updated some of the estimates in Taylor-Robinson and others (2015), for example, by using micro-data provided by the original trial authors.
10. Hall and others (2006) conducted a cluster randomized study of the impact of deworming on health and test score outcomes in Vietnam. Because there is no publicly available version of this paper, we do not discuss this study in detail.
11. This measure includes the direct impact on the treated, as well as indirect impacts accruing to the untreated, population.
12. A parish is an administrative division in Uganda comprising several villages.
13. A two-part reanalysis (Aiken and others 2015; Davey and others 2015) questioned some aspects of this study. However, several independent analysts have cast doubt on the methods and conclusions of the reanalyses, and concluded that the studies leave the case for deworming fundamentally unchanged (see, for instance, Berger 2015; Clemens and Sandefur 2015; Healthcare Triage 2015; and Ozler 2015).
14. Several early studies assessed the impacts of deworming on school attendance, using individually randomized evaluations. For example, Simeon and others (1995) studied treatment among Jamaican children ages 6–12 years; Watkins, Cruz, and Pollitt (1996) studied treatment of children ages 7–12 years in rural Guatemala; and Kruger and others (1996) studied treatment of children ages 6–8 years in South Africa. None of these studies found an impact on school attendance. However, any gains are likely to be underestimated since these are individually randomized studies that do not consider treatment externalities. In addition, attendance in the Watkins, Cruz, and Pollitt (1996) study was measured through the use of school register data, which is unreliable in many low-income countries and which excluded any students who dropped out during the study. Since dropping out is very likely correlated with treatment status, there is a high risk that this gives a biased picture of school participation over time. There is also the potential for school officials to overstate attendance because of their awareness of the program and the data collection.
15. Hall and others (2006) similarly found no impact on test scores of deworming in Vietnam. As noted previously, there is no publicly available version of this paper, so we do not discuss this study further.
16. The original deworming trial was conducted in 48 communities in five districts in Eastern Uganda. Croke (2014) used educational data collected by the Uwezo project. The Uwezo survey randomly sampled communities and households from all five of these districts, creating in effect a random subsample of communities from the original trial. Croke (2014) provided evidence that the sampling of communities by Uwezo was effectively a random sample of the original trial clusters by showing that the communities have no statistically significant differences across a wide range of variables related to adult outcomes. To further support his econometric identification strategy, Croke (2014) explored the pattern of test scores of all children tested in these parishes. The youngest children would have been too young to receive more than two rounds of deworming, while the oldest children, at age 16 years, would have never received the program. One would expect that if effects are truly from the deworming intervention, the impacts would be lower at the two extremes and higher for children in the middle age group, which is what the study found.

17. Two earlier studies looked at the relationship between deworming and labor market outcomes using nonrandomized methods. Using a first-difference research design, Schapiro (1919) found wage gains of 15 percent to 27 percent on Costa Rican plantations after deworming. Weisbrod and others (1973) observed little contemporaneous correlation in the cross-section between worm infections and labor productivity in St. Lucia.
18. This abstracts from curvature of the utility function. Because deworming is inexpensive, and there is no evidence that deworming has serious side effects; because there is evidence for large effects in some cases; and because those with the highest-intensity infections are likely to be poorer than average, risk-averse policy makers or those concerned with equity would be more willing to institute mass deworming than this equation implies.
19. This estimate is conservative, only taking into account direct deworming benefits and ignoring positive externality benefits.
20. GiveWell (2016) calculates the cost of deworming for STHs in India to be US$0.30 per child per treatment, which includes both drug and delivery costs, including the value of staff time.
21. Another screening approach could be to simply ask individuals if they have experienced any of the common side effects of worm infections. Although this screening method is cheaper and potentially useful in environments where stool testing is not practical, it is likely to be very imprecise.

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Chapter 30

The Effects of Education Quantity and Quality on Child and Adult Mortality: Their Magnitude and Their Value

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INTRODUCTION

This chapter analyzes the economic returns to education investments from a health perspective.[1] It estimates the effects of education on under-five mortality, adult mortality, and fertility. It calculates the economic returns to education resulting from declines in under-five mortality and adult mortality, while considering the effects of education investments on income. It also develops policy-relevant recommendations to help guide education investments.

Our study adds to the evidence that education is a crucial mechanism for enhancing the health and well-being of individuals. The relationship between education and health is bidirectional, because poor health could affect educational attainment (Behrman 1996; Case, Fertig, and Paxson 2005; Currie and Hyson 1999; Ding and others 2009). Historical findings in the education and health literature have highlighted the strong association between education and health. Recent literature has exploited natural experiments to provide causal evidence of the impact of education on health. Studies show that education plays a critical role in reducing the transmission of human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) in women by improving prevention and treatment. Keeping adolescent girls in secondary school significantly attenuates the risk of HIV/AIDS infection (Baird and others 2012; Behrman 2015; De Neve and others 2015). Early child development has a lifelong impact on the mental and physical health of individuals.[2] Other studies have demonstrated that progress in education can increase positive health-seeking behaviors (such as accessing preventive care) and reduce overall dependency on the health system (Cutler and Lleras-Muney 2010; Feinstein and others 2006; Kenkel 1991; Sabates and Feinstein 2006).

Previous literature on education, health, and economic productivity suggests that the impact of education is more significant in times of rapid technological progress (Preston and Haines 1991; Schultz 1993). The morbidity and mortality differentials across levels of schooling are significant in the presence of increasing scientific knowledge about diseases and behaviors, as well as access to medicines and vaccines. Additionally, analysis by Jamison, Murphy, and Sandbu (2016) shows that most variation in under-five mortality can be explained by heterogeneities in the speed at which countries adopt low-cost health technologies to increase child survival.

Different studies that have assessed the effects of education on mortality and fertility show an association between educational attainment and reductions in both outcomes.[3] This chapter goes beyond previous work by using improved and updated data, and by controlling

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tightly for country-specific effects in both levels and rates of change of mortality. Although several studies have examined the effects of female schooling on child mortality, we are aware of only one other cross-national study (Wang and Jamison 1998) that estimated the macro effects of schooling on adult mortality. Other studies have focused on the relationship between schooling and adult health, but they primarily do so for a single country or small set of countries.[4] Some key findings from our study are highlighted in box 30.1.

Our study comes at a critical juncture for education and health, as the global community moves forward in the context of the Sustainable Development Goals, which stress the importance of taking into account the cross-sectoral nature of global development challenges.

This chapter is organized into three broad sections:

- The first section presents the results of our regression analysis, which examines the effects of increases in mean years of schooling, as well as schooling quality, on under-five mortality, adult female mortality, adult male mortality, and fertility. We also decompose the changes in mortality between 1970 and 2010, and estimate the mortality impact of education gains in the Millennium Development Goal (MDG) period. The findings from our regression inform the subsequent sections, which use the estimated effect size to determine the rates of return to and benefit-cost ratios (BCRs) of education.
- The second section explores the effects of augmenting the traditional rates of return analysis for education with its mortality-related health effects. We also estimate the BCR of education from earnings-only and health-inclusive perspectives, and address the question: What would be the returns to investing US$1 in education in low-, lower-middle-, and upper-middle-income countries?
- Finally, we discuss our findings, present recommendations, and consider the next steps the global education community might take to ensure that all countries make substantial progress toward global education targets.

