Chapter 19

Health Gains and Financial Risk Protection Afforded by Treatment and Prevention of Diarrhea and Pneumonia in Ethiopia: An Extended Cost-Effectiveness Analysis

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INTRODUCTION

Universal health coverage (UHC) continues to receive considerable attention from the global health community. UHC was the main topic of the 2010 *World Health Report* (WHO 2010), the main topic in 2012 issues of *The Lancet* (2012) and *Health Policy and Planning* (McIntyre and Mills 2012), and the theme of the Second Global Symposium on Health Systems Research in Beijing in 2012. Margaret Chan, Director-General of the World Health Organization (WHO), stated that "universal health coverage [is] the single most powerful concept that public health has to offer" (Chan 2012). This continued attention led to the 2013 *World Health Report*, which discusses the role that research can play in answering important questions about UHC (WHO 2013).

Although substantial variation is a hallmark of UHC initiatives, UHC is generally viewed along three dimensions: who is covered, what services are covered, and the proportion of the costs that are covered (WHO 2010). One financing option, universal public finance (UPF), involves the government shouldering the entire cost of specific services, regardless of who receives them. The potential benefits of UPF include improved health outcomes and improved financial risk protection (FRP). However, the evidence available to policy makers is limited with respect to the magnitude and distribution of these benefits.

Extended cost-effectiveness analysis (ECEA) (Verguet, Gauvreau, and others 2015; Verguet and Jamison 2015; Verguet, Laxminarayan, and Jamison 2015; Verguet, Olson, and others 2015; Verguet and others 2013) provides a tool with which to gain a more complete understanding of the health and financial benefits associated with different health policies and interventions. ECEA combines the traditional health system perspective of cost-effectiveness analysis (CEA) with the patient perspective, notably through the quantification of the benefits associated with avoiding medical impoverishment and the assessment of the distributional consequences, that is equity, of policies (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 health gains, FRP and equity benefits.

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In 2013 in Ethiopia, about 60,000 children under age five years died as a result of pneumonia or diarrhea, the fifth-highest absolute level worldwide (IVAC 2013). Studies have associated the incidence of both conditions with socioeconomic status (Fekadu, Terefe, and Alemie 2014; Mihrete, Alemie, and Teferra 2014), suggesting that an evaluation of the impact of prevention and treatment services by income quintile would be suitable.

This chapter uses ECEA methods to examine UPF of the prevention and treatment of pneumonia and diarrhea in Ethiopia, with a focus on children under age five years. The combination of prevention and treatment options illustrates health and FRP benefits brought by the different intervention packages available to decision makers. This analysis also examines these benefits by income quintile so that policy makers can better understand how each package affects different segments of the population—a critical element of UHC. A 20 percentage point increase in coverage is modeled. Our purpose is to expose with simplicity the broad implications for policy makers rather than to provide them with definitive estimates, hence the presentation of limited rudimentary sensitivity analyses. After we summarize current child health services in Ethiopia, we outline the methods used in this chapter, which draw from the ECEA methodology (Verguet, Laxminarayan, and Jamison 2015). Then, we present results—both health and financial protection—for the following:

- Pneumonia treatment
- Combined pneumonia treatment and pneumococcal conjugate vaccination (PCV)
- Diarrhea treatment
- Combined diarrhea treatment and rotavirus vaccination.

Finally, we discuss the implications of the findings and conclude.

CHILD HEALTH AND HEALTH CARE SERVICES IN ETHIOPIA

Ethiopia has made substantial progress in reducing the mortality rate of children under age five years—from 205 deaths per 1,000 live births in 1990 to 68 in 2012 and to 59 in 2015 (You and others 2015)—achieving Millennium Development Goal 4 three years early (UNICEF 2013a, 2013b; UN IGME 2015). Despite this progress, substantial need remains for child health interventions. In 2012, approximately 205,000 Ethiopian children died from preventable causes and treatable diseases before reaching their fifth birthday. Apart from neonatal causes, the two major killers of children in Ethiopia were acute respiratory infections and diarrhea (Liu and others 2012).

The coverage of child health care services remains very low compared with other low- and middle-income countries (LMICs) (WHO 2015). According to Ethiopia's 2011 Demographic and Health Survey (DHS) (Central Statistical Agency and ICF International 2011), coverage of measles vaccine, pentavalent 3 (third dose of diphtheria, pertussis, tetanus, *Haemophilus influenzae* type b, and hepatitis B vaccines), care-seeking for acute respiratory infection, and care-seeking for diarrhea were 56 percent, 35 percent, 27 percent, and 32 percent, respectively. Inequities in child mortality and access to care between urban and rural dwellers and across wealth quintiles remain large. According to Ethiopia's 2011 DHS, infant mortality is 29 percent higher in rural areas than in urban areas. The urban-rural difference is even more pronounced for mortality in children under age five years, and up to 37 percent higher in rural areas than in urban areas. Furthermore, wide regional variations are observed in mortality rates in infants and children, with more than a twofold difference, for example, between Addis Ababa and Benishangul-Gumuz in the western part of the country. In addition to the increased risk of diarrheal illnesses and pneumonia among children from the lowest wealth quintile, children from the wealthiest quintiles were considerably more likely to receive care from health facilities or providers (Central Statistical Agency and ICF International 2011).

There are about 12 million children under age five years in Ethiopia (table 19.1) and strong demographic and mortality disparities exist between the different wealth strata of the Ethiopian population (table 19.2). More specifically, strong inequalities in pneumonia- and diarrhea-related deaths can be observed in the country. Using the Lives Saved Tool (LiST), a partial cohort model that projects mortality by age and cause of death using inputs on health status and intervention coverage

Table 19.1 Distribution of the Population of Children Younger than Age Five Years, by Gender, Ethiopia

	Population	
Age group in years	Male	Female
0–1	1,230,000	1,210,000
1–2	1,220,000	1,200,000
2–3	1,200,000	1,180,000
3–4	1,190,000	1,170,000
4–5	1,180,000	1,170,000
Total	6,020,000	5,930,000

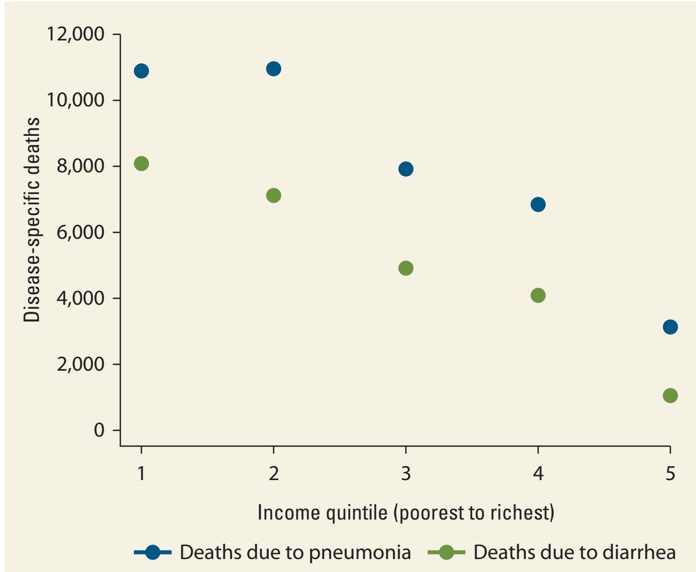
Source: United Nations 2014.