MODELING THE EFFECTS OF EDUCATIONAL ATTAINMENT ON HEALTH

Data and Methods

We estimated the effects of educational attainment over time, measured in mean years of schooling for ages 25 years and older. This age group was selected to ensure that the data were unlikely to contain censored observations.[5] Data on mean years of schooling were obtained through the Barro and Lee (2013) dataset, which includes 92 low- and middle-income countries (LMICs), each of which included observations at five-year intervals between 1970 and 2010. Mortality rates were defined as the probability of dying between age 0 and age 5 years for under-five mortality, and the probability of dying between age 15 and age 60 years for adult mortality. The United Nations (UN) World Population Prospects (2015 revision) was used for all fertility and mortality estimates (table 30.1). Annex 30A contains a full list of countries included in

Box 30.1

Key Findings

Of the impressive reductions in mortality seen in low- and middle-income countries (LMICs) between 1970 and 2010, we estimate that 14 percent of the reductions in under-five mortality, 30 percent of the reductions in adult female mortality, and 31 percent of the reductions in adult male mortality can be attributed to gains in female schooling. Quality (as measured by standardized test scores) also has a substantial effect on health outcomes.

Gains in educational attainment during the Millennium Development Goals period saved an estimated 7.3 million lives in LMICs between 2010 and 2015.

The health benefits of additional schooling are higher for earlier years of schooling. The marginal impact of schooling at the primary level is higher compared with the impact at the secondary level.

Every dollar invested in schooling would return US$10 in low-income and US$3.8 in lower-middle-income countries. These values reflect increased earnings plus the value of reductions in under-five and adult mortality.

Table 30.1 Sources of Data in the Study

Variable	Description	Data sources
Educational attainment (mean years of schooling)	Mean years of total schooling among the population ages 25 years and older. Both overall and gender-specific estimates were used.	Barro and Lee (2013) dataset, version 2.0
Standardized achievement test scores	Aggregate standardized test scores, developed by Angrist, Patrinos, and Schlotter (2013) on the basis of global and regional achievement tests.	World Bank EdStats Global Achievement database
Under-five mortality	Probability of dying between birth and exact age five years, expressed as deaths per 1,000 live births.	UN World Population Prospects 2015
Adult mortality	Expressed as deaths under age 60 years per 1,000 alive at age 15 years, calculated at current age-specific mortality rates. Both overall and sex-specific estimates were used.	UN World Population Prospects 2015
Male and female deaths, by broad age group	Number of male/female deaths by five-year age groups.	UN World Population Prospects 2015
Fertility	Total fertility rate (children per woman).	UN World Population Prospects 2015
GDP per capita	Per capita expenditure-side real GDP (PPP-adjusted).	Penn World Tables, version 8.1 (April 2015) (Feenstra, Inklaar, and Timmer 2015)

Note: GDP = gross domestic product; PPP = purchasing power parity; UN = United Nations.

the analysis. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017).

Regression Models

We modeled the effects of educational attainment (female schooling, male schooling, and overall schooling) on under-five mortality, adult female mortality, and adult male mortality controlling for time and income (gross domestic product [GDP] per capita) using hierarchical linear models (HLMs) as in equation (30.1). Jamison, Murphy, and Sandbu (2016) provide a range of comparative models on under-five mortality and assess their statistical properties. They concluded that the HLM structure has the best fit to macro-level data to determine the macro-level impact of education on mortality, and we therefore develop their modeling approach here.

$$y_{it} = \beta_0 + \beta_1 \text{educ}_{it} + \sum_{a=1}^{t} \beta_{2a} time_t + \beta_3 Log(GDP_{PC}) + \beta_{2i} time_t + u_i + \epsilon_{it} \quad (30.1)$$

The under-five mortality model estimates the impact of adult education (education of those ages 25 years and older) on the mortality of those under age 5 at each time period *t*, while the adult mortality models estimate the impact of adult education on aggregate adult mortality or self and peer mortality, adjusting for income, any technological advancements, and secular time trends. Time is specified as a categorical variable that indicates five-year increments from 1970 to 2010, and is a proxy variable for measuring technological progress over the study period. Annex 30B contains descriptive statistics for countries included in the regression, including means and standard deviations for mortality and fertility rates, years of schooling, and test scores.

Preston (1975, 2007) shows that national income plays a critical role in improving health outcomes. He further argues that factors exogenous to income have played a crucial role in improving mortality. An influential paper by Pritchett and Summers (1996) pointed to education as well as income as being among the important factors influencing mortality decline. As highlighted by Jamison, Murphy, and Sandbu (2016), technological progress, which includes research, development and implementation advances in vaccines, sanitation, clinical care, and disease control, has played a driving role in improving health outcomes in recent years. In line with these authors, we also loosened the assumption of homogeneity of technical advancements across countries. By allowing the impact of time or technological progress to vary every five years, and by allowing for a country-specific impact of technological progress on mortality in addition to controlling for GDP, we provide conservative estimates of the impact of education on mortality and fertility. Annex 30C provides additional details on the model, and annex 30D tabulates all regression results in detail.

Decomposition Analysis

Results from the regressions were then used to decompose the changes in under-five, adult male, and female mortality between 1970 and 2010. In this analysis, we first calculate the difference in mean covariates in the sample in 2010 compared with 1970. Then, we calculate the overall reduction in mortality when education increases by the difference in mean from 2010 to 1970, which is the impact estimate from the HLM model multiplied by the difference in the mean of that covariate. The fraction attributable to any particular covariate is then the overall reduction in mortality attributable to the changes in that particular covariate, divided by the overall change in mortality over the period. For example, equation (30.2) illustrates the estimation process for the fraction attributable to education, $\Delta Mort_{ed}$, where $\Delta Educ = \overline{Educ_{2010}} - \overline{Educ_{1970}}$ and β_{ed} = the estimate of impact of education on mortality from the HLM model.

$$\Delta Mort_{ed} = \frac{\beta_{ed} \times \Delta Educ}{\beta_{ed} \times \Delta Educ + \beta_{\text{gdp}} \times \Delta GDP + \beta_{2010} \times \Delta T} \quad (30.2)$$

Estimating the Mortality Impact of Education Gains in the MDG Period

To understand the impact of education gains during the MDG period on under-five and adult mortality, we also estimate the number of excess deaths that could have occurred had educational attainment stayed at the 1990 levels. In this analysis, we model the counterfactual scenario of the number of additional deaths during 2010–15 had education stagnated at 1990 levels, where we apply the increases in education in low-income countries (LICs) and lower-middle-income countries to the coefficient from our HLM results to calculate the excess deaths. Annex table 30C.2 provides estimation details.

Results

Effects of Schooling on Adult and Under-Five Mortality and Fertility

We modeled the effects of education based on three different schooling variables: mean years of schooling for girls, boys, and both genders. The results of our analysis, which examined female and male adult mortality separately, make an important contribution to the existing evidence base. Very few studies have focused on any potential impacts that educational attainment may have on adult mortality at the macro level. To the best of our knowledge, the most recent cross-country study that specifically assessed the macro effects of schooling on adult mortality is from 1998 (Wang and Jamison 1998).