Table 19.2 Demographic and Mortality Disparities between the Different Wealth Strata of the Population, Ethiopia

Wealth quintile	Total fertility rate	Under-five mortality rate (per 1,000 live births)
I (poorest)	6.0	137
II	5.7	121
III	5.3	96
IV	5.0	100
V (richest)	2.8	86

Source: Central Statistical Agency and ICF International 2011.

Figure 19.1 Estimated Mortality in Children Younger than Age Five Years Due to Pneumonia and Diarrhea across Income Groups in Ethiopia



and effectiveness (Winfrey, McKinnon, and Stover 2011), and methods described elsewhere (Amouzou and others 2010), we estimate total under-five deaths due to pneumonia and diarrhea by income group (figure 19.1). Subsequently, we see that such disease-specific mortality rates are about four times higher in the poorest quintile than in the wealthiest quintile.

As in many low-income countries, government per capita spending on health in Ethiopia is very low at about US$15 (WHO 2015). The national health policy strongly emphasizes fulfilling the needs of the underserved rural population, which constitutes 84 percent of the total population. Ensuring health care accessibility for the whole population is one of the main strategic objectives of Ethiopia's health sector development program IV (2011–15) (Federal Democratic Republic of Ethiopia 2010). The Ministry of Health envisages the health extension program (HEP) as a primary vehicle for delivering critical and basic preventive and curative care to the community (Banteyerga 2011). The HEP is an innovative, community-based program that makes essential health services available at the grassroots level. It proposes a package of basic preventive and curative health services that targets rural households (Banteyerga 2011).

HEP comprises the following four health subprograms, which correspond to the elements of primary health care as defined in the Alma Ata Declaration (WHO 1978):

- Disease prevention
- Family health
- Environmental hygiene and sanitation
- Health education and communication.

Every village with at least 1,000 households—about 5,000 residents—builds a health post. Two female health extension workers (HEWs), who have completed tenth grade, are recruited from the same community and trained in HEP modules for one year; upon completion of their training, they return home as salaried frontline health care staff. The major goals of the HEWs are to provide communities and households with increased knowledge and skills regarding preventable diseases, accessible health services at health posts, and facilitated referrals to health centers and hospitals.

Ample evidence suggests that community health workers can identify, refer, or treat childhood illnesses outside of health facilities (Bang and others 1999; Baqui and others 2009; Bhutta and others 2005; Haines and others 2007). The HEWs have substantial potential to increase coverage of highly cost-effective child survival interventions at the community level. Starting in 2011, the government of Ethiopia took an additional step and allowed the HEWs to provide community case management of childhood pneumonia, malaria, and diarrheal illnesses. The HEP offers an opportunity to scale up child health services in Ethiopia and is expected to narrow the gap between different income quintiles and geographic locations.

Despite the government's current attempt to provide certain essential services free of charge—including those that relate to family health, communicable disease control, hygiene and environmental sanitation, and health education and communication—34 percent of health expenditure is privately financed as of 2012

(WHO 2012). This expenditure consists of households' direct outlays, including gratuities and in-kind payments, for health services.

To prevent deaths from pneumonia and diarrhea, the two biggest killers for those younger than age five years in Ethiopia (Liu and others 2012), preventive and curative interventions must be intensified to reach all segments of the population. Establishing healthy environments to protect children from pneumonia and diarrhea, and increasing access to cost-effective interventions for both prevention and treatment, will greatly reduce mortality rates from those conditions. Although little work has examined the cost-effectiveness of pneumonia and diarrhea interventions in an Ethiopian or other low-income setting (Kim and others 2010; Laxminarayan and others 2006; Rheingans, Atherly, and Anderson 2012; Sinha and others 2007), efficacious rotavirus and PCVs have been licensed (Fischer Walker and Black 2011; Theodoratou, Johnson, and others 2010). Treatment interventions for pneumonia (for example, community case management with antibiotics) and diarrhea (for example, oral rehydration salts) have proven to be effective (Munos, Fischer Walker, and Black 2010; Theodoratou, Al-Jilaihawi, and others 2010). Evidence-based information on the expected health, equity, and FRP outcomes for various diarrhea and pneumonia strategies is crucial for setting priorities. Verguet and others (2013) conducted a preliminary ECEA of public finance of rotavirus vaccination in Ethiopia that points to the substantial health benefits (such as deaths averted) and FRP benefits (such as prevention of medical impoverishment) that would accrue to the poorest socioeconomic groups.

Here we use ECEA methods to evaluate the consequences of UPF on health, equity, and impoverishment for a hypothetical program targeting children under age five years in Ethiopia. This program would consist of four interventions:

- Pneumonia treatment
- Combined pneumonia treatment and PCV
- Diarrhea treatment
- Combined diarrhea treatment and rotavirus vaccination.

We measure program impact along four dimensions: under-five deaths averted, household expenditures averted, FRP afforded, and distributional consequences across the wealth strata of the country population.

METHODS

Extended Cost-Effectiveness Analysis

ECEA (Verguet, Gauvreau, and others 2015; Verguet and Jamison 2015; Verguet, Laxminarayan, and Jamison 2015; Verguet, Olson, and others 2015; Verguet and others 2013) expands on the standard approach to economic evaluation proposed by CEA, by evaluating aspects of health policies that are important for policy makers. Specifically, in addition to health benefits, ECEA estimates the impact of policies along three dimensions: (1) household out-of-pocket (OOP) expenditures averted by the policy, (2) FRP benefits provided, and (3) distributional consequences (for example, according to socioeconomic status or geographical setting). Thus, this study examines provision of diarrhea and pneumonia interventions within the broader framework of UPF. The broader household financial consequences of publicly financed prevention and treatment interventions could then be analyzed, evaluating their impact on the reduction of household OOP expenditures and FRP. The distributional impact is also considered across income quintiles, highlighting the equity potential of UPF.

Interventions Analyzed

Pneumonia Treatment with Antibiotics

We assume that current coverage of pneumonia treatment (antibiotics) across all income groups is increased by 20 percentage points (table 19.3). The average baseline coverage of pneumonia treatment was 27 percent before UPF. After UPF, coverage increases, on average, to 47 percent. Health gains as measured by deaths averted are calculated for the increase. We chose a 20 percentage point increase, a rather small increase, to capture a realistic scenario that can be achieved by the Ethiopian health system. The effectiveness of pneumonia treatment also drew on a meta-analysis of studies used for populating LiST; community case management with antibiotics was found to reduce pneumonia-related deaths by 70 percent (Theodoratou, Al-Jilaihawi and others 2010).

Combined Pneumonia Treatment and Pneumococcal Conjugate Vaccination

As a complement to the scale-up of pneumonia treatment, we assume that UPF scales up coverage of PCV from 0 percent to 20 percent across income groups (table 19.3).

PCV-13 protects against the 13 serotypes (1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F, 23F) that are typically associated with invasive diseases like pneumonia, sepsis, and meningitis. These 13 serotypes have been estimated to cause 70 percent of all invasive pneumococcal diseases in Gavi-eligible countries (Johnson and

Table 19.3 Input Parameters Used for Analysis of Pneumonia Treatment and Combined Pneumonia Treatment and Pneumococcal Conjugate Vaccination

Parameter	Value	Sources
Epidemiology		
Under-five deaths due to pneumonia in 2011, from poorest to richest (income quintiles 1–5)	10,900; 11,000; 7,900; 6,800; 3,100	Authors' calculations using LiST based on Amouzou and others 2010; Fischer Walker and others 2013
Proportion of under-five pneumonia deaths attributed to pneumococcal disease	33 percent	Fischer Walker and others 2013
Interventions		
Antibiotic effectiveness	0.70	Theodoratou, Al-Jilaihawi, and others 2010
Vaccine (PCV-13) effectiveness (per three-dose course)		
• Pneumonia (all causes)	0.26	Theodoratou, Johnson, and others 2010
• Pneumonia (pneumococcal)	0.68	Cutts and others 2005
• Meningitis	0.64	Hsu and others 2009
• Nonpneumonia nonmeningitis	0.89	Black and others 2000
Coverage of antibiotics, from poorest to richest (income quintiles 1–5), before UPF	16%; 25%; 22%; 33%; 62%	Central Statistical Agency and ICF International 2011
Coverage of antibiotics, from poorest to richest (income quintiles 1–5), after UPF	36%; 45%; 42%; 53%; 82%	
Coverage of vaccine, from poorest to richest (income quintiles 1–5), before UPF	0%; 0%; 0%; 0%; 0%	Central Statistical Agency and ICF International 2011
Coverage of vaccine, from poorest to richest (income quintiles 1–5), after UPF	20%; 20%; 20%; 20%; 20%	
Costs (2011 US$)		
Hospitalization cost for disease[a]		Stack and others 2011;
Pneumonia	$84	WHO-CHOICE 2014
Meningitis or nonpneumonia nonmeningitis	$182	
Outpatient clinic visit cost for pneumonia	$45	Stack and others 2011; WHO-CHOICE 2014
Probability of hospitalization, from poorest to richest (income quintiles 1–5)	0.09 for pneumonia cases; 0.75 for meningitis and nonpneumonia nonmeningitis cases	Rudan and others 2004;
Probability of outpatient visit, from poorest to richest (income quintiles 1–5)	0.16; 0.25; 0.22; 0.33; 0.62	Central Statistical Agency and ICF International 2011
Pneumococcal conjugate vaccine price (per vial, 3 doses needed)		Gavi 2014
Base case	$3.5	
With Gavi subsidy	$0.2	
Vaccination system cost (per vial, 3 doses needed)	$0.5	Griffiths and others 2009

table continues next page

Table 19.3 Input Parameters Used for Analysis of Pneumonia Treatment and Combined Pneumonia Treatment and Pneumococcal Conjugate Vaccination (continued)

Parameter	Value	Sources
Ethiopia's gross domestic product per capita	$360	World Bank 2013
Ethiopia's Gini index	0.3	
Utility function as a function of individual income *y*	$\frac{y^{1-r}}{1-r}$ with r = 3 (r = coefficient of relative risk aversion)	McClellan and Skinner 2006; Verguet, Laxminarayan, and Jamison 2015

Note: LiST = Lives Saved Tool; PCV = pneumococcal conjugate vaccine; UPF = universal public finance.
a. Severe infections and hospitalizations were not included.

others 2010). We found no studies reporting serotype distribution in Ethiopia. Our estimates of the efficacy of PCV-13 come from clinical trials (Black and others 2000; Cutts and others 2005; Hsu and others 2009) and from a meta-analysis of PCV-9 and PCV-11 used for populating LiST, where all-valent PCV was found to reduce radiologically confirmed pneumonia by 26 percent (Theodoratou, Johnson and others 2010).

To estimate pneumococci deaths averted—33 percent of all pneumonia deaths are due to pneumococci (Fischer Walker and others 2013)—the model follows the current Ethiopian birth cohort. Depending on disease-specific mortality (pneumonia, meningitis, nonpneumonia nonmeningitis), we estimated intervention coverage, intervention effectiveness, and reductions in disease-specific deaths in each income group. This static approach does not capture epidemiological changes such as herd immunity and serotype replacement from vaccination, which could be captured more fully in, for example, a dynamic transmission model. However, the extent of such indirect effects on the nonvaccinated population is unclear, leading to their exclusion from this analysis (Weinberger, Malley, and Lipsitch 2011).

Diarrhea Treatment with Oral Rehydration Salts

Oral rehydration salts (ORS) are evaluated as a treatment for diarrhea in this analysis. To determine the number of deaths averted by UPF of ORS, we assume a 20 percentage point increase in treatment-seeking above the level reported for each income quintile in the DHS (Central Statistical Agency and ICF International 2011). We also assume ORS is 93 percent effective in preventing deaths from diarrhea, following estimates based on a systematic review from the Child Health Epidemiology Reference Group (Munos, Fischer Walker, and Black 2010). Deaths averted by income quintile are the product of the baseline number of diarrhea deaths, the increase in treatment coverage, and the effectiveness of treatment.

Combined Diarrhea Treatment and Rotavirus Vaccination

As a complement to the scale up of diarrhea treatment, we assume that UPF scales up rotavirus vaccination from 0 percent to 20 percent coverage across income groups (table 19.4) to mimic coverage achievable by the Ethiopian health system.

After determining the baseline number of diarrhea deaths by income quintile, we attribute 27 percent of diarrhea deaths to rotavirus (Fischer Walker and others 2013). This yields the number of rotavirus-attributable deaths by income quintile (table 19.4). Although estimates of vaccine efficacy vary in Sub-Saharan Africa and by strain, we use an effectiveness of 50 percent taken from a meta-analysis (Fischer Walker and Black 2011) and assume it prevented visits to health facilities as well as mortality (Verguet and others 2013). Specifically, to estimate rotavirus deaths averted, the model follows the current Ethiopian birth cohort; rotavirus deaths averted are the product of baseline rotavirus deaths, vaccine coverage, and vaccine effectiveness (Verguet and others 2013). This static approach is unable to capture epidemiological changes such as herd immunity, which has only been documented in a few countries (Buttery and others 2011; Tate and others 2011; Yen and others 2011).