Table 30.2 shows the results of our hierarchical models; each column represents the results for the five dependent variables—overall adult mortality, adult male mortality, adult female mortality, under-five mortality,

Table 30.2 Impact of Schooling on Health Outcomes: Results from Hierarchical Linear Models

	Dependent Variables				
	Ln[Adult mortality rate], both sexes	Ln[Adult mortality rate], male	Ln[Adult mortality rate], female	Ln[Under-five mortality rate]	Ln[Total fertility rate]
Independent variables					
Panel A:					
Mean years of schooling, both sexes	–0.030***	–0.025**	–0.031***	–0.033**	–0.024***
Ln[GDP per capita]	–0.057***	–0.040**	–0.083***	–0.13***	–0.047***
Panel B:					
Mean years of schooling (female)	–0.030***	–0.022**	–0.037***	–0.042***	–0.024***
Schooling ratio (male:female)	0.016	0.019*	0.010	–0.009	–0.011
Ln[GDP per capita]	–0.052**	–0.034*	–0.079***	–0.13***	–0.047***
Panel C:					
Mean years of schooling (male)	–0.015	–0.014	–0.010	–0.015	–0.015*
Schooling ratio (male:female)	0.018*	0.020**	0.013	–0.008	–0.011
Ln[GDP per capita]	–0.058***	–0.039**	–0.084***	–0.13***	–0.047***

Note: GDP = gross domestic product. Ln[*x*] denotes natural log of variable *x*. Period: 1970–2010. Countries: 80. Observations: 688. Standard errors and goodness of fit measures reported in annex 30D.
*$p < .10$; **$p < .05$; ***$p < .01$.

and fertility. Panel A shows results for models in which we consider the impact of average male and female schooling on the five health outcomes. Panels B and C show the impact of female and male schooling, respectively, while controlling for the ratio of male to female years of schooling. The schooling ratio is included to control for any differential impact of male and female schooling in panels B and C, respectively.

Table 30.2 demonstrates that improvements in female educational attainment drove declines in mortality and fertility in LMICs between 1970 and 2010: A one-year increase in a country's mean years of schooling (both sexes) is associated with a 2.5 percent reduction in male adult mortality and 3.1 percent reduction in female adult mortality, a 3.3 percent reduction in under-five mortality, and a 2.4 percent reduction in the total fertility rate (TFR), in LMICs (panel A of table). The effect of male schooling on adult and under-five mortality and TFR is small and often not significant. In contrast, improvements in female schooling are associated with large declines in both female and male adult mortality, accounting for much of the observed effects of education on health. A one-year increase in mean years of schooling for girls (panel B of table) is associated with reductions in female and male adult mortality of 3.7 percent and 2.2 percent, respectively; under-five mortality declines by 4.2 percent, and the TFR by 2.4 percent. The comparison of the effect of male (panel C of table) and female schooling (large effect) on adult mortality, under-five mortality, and fertility clearly shows that the education-related declines in mortality between 1970 and 2010 in LMICs are strongly linked to increases in female schooling.[6]

Decomposition Analysis: Reductions in Adult and Under-Five Mortality Rates from Gains in Female Schooling, 1970–2010

Based on the results of our HLM, we developed estimates of the proportion of mortality reductions between 1970 and 2010 that can be attributed to improvements in female schooling. Adult female, adult male, and under-five mortality all saw impressive reductions over this period, with particularly dramatic improvements seen in under-five mortality. Between 1970 and 2010, the global under-five mortality rate declined by 64 percent, from 139 deaths under age five years per 1,000 live births to 50 in 2010. In LICs, gains have been particularly strong since 1990: under-five mortality declined by more than 50 percent, from 186 deaths per 1,000 live births to 91, during this 20-year span. The adult mortality rate, that is, the probability that a person dies (expressed per thousand persons) between age 15 and age 60 at prevailing mortality rates, also recorded a notable decline between 1970 and 2010, falling 38 percent globally, from 247 to 153. Reductions in adult female mortality were particularly substantial, declining by 43 percent over the 40-year period.

Our decomposition analysis suggests that of the reductions in mortality seen in LICs and middle-income countries (MICs) between 1970 and 2010, 14 percent of reductions in under-five mortality, 30 percent of reductions in adult female mortality, and 31 percent of reductions in adult male mortality can be attributed to gains in female schooling (figure 30.1, panel A). This panel shows that technological progress, and to a much lesser extent income, affected mortality over this period, a finding in line with other studies (Jamison, Murphy, and Sandbu 2016).

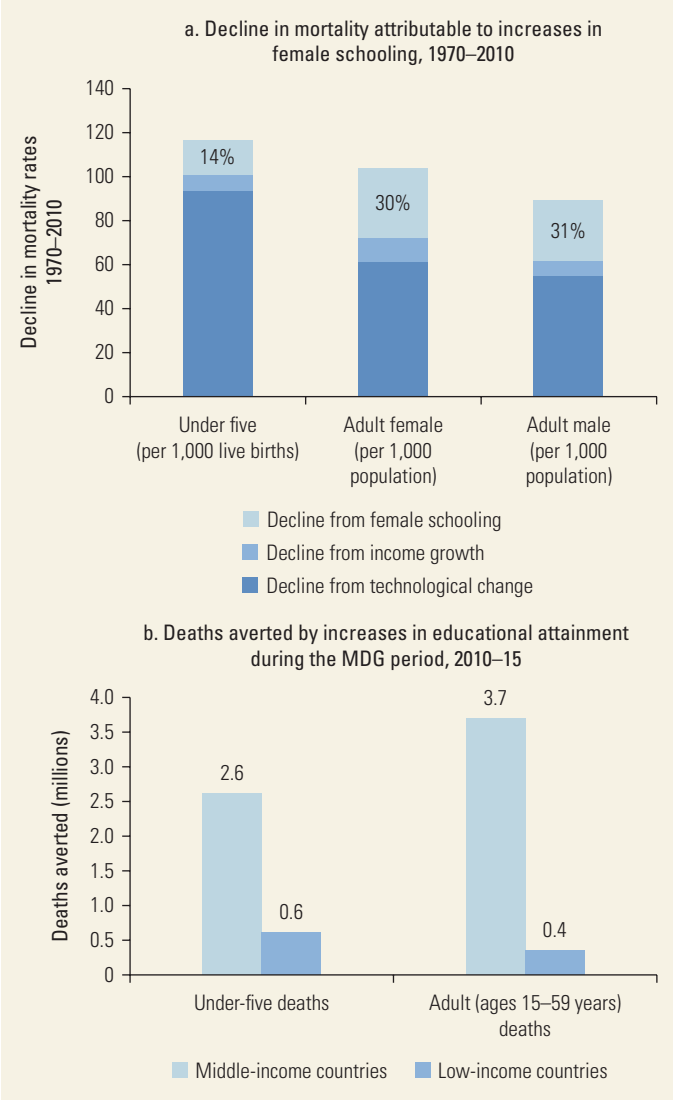
Mortality Impact of Increases in Educational Attainment during the MDG Period

A complementary way of assessing the magnitude of education's impact on mortality is to look at the reduction in the number of deaths resulting from a given increase in education levels. We take as an example the increase in female education in LMICs during the MDG period from 1990 to 2015. This increase was 1.5 years in LICs and 2.4 years in MICs. We ask the question: Based on the results of our model (table 30.2), how many more deaths would have occurred in children under age 5 years and in adults ages 15–59 years if education levels had remained at their 1990 levels? Panel B of figure 30.1 shows the results. We estimate that a total of 7.3 million under-five and adult deaths were averted between 2010 and 2015 because of increases in educational attainment since 1990. Total deaths averted in MICs were substantially higher than in LICs because the population exposed to mortality risk is about six times larger in MICs compared with LICs, and MICs saw a greater increase in average years of female schooling during the MDG period than did LICs.