Treatment Expenditures Averted

Household private expenditures averted through UPF of vaccinations are calculated differently than for treatment. Vaccine intervention–related private

Table 19.4 Input Parameters Used for Analysis of Diarrhea Treatment and Combined Diarrhea Treatment and Rotavirus Vaccination

Parameter	Value	Sources
Epidemiology		
Under-five deaths due to diarrhea in 2011, from poorest to richest (income quintiles 1–5)	8,100; 7,100; 4,900; 4,100; 1,100	Authors' calculations using LiST based on Amouzou and others 2010; Fischer Walker and others 2013
Proportion of under-5 diarrhea deaths attributed to rotavirus	27%	Fischer Walker and others 2013
Interventions		
ORS effectiveness	0.93	Munos, Fischer Walker, and Black 2010
Rotavirus vaccine effectiveness (per two-dose course)	0.50	Fischer Walker and Black 2011
Coverage of ORS, from poorest to richest (income quintiles 1–5), before UPF	22%; 25%; 35%; 33%; 53%	Central Statistical Agency and ICF International 2011
Coverage of ORS, from poorest to richest (income quintiles 1–5), after UPF	42%; 45%; 55%; 53%; 73%	
Coverage of vaccine, from poorest to richest (income quintiles 1–5), before UPF	0%; 0%; 0%; 0%; 0%	Central Statistical Agency and ICF International 2011
Coverage of vaccine, from poorest to richest (income quintiles 1–5), after UPF	20%; 20%; 20%; 20%; 20%	
Costs (2011 US$)		
Hospitalization cost for diarrhea[a]	$49	Stack and others 2011; WHO-CHOICE 2014
Outpatient clinic visit cost for diarrhea	$9	Stack and others 2011; WHO-CHOICE 2014
Probability of hospitalization for diarrhea, from poorest to richest (income quintiles 1–5)	0.02; 0.02; 0.01; 0.02; 0.01	Authors' calculations based on Central Statistical Agency [Ethiopia] and ICF International 2011; and Lamberti, Fischer Walker, and Black 2012
Probability of outpatient visit for diarrhea, from poorest to richest (income quintiles 1–5)	0.22; 0.25; 0.35; 0.33; 0.53	Central Statistical Agency and ICF International 2011
Rotavirus vaccine price (per vial, two doses needed)		Gavi 2014
Base case	$2.5	
With Gavi subsidy	$0.2	
Vaccination system cost (per vial, two doses needed)	$0.5	Griffiths and others 2009
Ethiopia's gross domestic product per capita	$360	World Bank 2013
Ethiopia's Gini index	0.3	
Utility function as a function of individual income y	$\frac{y^{1-r}}{1-r}$ with r = 3 (r = coefficient of relative risk aversion)	McClellan and Skinner 2006; Verguet, Laxminarayan, and Jamison 2015

Note: LiST = Lives Saved Tool; ORS = oral rehydration salts; UPF = universal public finance.
a. Severe infections and hospitalizations were not included.

expenditures averted depend on the number of cases of a specific infection (a subset of total cases), vaccine coverage, vaccine effectiveness, probability of seeking either inpatient or outpatient care in the absence of the vaccine, and cost of inpatient and outpatient care. Details of the methods are given elsewhere (Verguet and others 2013). Before UPF is implemented, households pay at a 34 percent level for inpatient and outpatient care (the remaining 66 percent is covered by the government) (WHO 2012). After UPF is implemented, individuals would pay 0 percent for inpatient and outpatient care, and the government would pay 100 percent of the costs.

Government Costs

Government costs due to UPF of the vaccine also differ from those for treatment. Government costs for the vaccine are based on the size of the birth cohort, vaccine coverage, the costs of the vaccine itself, and the associated system costs of delivery. Because the vaccine also averts future government treatment costs, these averted costs are subtracted from the cost of delivering the vaccine to estimate the net costs of the combined treatment-vaccine interventions from the government's perspective.

Government costs for diarrhea and pneumonia treatment include 66 percent of the costs for inpatient and outpatient care for currently covered households, plus 100 percent of the costs for inpatient and outpatient care for the 20 percentage point increment in coverage.

Financial Risk Protection

UPF provides FRP benefits to households by shielding them from the OOP costs and impoverishment-related consequences of the covered health care services. UPF "insures" households against the OOP cost of diarrhea and pneumonia treatment, and in doing so can prevent households from related impoverishment.

Several metrics can be used to quantify the FRP benefits of health policies. One approach is to estimate the amount of households' OOP expenditures averted by the policy; another is to estimate the number of cases of poverty averted (that is, counting the number of individuals no longer falling under a poverty line or threshold because of substantial OOP medical expenditures). In this study, we use the money-metric value of insurance provided by UPF as the FRP metric (Verguet, Laxminarayan, and Jamison 2015). The money-metric value of insurance metric quantifies "insurance risk premiums"; it reflects risk aversion, in which individuals would prefer the certainty of insurance to the uncertainty or risk of possible OOP expenditures, and hence they are willing to pay a certain amount of money to avoid that risk.

As explained in great detail in Verguet, Laxminarayan, and Jamison (2015), to estimate the FRP (for example, the money-metric value of insurance) to an individual who is provided UPF, we first estimate the individual's expected income before UPF, depending on treatment coverage and associated costs. We then estimate the individual's certainty equivalent by assigning individuals utility functions that specify their risk aversion (tables 19.3 and 19.4), which is equivalent to calculating their willingness to pay for insurance against risks of medical expenditures. This certainty equivalent reflects the final income that individuals are willing to accept to make the outcome certain. Finally, we derive a money-metric value of insurance provided (risk premium) as the difference between the expected value of income and the certainty equivalent (Brown and Finkelstein 2008; Finkelstein and McKnight 2008; McClellan and Skinner 2006; Verguet, Laxminarayan, and Jamison 2015). Aggregating the money-metric value of insurance provided using an income distribution in the population (with a proxy based on country gross domestic product per capita and Gini coefficient [Salem and Mount 1974]) yields a dollar value of FRP at the societal level.

All mathematical derivations used are presented in annex 19A. All calculations are estimated using the R statistical software (www.r-project.org).

RESULTS

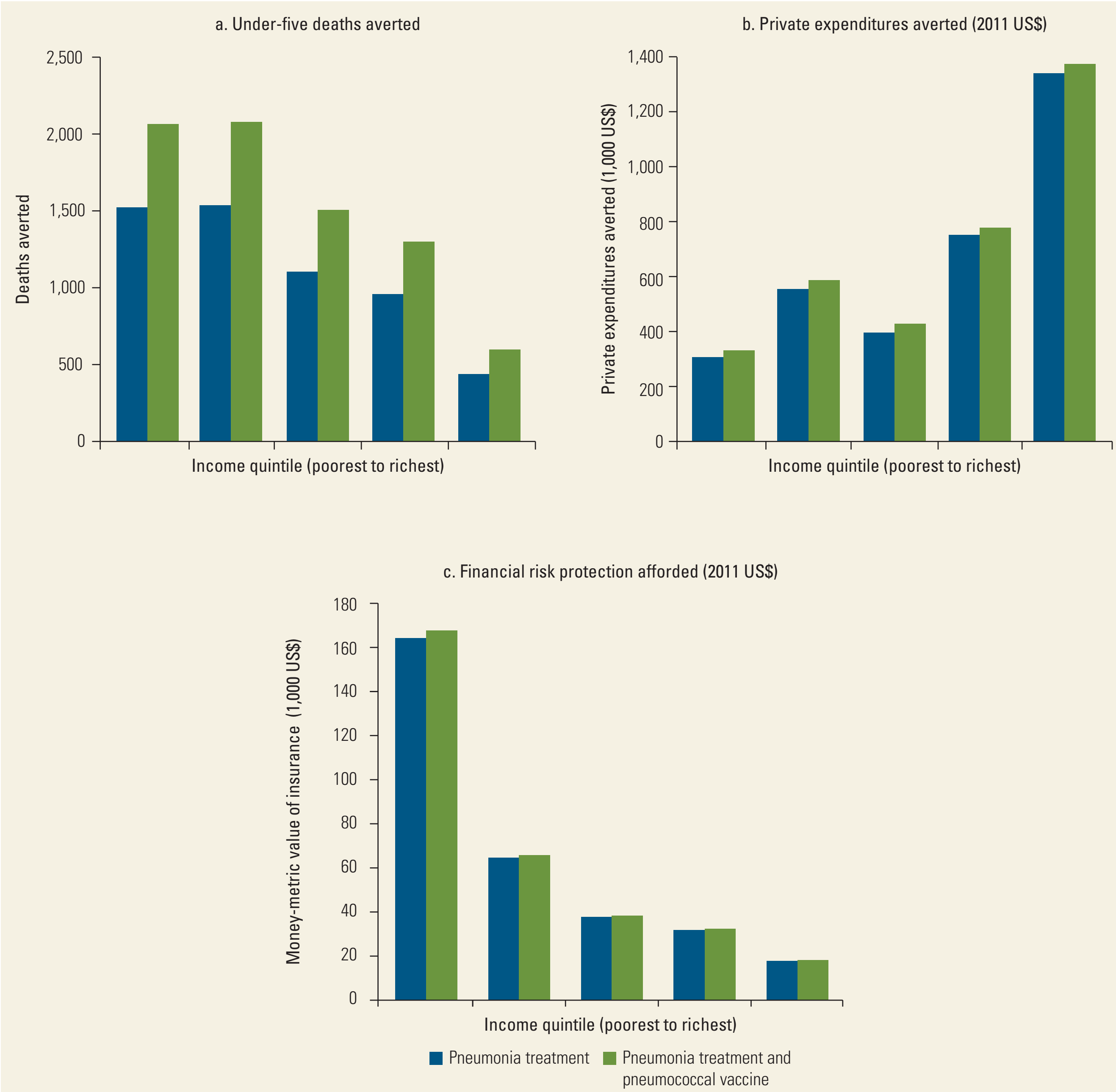
Pneumonia Treatment and Combined Pneumonia Treatment and Pneumococcal Conjugate Vaccination

Deaths Averted

Annually, pneumonia treatment would avert about 5,600 deaths; the combined treatment-vaccine package would avert about 7,500 deaths (figure 19.2, panel a). Pneumonia treatment would save more lives among the poorest income group because of the higher disease burden in this population and would evenly increase coverage among all income groups.

Combined pneumonia treatment and PCV would save more lives among the bottom income quintiles because the higher burden of disease is concentrated in the poorest income groups. Yet, 32,000 pneumonia-related deaths would still occur; of these, 8,000 would occur in the poorest income quintile.

Figure 19.2 Benefits of Pneumonia Treatment and Combined Pneumonia Treatment and Pneumococcal Vaccination



OOP Expenditures Averted

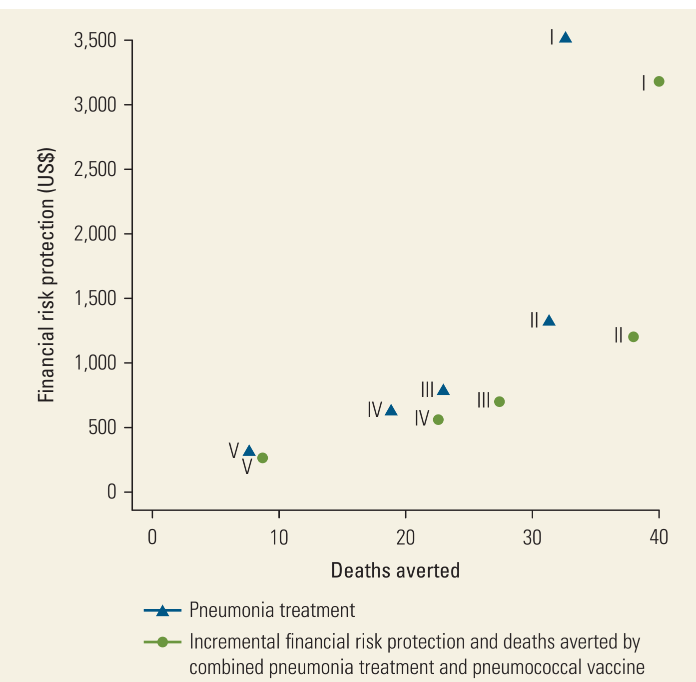
The health benefits finding is the opposite of the distribution of OOP expenditures averted because of the variations in current coverage of pneumonia treatment, from 16 percent in the bottom income quintile to 62 percent in the top income quintile. Wealthier people have better access to care in both programs, which would lead to reductions in household private expenditures for those who have access (figure 19.2, panel b).

Financial Risk Protection

Both programs would offer the highest FRP for the poorest income quintile (figure 19.2, panel c). There would, however, be a shift in gradients between private expenditures averted and FRP. The poorest would have, in absolute terms, the lowest private expenditures averted but the highest FRP. This outcome occurs because the poorest quintile would have substantially lower disposable income than the richest in absolute terms; therefore the change in income due to the interventions would be much higher.

To illustrate the results per dollar of expenditure, an arbitrary budget constraint of US$1 million is introduced (figure 19.3). The two dimensions of health gains and FRP afforded (measured by a money-metric value of insurance) are given for the five income groups, for UPF of pneumonia treatment, and UPF of combined pneumonia treatment and PCV. Per dollar expenditure, the combined treatment-vaccine package would save slightly more lives compared with treatment alone. However, the FRP afforded would be slightly reduced in each quintile. This slight reduction in FRP, when vaccines are added, is due to the fact that vaccines provide less FRP per dollar spent than treatment. In particular, vaccines protect only against pneumococcal pneumonia, whereas full public finance of treatment is more targeted. In both instances, health and FRP benefits would disproportionally aid the poorest income groups given that both the health and FRP benefits would be substantially larger in the poorest income quintile than in the richest income quintile.