Effects of Different Levels of Schooling on Mortality and Fertility

In addition to analyzing the overall impact of increasing average schooling by one year in a country, we considered whether differential effects accrue at different levels of schooling (table 30.3). We conducted a quadratic analysis that relaxes the assumption that each additional year of schooling has the same impact on health, hence allowing the relative change in mortality with changing years of attainment to be evaluated.[7] Our analysis indicates that additional years of schooling have sustained effects on all the health outcomes we examined. The coefficient on the squared years of female schooling term is positive and significant for all health outcomes, indicating that the

Figure 30.1 Education's Contribution to Mortality Decline



Note: MDG = Millennium Development Goal.

relative effect of education on health outcomes declines with increasing years of educational attainment. This result means that the marginal impact of schooling at the primary level is higher compared with the impact at the secondary level.

Effects of Educational Quality

In addition to the effect of years of schooling on health, we evaluated the effects of educational quality on health outcomes. This analysis proved challenging for a variety of reasons. Most fundamentally, cross-country data on educational quality are extremely limited, particularly for LICs and lower-middle-income countries. Researchers have used results from global or regional achievement tests (such as PISA, TIMSS, SACMEQ, PASEC, and LLECE[8]) to standardize estimates of educational quality, based on country performance on such exams. However, significant gaps remain in both longitudinal and country coverage, and concerns have been raised about the validity of using results from a limited set of tests as a proxy for educational quality.

Because of the limited number of LMICs with longitudinal data on quality, we expanded our analysis to include high-income countries (HICs) with data on quality in the Barro and Lee (2013) dataset. Annex 30A provides a full list of countries used in the HLM regressions on quality.

To evaluate the impact of education quality on health, we ran an augmented version of the HLM in table 30.2, panel B, to which we added a variable measuring schooling quality (standardized achievement test scores).

Our findings largely underscore the robustness of the impact of years of schooling on health outcomes, and further suggest that quality can have an additive and substantial impact on health outcomes (table 30.4).

Table 30.3 Impact of Schooling Levels on Health Outcomes

	Dependent Variables				
	Ln[Adult mortality rate], both sexes	Ln[Adult mortality rate], male	Ln[Adult mortality rate], female	Ln[Under-five mortality rate]	Ln[Total fertility rate]
Independent variables					
Mean years of female schooling (linear)	–0.081***	–0.071***	–0.089***	–0.14***	–0.10***
Mean years of female schooling (quadratic)	0.005***	0.005***	0.005***	0.010***	0.008***
Ln[GDP per capita]	–0.043**	–0.026	–0.070***	–0.11***	–0.032**

Note: GDP = gross domestic product. Ln[x] denotes natural log of variable x. Period: 1970–2010. Countries: 80. Observations: 688. Standard errors and goodness of fit measures reported in annex 30D.
*$p < .10$; **$p < .05$; ***$p < .01$.

Table 30.4 Impact of School Quality on Health Outcomes: Results from Hierarchical Linear Models

	Dependent variables					
	Ln[Adult mortality rate], both sexes		Ln[Under-five mortality rate]		Ln[Total fertility rate]	
	(A)	(B)	(A)	(B)	(A)	(B)
Independent variables						
Mean years of schooling (female)	–0.017*	–0.016*	–0.057***	–0.058***	–0.031***	–0.031***
Schooling ratio (male:female)	–0.013	–0.019	0.19***	0.18***	0.20***	0.20***
Ln[GDP per capita]	–0.020***	–0.20***	–0.45***	–0.46***	–0.16***	–0.16***
Test scores		–0.0025**		–0.0035**		–0.00024

Note: GDP = gross domestic product. Ln[x] denotes natural log of variable x. Period: 1970–2010. Countries: 103. Observations: 362. Standard errors and goodness of fit measures reported in annex 30D.
*$p < .10$; **$p < .05$; ***$p < .01$.

Table 30.5 Impact on Health Outcomes of a One Standard Deviation Change in Education Quantity and Quality

	Dependent Variables				
	Ln[Adult mortality rate], both sexes	Ln[Adult mortality rate], male	Ln[Adult mortality rate], female	Ln[Under-five mortality rate]	Ln[Total fertility rate]
Independent variables					
Test scores	–0.024**	–0.02*	–0.023**	–0.034**	–0.002
Mean years of schooling (female)	–0.048*	–0.033	–0.072**	–0.18***	–0.093***
Ratio (years:test scores)	2.0	1.7	3.1	5.2	40

Note: Appendix 30B, table 30B.5 tabulates the mean and standard deviation of the test scores and years of schooling used in this analysis. Ln[*x*] denotes natural log of variable *x*. Period: 1970–2010. Countries: 103. Observations: 362.
*$p < .10$; **$p < .05$; ***$p < .01$.

Column (B) under each dependent variable shows the results of the HLM model with education quality proxied by the composite test scores. Comparison of the returns to mean years of schooling in column (B) as compared to column (A), where the HLM model does not control for quality, shows that the impact of returns to schooling is about the same with or without controlling for test scores. In fact, improvements in test scores are predicted to reduce mortality and fertility further, above and beyond the improvements in years of schooling.

Given the substantial difference in a one-unit change between educational attainment (one year of schooling) and test scores (a one-point increase in scores), we also present the results of both quantity and quality by using a one standard deviation change above their mean values to enable better comparability between the two (table 30.5). The results of this analysis suggest that the impact of quality is substantial. A one standard deviation change in educational quality, measured by standardized achievement scores, is associated with a 2.4 percent decline in the overall adult mortality rate, a 2.3 percent decrease in adult female mortality, and a 3.4 percent decrease in under-five mortality. In all cases, however, the impact of female educational attainment remains larger than the impact of educational quality. For the three health outcomes for which both years of schooling and test scores are significant—overall adult mortality, female mortality, and under-five mortality—the impact of female years of schooling ranges from 2 to 5.2 times the impact of quality.

Our estimates of the magnitude of the effect of education quality on under-five mortality substantially exceed those of Jamison, Jamison, and Hanushek (2007), perhaps because (1) we estimate the impact on under-five mortality rather than on infant mortality, and (2) we have more observations from LMICs than these authors. However, our sample would still benefit from additional observations for LICs, lower-middle-income countries, and upper-middle-income countries (UMICs).

Our findings show that the impact of school quality on health outcomes is considerable and merits further scrutiny. It also highlights the limitations of the data, a challenge that should be considered when interpreting these results. Of the 103 countries included in the analysis, 59 countries have fewer than four years of observations. Of those with four or more observations, 35—or 80 percent of the sample—are HICs. Further work is needed to develop robust measures of education quality that are comparable across countries and tracked over time.

CALCULATING HEALTH-INCLUSIVE RATES OF RETURN TO EDUCATION AND BENEFIT-COST RATIOS

Previous analyses have estimated the returns to education. Using household and labor market survey data, Montenegro and Patrinos (2013, 2014) have estimated the private returns accruing from increased schooling. They note that three major findings have held across analyses:

- Private returns to schooling tend to remain in the range of 10 percent per year of schooling.
- Returns are, on average, higher in LMICs.
- Returns to primary schooling are higher than returns to secondary schooling.

When estimating private returns to education, researchers assume that costs of schooling are absorbed by the government and that the only costs to students are the opportunity costs of forgone earnings; any gains reflect the income differential between the earnings earned by students with different levels of educational attainment. The term *social rates of return* refers to the rate of return to education when the full cost of schooling is incorporated. In an analysis of 15 LMICs, Psacharopoulos, Montenegro, and Patrinos (2017) further considered the full cost of schooling. They found that the social rates of return to primary education were higher than those to secondary and tertiary education for both LICs and lower-middle-income countries.[9]

Our analysis makes an important contribution to existing research on the rates of return to education by expanding the traditional focus on earnings returns to consider some health-related (nonmarket) externalities associated with increased educational attainment (Lochner 2011; Oreopoulos and Salvanes 2011). By capturing reductions in mortality, our analysis provides a more comprehensive evaluation of returns to schooling and strengthens the investment case for education by quantifying health returns in addition to earnings returns.

Methods

The empirical work conducted as a first step in this analysis generated coefficients for the effect of one additional year of female education on under-five mortality, adult female mortality, and adult male mortality. In this section, we use these coefficients to generate the valuation of these changes in monetary terms. Earlier research by our team, funded by the Norwegian government, reviewed available evidence on the effects of education and then estimated the economic returns resulting from the reduction in under-five mortality attributable to increases in female education (Schäferhoff and others 2015). Our analysis follows the general approach used in this previous study, but improves the methodology and expands it to incorporate the monetary value of both under-five and adult mortality reductions.[10]

The literature in economics of education typically reports its benefit-cost analyses as internal rates of return, namely, the value of the discount rate that makes equal the present values of the cost and benefit streams. We calculate both the rate of return and more standard benefit to cost ratios.

Estimating both internal rates of return and BCRs involved the following four broad steps:

First, we used the effects of education on under-five mortality, adult male mortality, and adult female mortality from our cross-country regressions as the basis for our health-inclusive rate-of-return (RoR) and BCR analysis. From the regressions, we obtained the level of mortality reductions resulting from one more year of female schooling for each income group. For example, the average years of schooling in lower-middle-income countries is six years; our RoR and BCR calculations for these countries then estimated the rate of return to increasing female schooling from six years, on average, to seven years.

Second, applying methods similar to Global Health 2035 (Jamison and others 2013a, 2013b) and our Norwegian Agency for Development Cooperation (Norad) study, we placed dollar values on these mortality reductions. We calculated the expected health value at age a, expressed in dollars, associated with the assumed one-year increase in education level using the information on dollar value of mortality reductions combined with status quo mortality rates and fertility rates. The value-of-a-life-year (VLY) methodology used here underestimates the VLY in LICs compared with UMICs. While there is some evidence in the literature to support this assumption because the economic component of

the VLY is dependent on the economic productivity of a country, there is limited reason to assume that the social VLY would differ by a country's economic productivity (Stenberg and others 2016). We applied a conservative value of a statistical life (VSL) estimate in our study, and provide upper and lower bounds of RoR estimates and BCRs in annex 30D to illustrate the uncertainty around life year valuations.

Third, we calculated the earnings value for an increment in education. We received smoothed age-earnings profiles for LICs, lower-middle-income countries, and UMICs from Psacharopoulos, Montenegro, and Patrinos (2017) for different levels of schooling. We then estimated the marginal increase in earnings at each age across each schooling level (as in our example, where we estimated the expected level of mortality reductions resulting from one additional year of schooling for individuals with a starting level of six years). The earnings value of this increment in education for a person of age a is simply the difference between the age-earnings profiles of a secondary school graduate and a primary school graduate divided by the number of years of secondary schooling.

Fourth, we drew on cost data from the International Commission on Financing Global Education Opportunity, which provides estimates of the direct cost (c_1) for schooling at the respective grade levels in each income group (table 30.6). The direct cost is the cost of teacher time, implicit rent on facilities, and consumables such as textbooks. We assumed that if children are in school, they forgo earnings, so the earning value of a person of age a will be negative at the age of entry for the additional year of schooling (A). The direct cost of schooling at ages greater than A is assumed to be zero. Similarly, the opportunity cost (c_2) of attending one more year of school was calculated as the earnings forgone by attending one more year of school. Similar to direct costs, the opportunity costs of schooling at ages greater than A is also zero. Annex 30D discusses our approach in estimating the direct and opportunity costs of schooling in detail, and it tabulates the costs used in our analysis.

Table 30.6 Direct per-pupil annual costs of schooling (unweighted), in 2012 US$

	Low income	Lower middle income	Upper middle income
Primary	$68	$230	$1,300
Lower secondary	$140	$300	$1,400
Upper secondary	$300	$430	$1,300

Note: The table includes the estimated average (unweighted) per pupil costs by income group (YR2012, in 2012 US$). These cost estimates were provided by the International Commission on Financing Global Education Opportunity and were also used by Psacharopoulos, Patrinos, and Montenegro (2017).

Estimating Internal Rate of Return

Equation (30.3) expresses the net present value of costs and benefits ($ePVNR[r_s]$), in a standard RoR (r_s) analysis:

$$ePVNR(r_s) = \sum_{a=A}^{65} \frac{ev(a) - c_1(a) - c_2(a)}{(1+r_s)^{a-A}}. \quad (30.3)$$

The standard RoR (r_s) is simply the value of r_s such that the net present value of earnings ($ePVNR[r_s]$) is zero. Standard RoRs calculated are then compared with the health-inclusive RoRs, which we label hRoRs. Equation (30.4) gives the present value of net benefits when the benefit stream is augmented by the value of education's health effect:

$$hPVNB(r_h) = \sum_{a=A}^{65} \frac{ev(a) + hv(a) - c_1(a) - c_2(a)}{(1+r_h)^{a-A}}. \quad (30.4)$$

The health-inclusive RoR (r_h), hRoR, is simply that value of r_h such that the health-inclusive net present value ($hPVNR(r_h)$) is zero.

Estimating Benefit-Cost Ratios

To calculate the health-inclusive BCRs, we simply apply the annual discount rate of 3 percent to all costs and benefits. The health-inclusive BCR at discount rate (r), $hBCR(r)$, is listed below in equation (30.5), and the earnings-only BCR, $eBCR(r)$ in equation (30.6).

$$hBCR(r) = \frac{\sum_{a=A}^{65}\left[ev(a)(1+r)^{A-a} + hv(a)(1+r)^{A-a}\right]}{\sum_{a=A}^{65}\left[c_1(a)(1+r)^{A-a} + c_2(a)(1+r)^{A-a}\right]} \quad (30.5)$$

$$eBCR(r) = \frac{\sum_{a=A}^{65}[ev(a)(1+r)^{A-a}]}{\sum_{a=A}^{65}[c_1(a)(1+r)^{A-a} + c_2(a)(1+r)^{A-a}]} \quad (30.6)$$

Annex 30D provides the detailed methods used for RoR and BCR calculations, and an example of how benefits to reductions in under-five and adult male and female mortalities are valued.