Figure 19.3 Health Benefits and Financial Risk Protection Afforded from Investing $1 Million in Pneumonia Treatment and Combined Pneumonia Treatment and Pneumococcal Vaccination



Note: Results are shown for five income quintiles (I is poorest; V is richest).

Program Costs

The total costs of scaling up pneumonia treatment by 20 percentage points across all income groups (and of providing UPF for those who currently have access to pneumonia treatment) would be approximately US$49.6 million. The costs of the combined treatment-vaccine package vary substantially, depending on the vaccine price and Gavi eligibility. The total costs of the combined pneumonia treatment and PCV package would be approximately US$56.1 million (88 percent of which is for pneumonia treatment, 12 percent of which is for pneumococcal vaccine) based on a vaccine price of US$3.50 per dose, which is the market price currently paid by Gavi. If the fully Gavi-subsidized cost of US$0.20 per dose were to be used, the total cost of the combined treatment-vaccine package would be US$50.6 million. Regardless of vaccine price, more of the combined treatment-vaccine program funding would go to the richest groups of the population, since they are expected to have higher utilization rates.

Diarrhea Treatment and Combined Diarrhea Treatment and Rotavirus Vaccination

Deaths Averted

UPF for diarrhea treatment would avert 4,700 deaths each year. Combined diarrhea treatment and rotavirus vaccination would avert 5,400 deaths each year. Yet, 20,000 diarrhea-related deaths would still occur; of these, 6,000 would occur in the poorest income quintile (figure 19.4, panel a).

OOP Expenditures Averted

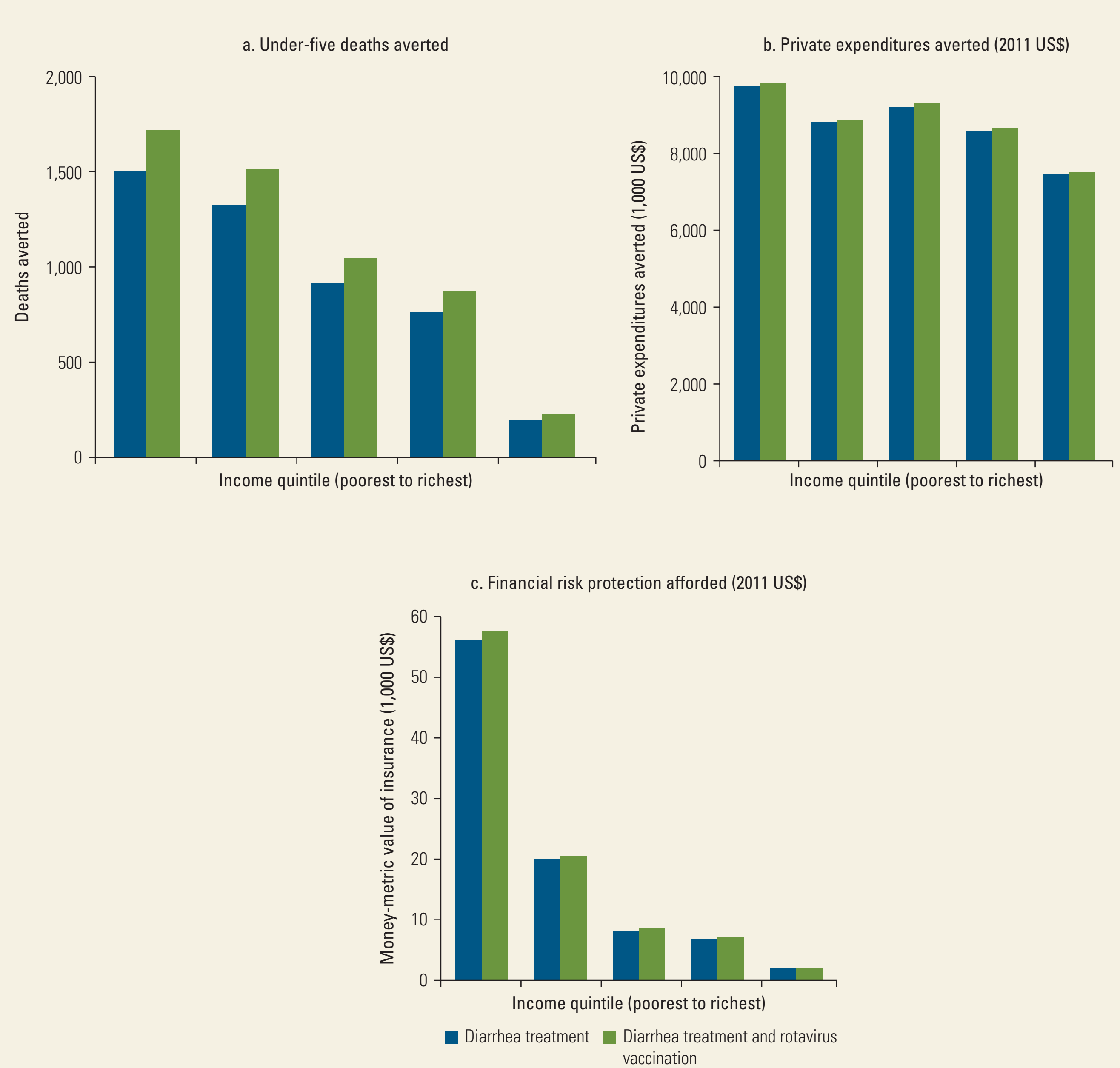
On an annual basis, UPF for diarrhea treatment would avert US$43.8 million of OOP expenditures. It would also provide insurance valued at US$93,000 at a cost of approximately US$100.9 million to the government.

Combined diarrhea treatment and rotavirus vaccination would avert US$44.1 million in OOP expenditures, and it would provide insurance valued at US$96,000 at a net cost of US$103.3 million to the government (gross government expenditure for rotavirus vaccination is approximately US$3.2 million) (figure 19.4, panel b).

Financial Risk Protection

Diarrhea treatment would provide about US$1,000 in FRP benefits per US$1 million spent. Combined diarrhea treatment and rotavirus vaccination would provide approximately US$1,000 in FRP benefits per US$1 million spent. For both diarrhea treatment and combined diarrhea treatment and rotavirus vaccination, health and FRP benefits would be substantially larger among the poorer income quintiles than the richer income quintiles (figure 19.4, panel c; figure 19.5).