Results

Health-Inclusive Rate of Return from Investments in Education

The standard social rate of return or earnings return is the rate of return to schooling considering direct costs, opportunity costs, and earnings benefits from schooling. Our initial calculations suggest that the earnings return

of investing in an additional year of schooling in LICs is 11 percent (table 30.7). These standard social rates of return, however, do not consider other social benefits of schooling. Here, we consider the added benefit of schooling on potential reductions in under-five mortality, adult male mortality, and adult female mortality.

Including the health benefits due to an additional year of schooling, the rate of return to investing in an additional year of schooling in LICs increases to 16 percent (14 percent to 18 percent).[11] This means that the rate of return to education increases significantly when the returns to education resulting from reductions in adult mortality and under-five mortality are added to the standard rate of return.

Figure 30.2 demonstrates that the health benefits accruing from education are comparable to and at certain ages even exceed earnings benefits in LICs. This is particularly true during early adulthood (ages 20–40 years), when the benefits of reduced adult and under-five mortality are 20 percent larger than the earnings benefits. The protective benefit of education for reducing under-five mortality is particularly impressive in these settings, where under-five mortality rates remain high.

The health-inclusive social rate of return calculations that consider health benefits show that the returns resulting from lower mortality are high in lower-middle-income countries, where the updated social returns with health, at 9.3 percent (8.4 percent to 10 percent) are 34 percent (21 percent to 46 percent) of the standard social rate of return (see table 30.7 and figure 30.3).

In addition to calculating rates of return for LICs and lower-middle-income countries, we estimate that the standard social rate of return of increasing schooling by a year in UMICs is 3.0 percent (table 30.7 and figure 30.4). The health-inclusive RoR is 4.7 percent (4.1 percent to 5.3 percent), which is approximately 55 percent (36 percent to 74 percent) of the returns from earnings.

The results tabulated in the chapter consider the VSL to be 130 times GDP per capita, which is a conservative estimate compared with the Global Health 2035 series and our previous Norad report. The estimated health-inclusive rates of return are sensitive to the VSL assigned to mortality reductions. In annex figure 30F.1, we also present the estimated internal rates of return at VSLs of 80 to 180 times GDP per capita. At 14 percent and 8.5 percent rates of return, the health-inclusive returns to education are high in LICs and lower-middle-income countries, respectively, even with the lowest VSL multiplier used.

The health-inclusive rates of return are relatively larger in lower-middle-income countries, compared with UMICs, because of higher mortality in lower-middle-income countries. In particular, the returns to reductions in under-five mortality are higher in lower-middle-income countries than in UMICs, where under-five mortality rates are less than half those in lower-middle-income countries. As shown in figure 30.4, the earnings benefits of schooling are consistently higher than the health benefits across all ages in UMICs. In addition, compared with lower-middle-income countries, the absolute value of health benefits and earnings benefits are higher in UMICs because of differences in GDP and VSL valuations across these two income groups.

Table 30.7 Rate of Return of One Additional Year of Schooling in LICs, Lower-Middle-Income Countries, and UMICs

percent

	Standard private rate of return	Without health benefits (standard social rate of return)	Health-inclusive social rate of return
IRR			
LICs	16	11	16
Lower-middle-income countries	9.0	7.0	9.3
UMICs	5.0	3.0	4.7
Benefits and costs included			
Health benefits	No	No	Yes
Earnings benefits	Yes	Yes	Yes
Direct cost of an additional year of schooling	No	Yes	Yes
Opportunity cost of attending an additional year of schooling	Yes	Yes	Yes

Note: IRR = internal rate of return; LICs = low-income countries; UMICs = upper-middle-income countries.

Benefit-Cost Analysis

In addition to the internal rate of return, the returns to education can alternatively be conceptualized in the form of a benefit-cost analysis. Our results suggest that there is an enormous payoff to investing in education when investments are assessed from a health perspective. Every dollar invested in female schooling in LICs and lower-middle-income countries would return US$10 and US$3.8, respectively, in earnings and reductions in under-five and adult mortality.

For our analysis, we assumed a discount rate of 3.0 percent, which is consistent with the discount rate used in other benefit-cost calculations in public health, including the 2013 *Lancet* Commission on Investing in Health. Although benefits exceed costs for all income groups even when taking into account only the earnings effects of education, the additional benefits from health are significant, particularly in LICs and lower-middle-income countries.

As with RoR estimates, the BCRs are also estimated with some uncertainty. We present sensitivity analyses of the ratios in annex figure 30F.1 where we estimate BCRs for a VSL ranging from 80 to 180 times GDP per capita. In annex figure 30F.2 we present the range of BCR estimates for discount rates from 1.0 percent to 5.0 percent. Similar to internal rate of return results, we find that the health-inclusive benefit of an additional year of schooling is substantial for LICs and lower-middle-income countries even at the lowest VSL multiplier used, with returns of US$8.3 and US$3.3, respectively, for every dollar spent.

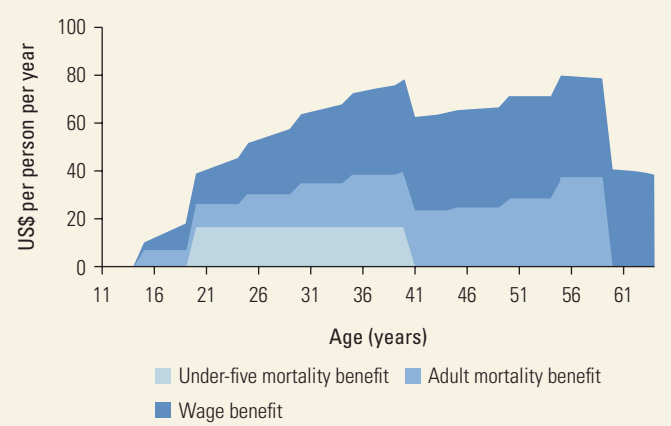
In LICs, the health benefits of education represent an impressive 92 percent increase over the earnings-only BCR; in lower-middle-income countries, health augments the traditional BCR by 44 percent. Put in other terms, 48 percent (US$4.7) of returns would come from the effect of schooling on mortality in LICs, while 31 percent (US$1.1) of the returns to education in lower-middle-income countries result from the effect on adult and under-five mortality. Even in UMICs, where lower mortality rates and higher educational attainment might suggest smaller gains, the BCR increases by 47 percent when health is taken into account, with health gains representing 32 percent (US$0.47) of the health-inclusive BCR (table 30.8).

DISCUSSION

Our results on under-five mortality are broadly consistent with previous robust analyses of the effect of schooling on under-five mortality, including that of Jamison, Murphy, and Sandbu (2016), who found that a one-year increase in female education was associated with a 3.6 percent decline in under-five mortality among 95 LMICs between 1970 and 2004. Our study, and other tightly controlled studies like Jamison, Murphy, and Sandbu (2016), yield estimates of education's effects on under-five mortality that fall well below what is often reported in the literature.