Figure 19.4 Benefits of Diarrhea Treatment and Combined Diarrhea Treatment and Rotavirus Vaccination

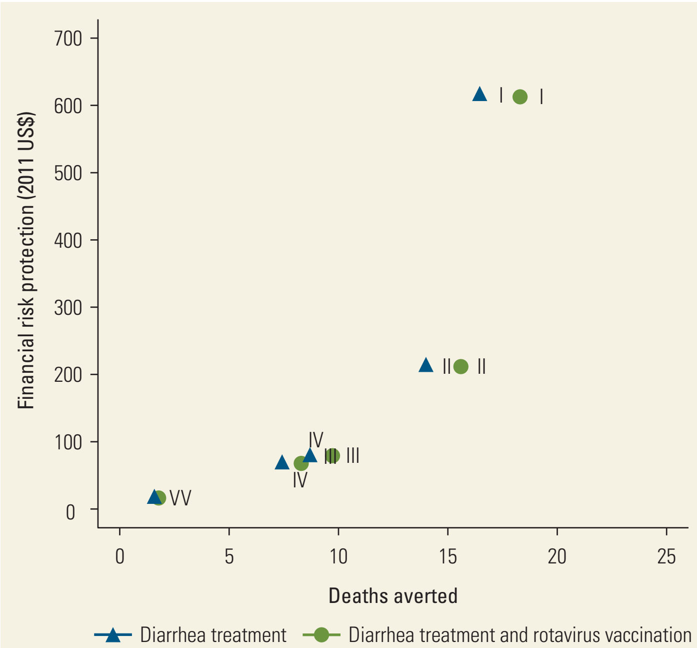


Program Costs

Diarrhea treatment would save lives at a cost of approximately US$21,000 per death averted; combined diarrhea treatment and rotavirus vaccination would save lives at an approximate cost of US$19,000 per death averted. If we view these results per US$1 million spent, diarrhea treatment would avert approximately 47 deaths and US$430,000 in private expenditures. Diarrhea treatment would provide about US$1,000 in FRP benefits per US$1 million spent (figure 19.5). Combined diarrhea treatment and rotavirus vaccination would avert 52 deaths and US$430,000 in private expenditures averted per US$1 million spent.

These results provide two outstanding messages. First, diarrhea treatment and combined diarrhea treatment and rotavirus vaccination provide similar FRP

Figure 19.5 Health Benefits (deaths averted) and Financial Risk Protection Afforded (Measured in 2011 US$) from Investing US$1 Million of Public Expenditures on Diarrhea Treatment and Combined Diarrhea Treatment and Rotavirus Vaccination



Note: Results are shown for five income quintiles (I is poorest; V is richest).

benefits per income group, and combined diarrhea treatment and rotavirus vaccination averts more deaths than diarrhea treatment alone. Second, the scale of the FRP benefits provided by UPF is small relative to the health benefits and private expenditures averted.

The numbers provide important information on the overall impacts of these interventions. However, it is also critical to view the results through the equity lens to understand the effects of UPF. The figures show how an investment of US$1 million in UPF in these interventions is distributed throughout the population. With regard to deaths averted, both diarrhea treatment and combined diarrhea treatment and rotavirus vaccination generally provide greater benefits to the poor. A major reason that both packages benefit the poorest is the higher burden of diarrheal disease among the poorest. An examination of private expenditures averted demonstrates a different trend. For both diarrhea treatment and combined diarrhea treatment and rotavirus vaccination the wealthy tend to experience greater relative gains in private expenditures averted, since private expenditures averted by UPF are relatively flat across income quintiles. Finally, the FRP benefits provided by UPF again favor the poorest by a substantial margin. In general, the poorest tend to gain more FRP benefits because their incomes are lower, and the marginal value of the reduction of risk is of lower value for the wealthier quintiles.

DISCUSSION

This chapter illustrates the potential broader benefits of providing UPF for child health interventions for pneumonia and diarrhea in Ethiopia. It also demonstrates that UPF could provide different benefits across the wealth distribution, in addition to FRP and equity.

Main Findings

UPF for pneumonia treatment and for combined pneumonia treatment and PCV would provide substantially higher FRP for the poor and save more lives for the poor. Similar results are seen for UPF for diarrhea treatment and for combined diarrhea treatment and rotavirus vaccine.

This analysis also highlights the role that organizations such as Gavi can play. In particular, for rotavirus and pneumococcal vaccines, both health and FRP benefits of the combined packages could be enhanced if Gavi were to fully subsidize the vaccine prices to the Ethiopian government so that the government paid $0.20 per dose (tables 19.5 and 19.6). Although interesting in its own right, this situation may become a practical concern if Gavi support were to expire. Acknowledgment of these altered benefits is important when considering Gavi eligibility and the sustainability of the inclusion of vaccine interventions in benefits packages. This issue is particularly compelling when a strong rationale, such as equity, supports an intervention that a country may not implement under current incentives.

Although this analysis focuses on Ethiopia, the findings may also speak to the value of these interventions in other countries facing similar coverage gaps and mortality burdens related to diarrhea and pneumonia. Ethiopia is one of 15 countries that account for 75 percent of the worldwide child deaths from pneumonia and diarrhea (IVAC 2013; Liu and others 2012), all of which are characterized by inadequate coverage of ORS and antibiotic treatment. This coverage issue underscores the relevance of using ECEA to understand distributional impact. Furthermore, future applications of ECEA should examine the impact of UPF for all four interventions studied here combined, and more broadly for a package of highly cost-effective child health interventions.

Limitations of the Analysis

Our analysis has several limitations. First, consistent with much of the cost-effectiveness literature, our disease models are static rather than dynamic. Dynamic models can more accurately capture synergies but require greater reliance on additional data and assumptions about disease behavior that may not be readily available. The inclusion of secondary cases prevented would lead to increased deaths averted and FRP benefits. Longer-term benefits of vaccination at ages older than five years were not addressed, however, because the burden of disease is largely concentrated among children under age five years.

Second, a more comprehensive accounting of household medical payments could be included, and other costs associated with the short-term treatment and long-term impacts of disease could be considered. In particular, direct nonmedical costs, such as for transportation and housing, and indirect costs due to disease or condition, including loss of earnings and impact on labor productivity, can be substantial, although empirical data are sparse. The focus on child health interventions in this study magnifies the productivity impacts associated with disease, given the inevitability of lost work time for caregivers and the higher number of years of lost productivity associated with childhood disability or death. For example, an economic analysis of the benefits of an array of vaccines estimated caretaker productivity to be roughly 20 percent of averted treatment costs for both pneumonia and rotavirus (Stack and others 2011). Averted productivity losses due to death from rotavirus and pneumonia were, respectively, approximately 15 and 18 times greater than treatment costs (Stack and others 2011). An economic analysis of rotavirus vaccine in Brazil includes costs associated with transportation and missed work in the total cost of treating gastroenteritis, finding that these costs constituted approximately 20 percent of the total cost per inpatient and almost 75 percent of the total cost per outpatient (Constenla and others 2008). Given the magnitude of costs involved in treatment beyond those strictly due to medical care, inclusion of nonmedical and indirect costs would increase the FRP benefits reported here and would also bolster the argument for prevention over treatment.