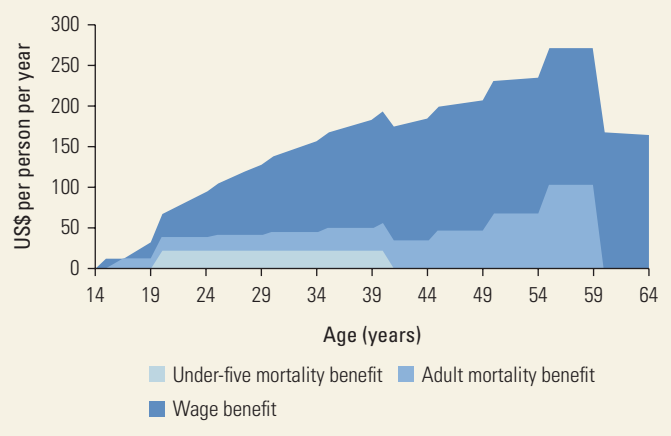
Our previous analyses have also established a clear link between schooling and improved under-five health. A meta-analysis, conducted as part of our previous study for the Oslo Summit on Education, found that one additional year of female schooling was associated with a decrease in under-five mortality of

Figure 30.2 Benefit Stream for LICs from One Additional Year of Schooling



Note: LICs = low-income countries. The benefit streams are per person with one additional year of schooling. Our models assume that the health benefits accrue only to female schooling but that the wage benefits accrue to both males and females. Hence, the estimates of the dollar value of health benefits is a weighted average with the weight depending on the fraction of the educated cohort that is female. The calculations assume the cohort is 50 percent female.

Figure 30.3 Benefit Stream for Lower-Middle-Income Countries from One Additional Year of Schooling



Note: The benefit streams are per person with one additional year of schooling. Our models assume that the health benefits accrue only to female schooling but that the wage benefits accrue to both males and females. Hence, the estimates of the dollar value of health benefits is a weighted average with the weight depending on the fraction of the educated cohort that is female. The calculations assume the cohort is 50 percent female.

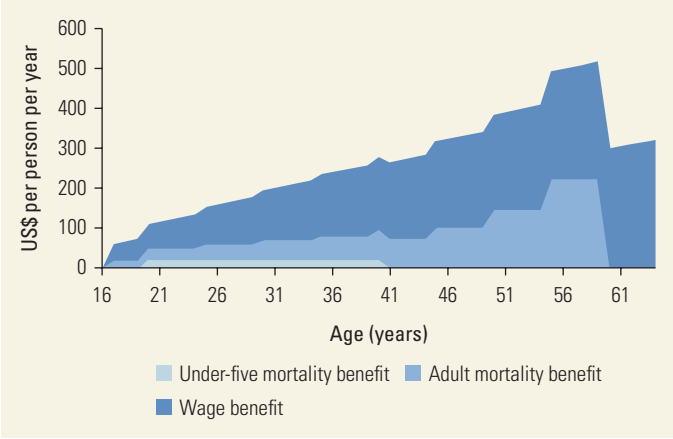
between 3.6 percent and 9.9 percent (Schäferhoff and others 2015). This finding shows that our estimate on under-five mortality, while still substantial, is at the bottom end of the range of previous studies. Even this lower estimate of effect size yields a quantitatively important effect on mortality and, as we have shown, is a significant addition to the estimated economic rate of return to education. Additionally, our results show that educational quality affects health above and beyond years of schooling, but better data and further research are needed to better understand the relationship, particularly in LMICs.

The strong impact that education has on female mortality is striking and contributes further evidence on the beneficial impacts of education to women's well-being. Schools are frequently used as channels for health information, notably, education on sexual and reproductive health. More-educated people have better access to and understanding of healthy behavior and practices. Moreover, the impact of education on women's empowerment and decision-making power is well documented (International Center for Research on Women 2005; World Bank 2014). Hence, educated women not only have increased access to health services and information, but they are better able to make healthier choices because of their increased bargaining and decision-making power within their households.

Gains in female educational attainment have been impressive over the past 40 years. The mean years of schooling attained by girls in low- and middle-income countries have increased from about 2 in 1970 to more than 6 in 2010; the ratio of male-to-female educational attainment has increased from 67 percent to 86 percent. As our analysis shows, these gains in female schooling were pivotal in reducing under-five mortality and adult mortality. However, women's educational attainment continues to lag behind men's. In the LICs included in our analysis, mean educational attainment for women remained only 2.8 years in 2010, suggesting that many girls either do not attend or at least fail to complete primary school. Further reductions in mortality can be achieved with health-focused policies, as well as education policies that address out-of-school children, especially out-of-school girls.

Our analysis is limited by the paucity of data. The VLY estimates used in the health-inclusive rate of return and BCR analysis are based on evidence mostly from developed economies. Given the range of literature from LMICs, UMICs, and HICs and the uncertainty around VLY, the results presented in this chapter are based on a conservative estimate. Further sensitivity analysis using a

Figure 30.4 Benefit Stream for UMICs from One Additional Year of Schooling



Note: UMICs = upper-middle-income countries. The benefit streams are per person with one additional year of schooling. Our models assume that the health benefits accrue only to female schooling but that the wage benefits accrue to both males and females. Hence, the estimates of the dollar value of health benefits is a weighted average with the weight depending on the fraction of the educated cohort that is female. The calculations assume the cohort is 50 percent female.

Table 30.8 Benefit-Cost Ratios of One Additional Year of Schooling in LICs, Lower-Middle-Income Countries, and UMICs

Income group		Earnings-only BCR	Health-inclusive BCR	% difference (health-inclusive versus earnings-only)
LICs		5.3	10	92
Lower-middle-income countries		2.6	3.8	44
UMICs		1.0	1.5	47
Benefits and costs included	Health benefits	No	Yes	
	Earnings benefits	Yes	Yes	
	Direct cost	Yes	Yes	
	Opportunity cost	Yes	Yes	

Note: BCR = benefit-cost ratio; LICs = low-income countries; UMICs = upper-middle-income countries.

range of VLY estimates is presented in annex 30F. Additionally, the rate of return analyses use modeled costs of schooling given the lack of comprehensive country data on private and public expenditures on schooling. While estimating the impact of schooling on health outcomes, we recognize that the bidirectionality of the relationship between education and health could bias our estimates. Our models on adult mortality estimate the relationship between education and self and peer mortality—poor health especially during school years could limit schooling, which in turn could affect health in adult years. It would be important to continue empirical research to precisely quantify this relationship. Investments in data are also needed to understand education quality—our analyses on education quality were severely restricted by the lack of data on education quality for LICs and lower-middle-income countries.

This study shows that the existing estimates of the rate of return to education are quantitatively important underestimates. This finding results from the systematic inclusion of the dollar value of education's favorable effect on health. Although investments in education are not undertaken specifically to improve health, they produce substantial health returns. In fact, returns to education investments on health are likely to be larger than reported in this study. To the best of our knowledge, our study is the most comprehensive assessment of the monetized health benefits resulting from education, but it underestimates the full effects of education on health. This is the case because it is focused on the impact of education on adult mortality and under-five mortality. Other health outcomes—most important, the effects of education on morbidity—are not considered in our study.

Nevertheless, a BCR that takes into account the health impact of increases in education provides a forceful rationale for a much stronger cross-sectoral collaboration between the education and health sectors.

CONCLUSIONS

This study shows that although investments in education are not undertaken specifically to improve health, they produce substantial health returns. Returns are particularly high in LICs and lower-middle-income countries. Our evidence also exemplifies the important determinants of health that lie outside the health sector. Addressing these determinants requires cross-sectoral collaboration and links between education and health. Other research has shown that improved health is also linked to better education.

The need for cross-sectoral work is captured in the Sustainable Development Goals, and certain funders have already begun to strengthen the links between the two sectors. The Global Fund to Fight AIDS, Tuberculosis and Malaria has begun to finance education by supporting conditional cash transfers to keep girls in school in four Sub-Saharan African countries with high HIV/AIDS prevalence and incidence, with the objective of reducing HIV transmission. The government of Norway has strengthened cross-sectoral links through its global health and education Vision 2030 initiative. Other donors could rethink their strategies, which in many cases still reflect separate approaches to education and health.

Based on our results, we conclude the following:

- Returns to education are substantially higher than generally understood, and it is important for donors and countries to reflect this in their investment decisions.
- The results strongly indicate that female education matters more than male education in achieving health outcomes. Investments targeted to girls' education yield a substantial return on health. Increased efforts are needed to close remaining gender gaps.
- It is important to get children into school because of the substantial health effects resulting from school attendance, even while awaiting further improvements in quality, which our analysis also show to be important.
- The highly positive BCR that takes into account the health impact of education provides a compelling rationale for much stronger cross-sectoral collaboration between the education and health sectors.
- Despite the recent shift in the global dialogue on quality of education in LMICs, substantial gaps remain in the availability of data on the quality of education and learning, among other data and knowledge gaps. These gaps are largely the result of limited donor investments in global public goods for education. Increased donor support would facilitate better research and progress measurement.

ANNEXES

The online annexes to this chapter are as follows. They are available at http://www.dcp-3.org/CAHD.

- Annex 30A. Countries Included in the Regression Analysis
- Annex 30B. Descriptive Statistics
- Annex 30C. Technical Annex: Hierarchical Linear Model
- Annex 30D. Incorporating Education's Effect on Mortality into Internal Rates of Return

- Annex 30E. Cost of Education, by Level
- Annex 30F. Sensitivity Analysis of Benefit-Cost Ratios and Internal Rate of Return

DISCLAIMER

This paper was initially prepared for the International Commission on Financing Global Education Opportunity as a background paper for the report, "The Learning Generation: Investing in Education for a Changing World." The views and opinions in this background paper are those of the author(s) and are not endorsed by the Education Commission or its members. For more information about the Commission's report, please visit http://report.educationcommission.org.

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NOTES

World Bank Income Classifications as of July 2015 are as follows, based on estimates of gross national income (GNI) per capita for 2014:

- 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$12,735
- High-income countries (HICs) = US$12,736 or more.

Since the chapter was written, the income classifications of some countries have changed. As of July 2016, Cambodia is a lower-middle-income country; Senegal is a low-income country; Tonga is a lower-middle-income country, and República Bolivariana de Venezuela is an upper-middle-income country.

1. See Schäferhoff and others (2015) for an initial study of the economic results of education from reductions in under-five mortality commissioned by Norad.
2. The foundations of lifelong health are built in early childhood. Center on the Developing Child at Harvard University (http://www.developingchild.harvard.edu).
3. For a systematic meta-analysis, see Schäferhoff and others (2015). See also, for example, Caldwell (1980); Wagstaff (1993); Filmer and Pritchett (1999); Grossman (2006); Gakidou and others (2010); Gupta and Mahy (2003); Kuruvilla and others (2014); Jamison and others (2013); Jamison, Murphy, and Sandbu (2016); Wang and others (2014).
4. Matsumura and Gubhaju (2001) on Nepal; Shkolnikov and others (1998) on the Russian Federation; Hurt, Ronsmans, and Saha (2004) on Bangladesh; Yamano and Jayne (2005) on Kenya; de Walque and others (2005) on Uganda; Lleras-Muney (2005) on the United States; Rowe and others (2005) on Nepal.
5. For example, years of schooling for students age 15 years would underestimate their full educational attainment because they are still in school.
6. Our results on the effects of schooling on fertility are in line with other cross-country studies that show declines in TFR as women's educational level rises (Bongaarts 2010; Martin and Juarez 1995; Mboup and Saha 1998; Muhuri, Blanc, and Rutstein 1994).
7. Conducting a categorical levels analysis would have required data on the length of each level of schooling for each country in each time period (year). For example, one country may define primary school as having a five-year duration, while another may define it as seven years; furthermore, country definitions of levels of schooling change over time. Because we lacked accurate data on levels over time, it was not possible to run such an analysis.
8. Program for International Student Assessment (PISA) (OECD 2012); Trends in International Mathematics and Science Study (TIMSS) (Mullis and Martin 2013); Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) (Hungi 2011); Program for the Analysis of CONFEMEN Education Systems (PASEC) (PASEC 2015); Latin American Laboratory for Assessment of the Quality of Education: Regional Comparative and Explanatory Study (LLECE) (UNESCO 2015).
9. The authors noted that this characterization of rates of return overlooks many of the important returns that might also be associated with improved educational attainment. Furthermore, the social rates of return were highest for tertiary education in UMICs. The authors note that given almost universal primary completion rates in UMICs, there is an unsatisfactory control group of noncompleters to compare with, likely understating returns at the primary level (Psacharopoulos, Montenegro, and Patrinos 2017).
10. Our methods build on those used by *The Lancet* Commission on Investing in Health, which used existing literature to propose a standardized approach to placing dollar values on mortality change. See Cropper, Hammitt, and Robinson (2011); Jamison and others (2013a, 2013b); Viscusi (2015).
11. All figures were calculated using a VSL of 130 times GDP per capita. We conducted additional analyses using a VSL of 80 times GDP per capita (lower bound) and 180 times GDP per capita (upper bound). The figures in parentheses refer to these lower- and upper-bound estimates.

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Contents of Volume 8, *Child and Adolescent Health and Development*

ECO-AUDIT

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About this Series: From its inception, the *Disease Control Priorities* series has focused attention on delivering effective health interventions that can result in dramatic reductions in mortality and disability at relatively modest cost. The approach has been multidisciplinary, and the recommendations have been evidence-based, scalable, and adaptable in multiple settings. Better and more equitable health care is the shared responsibility of governments and international agencies, public and private sectors, and societies and individuals, and all of these partners have been involved in the development of the series.

Disease Control Priorities, third edition (*DCP3*) builds on the foundation and analyses of the first and second editions (*DCP1* and *DCP2*) to further inform program design and resource allocation at the global and country levels by providing an up-to-date comprehensive review of the effectiveness of priority health interventions. In addition, *DCP3* presents systematic and comparable economic evaluations of selected interventions, packages, delivery platforms, and policies based on newly developed economic methods.

DCP3 presents its findings in nine individual volumes addressed to specific audiences. The volumes are structured around packages of conceptually related interventions, including those for maternal and child health, cardiovascular disease, infectious disease, cancer, and surgery. The volumes of *DCP3* will constitute an essential resource for countries as they consider how best to improve health care, as well as for the global health policy community, technical specialists, and students.

About the *Child and Adolescent Health and Development* Volume: More children born today will survive to adulthood than at any time in history. It is now time to emphasize health and development in middle childhood and adolescence—developmental phases that are critical to health in adulthood and the next generation. *Child and Adolescent Health and Development* explores the benefits that accrue from sustained and targeted interventions across the first two decades of life. The volume outlines the investment case for effective, costed, and scalable interventions for low-resource settings, emphasizing the cross-sectoral role of education. This evidence base can guide policy makers in prioritizing actions to promote survival, health, cognition, and physical growth throughout childhood and adolescence.

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