Third, data on the existing mix of public and private provision and purchase of health care are limited. Fourth, we did not pursue an uncertainty analysis because the purpose of this chapter is to expose broad implications for policy makers with simplicity and not to provide definitive estimates. Nevertheless, many sources of uncertainty underlie this analysis, including the imputed mortality rates derived from estimation, the efficacy of rotavirus and pneumococcal vaccines, and more generally the leap from efficacy to effectiveness for the treatment and prevention interventions studied here. The pricing of vaccines can also affect the findings (tables 19.5 and 19.6), a difference that can be even more pronounced when vaccines are considered standalone interventions. In addition, our modeling choices embody inherent uncertainty. For example, we assumed a uniform increase of 20 percentage points across all income quintiles to facilitate the interpretation of the results, although richer quintiles currently have higher treatment coverage than do poorer quintiles (tables 19.3 and 19.4). Finally, we chose to represent FRP according to the money-metric value of insurance provided. Alternatives include number of cases of poverty averted and avoided cases of forced borrowing and forced sales (Kruk, Goldmann, and Galea 2009).

Table 19.5 Deaths Averted and Financial Risk Protection Afforded by Combined Pneumonia Treatment and Pneumococcal Conjugate Vaccines, under Different Gavi Subsidies for Vaccines

	Income quintile				
	I (poorest)	II	III	IV	V (richest)
Deaths averted (per US$ 1million spent)					
$0.20 per dose	33	37	31	26	17
$3.50 per dose	31	34	27	23	15
Financial risk protection afforded (2011 US$)					
$0.20 per dose	2,710	1,170	780	640	510
$3.50 per dose	2,490	1,060	700	580	440

Table 19.6 Deaths Averted and Financial Risk Protection Afforded by Combined Diarrhea Treatment and Rotavirus Vaccines, under Different Gavi Subsidies for Vaccines

	Income quintile				
	I (poorest)	II	III	IV	V (richest)
Deaths averted (per US$1 million spent)					
$0.20 per dose	22	15	11	15	5
$2.50 per dose	14	14	10	9	3
Financial risk protection afforded (2011 US$)					
$0.20 per dose	480	190	80	70	30
$2.50 per dose	470	190	80	70	30

CONCLUSIONS

Future research will expand on this analysis by incorporating other essential features that promote realism of the scenario. Financial barriers are not the only barriers preventing individuals from seeking care: lack of information, limited availability of services, and distance to facilities are also important. In countries with weak health infrastructures, such as Ethiopia, health services may not be available even after the removal of some financial barriers. In particular, expanding health services to rural areas may require additional investments, such as strengthening or upgrading health facilities through training and deployment of skilled health workers, providing essential equipment, and improving infrastructure for service delivery. Inability to make these investments will, in turn, limit the expansion of coverage that UPF is able to achieve. To account for this challenge, we chose a specified coverage increment of 20 percentage points for all interventions. In addition, marginal costs of health care provision may increase substantially with increases in coverage, and these marginal costs may vary substantially depending on the population subgroups targeted (Brenzel and Claquin 1994; Brenzel and others 2006). This analysis also points to the substantial data requirements for understanding household health-seeking behaviors, OOP expenditures, and time and wages associated with illness.

The case study presented in this chapter is tailored to specific selected child health interventions. The interventions chosen for an essential child health package will involve other considerations, such as the acceptability of an intervention from a public health or clinical standpoint, and the scope of the chosen intervention. The scale and rate of intervention rollout should be evaluated in the context of a thorough understanding of the strengths and weaknesses of the host health systems.

Our approach permits the incorporation of FRP in the economic evaluation of health policies. This methodology enables packages of benefits to be selected based on the quantitative inclusion of information on how much FRP can be bought, in addition to how much health can be bought, per dollar expenditure on health care. Some interventions and packages will rank higher on one or both metrics relative to others. Although this methodology does not provide advice on what is to be selectively prioritized and included in a benefits package, it allows policy makers to take both health and FRP into account when making decisions and thereby to more effectively target scarce resources to specific policy objectives.

This analysis also provides policy makers with information on how they might sequence the development of health care packages as the health and financial needs of populations evolve and resource envelopes change. Here, we show that the interventions studied would largely benefit the poorest populations, which can help to both progressively and efficiently prioritize limited resources. In addition, we point to substantial FRP benefits, which can help demonstrate how worthwhile investments in health can be in comparison with investments in other sectors such as education or transport, which is critical from the viewpoints of ministries of finance and development. This is why, while most of the health economics literature has focused on determining the efficient purchase of health benefits, with ECEA we intend to directly estimate the efficient purchase of nonhealth benefits, starting with distributional consequences such as equity and FRP.

ANNEX

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

- Annex 19A. Health Gains and Financial Risk Protection Afforded by Treatment and Prevention of Diarrhea and Pneumonia in Ethiopia: An Extended Cost-Effectiveness Analysis.

NOTE

Portions of this chapter were previously published:

- K. A. Johansson, S. T. Memirie, C. Pecenka, D. T. Jamison, and S. Verguet. 2015. "Health Gains and Financial Protection from Pneumococcal Vaccination and Pneumonia Treatment in Ethiopia: Results from an Extended Cost-Effectiveness Analysis." *PLoSOne* 10 (12): e0142691. doi:10.1371/journal.pone.0142691. © COPYRIGHT OWNER Johansson and others. Licensed under Creative Commons Attribution (CC BY 4.0) available at: https://creativecommons.org/licenses/by/4.0/.
- C. Pecenka, K. A. Johansson, S. T. Memirie, D. T. Jamison, and S. Verguet. 2015. "Health Gains and Financial Risk Protection: An Extended Cost-Effectiveness Analysis of Treatment and Prevention of Diarrhoea in Ethiopia." *BMJ Open* 5:e006402. doi:10.1136/bmjopen-2014-006402. © COPYRIGHT OWNER Pecenka and others. Licensed under Creative Commons Attribution (CC BY 4.0) available at: https://creativecommons.org/licenses/by/4.0/.

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.

ACKNOWLEDGMENTS

We thank the Bill & Melinda Gates Foundation for funding through the Disease Control Priorities Network grant to the University of Washington, Seattle. Kjell Arne Johansson and Solomon Tessema Memirie were funded through the project Priorities 2020 by a grant from NORAD/The Norwegian Research Council. An earlier version of this paper was presented at a meeting of the authors of this volume, in Ferney-Voltaire, France, in November 2013. We received valuable comments from participants, including Robert E. Black, Zulfiqar Bhutta, Jerry Keusch, and Carol Levin, as well as from Elizabeth Brouwer and Zachary Olson.

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