ECONOMIC COSTS OF ROTAVIRUS DISEASE AND THE VALUE OF VACCINES

COSTS TO GOVERNMENTS AND HEALTH SYSTEMS

The cost of treating rotavirus illness can be substantial to governments and health care systems in countries at all levels of development. India spent an estimated $171 million treating rotavirus from birth to age 5 in a cohort of infants born in 2011, or $6.30 for every child born that year.[1] Rotavirus treatment cost the healthcare system of Malaysia an estimated $33.5 million in 2013—or $19 for every child under the age of 5 in the country, while Kenya's health care providers spent nearly $11 million in 2007, or $8.14 for every child under 5.[2]

As expected, the cost of treating a child hospitalized with rotavirus increases with a country's wealth. The average cost to the health care system per hospitalized child in Kenya was estimated to be US$104 (in 2007), compared to more than $2,000 in the high-income countries of Germany (in 2012) and Sweden (in 2015) (Figure 1).[3,4,5] However, in some countries, the costs of hospitalization are disproportionately higher relative to national wealth. While Poland's gross national income (GNI) is less than one-third of the U.K.'s GNI, its health system costs per hospitalized case of rotavirus is greater than that in the U.K. ($971 vs. $771).[6,7]

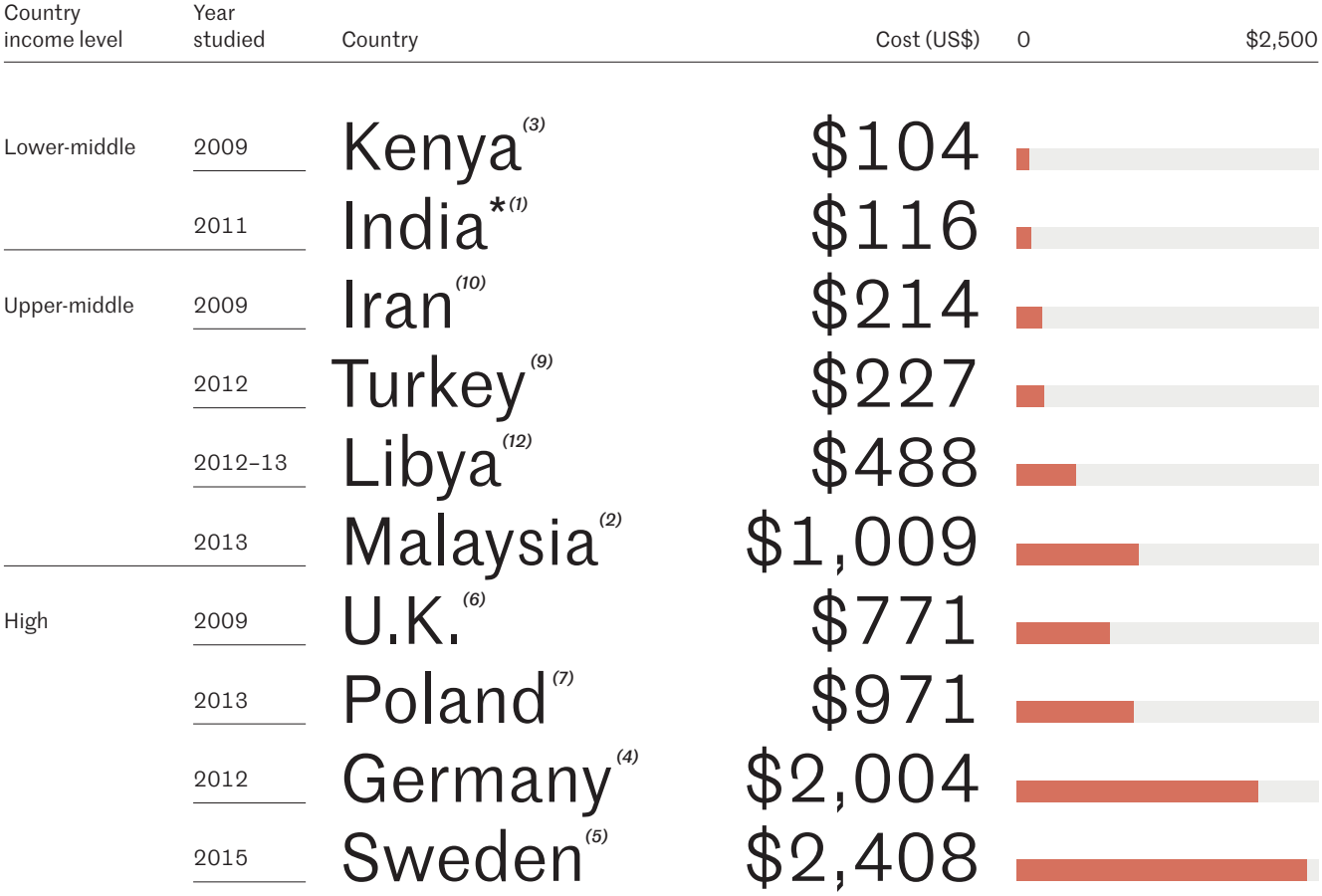
ASHA worker, Jonabi Handique, exits Bokel T.E. Hospital in Dibrugarh, India carrying an ice lined carrier containing vaccines.

TABLE 1 ESTIMATED MEDICAL COSTS OF TREATING ROTAVIRUS TO HEALTH CARE SYSTEMS, FOR EACH BIRTH COHORT (TO AGE 5 YEARS)

Country income level	Year studied	Country	Size of birth cohort	Total costs (US$, millions)	Costs per child in cohort (or as noted)(US$)
Lower-middle	2007	Kenya[3]	1,200,000	$10.8	*$8.14
	2011	Indonesia[8]	4,200,000	$9.7	$2.31
Upper-middle	2012	Turkey[9]	1,250,000	$17.9	$14.33
	2013	Malaysia[2]	508,000	$33.5	*$12.89
	2009	Iran[10]	1,230,000	$11.9	$9.67
High	2009	United Kingdom[6]	775,000	†$16.6–18	*$21.94
	2012	Saudi Arabia[11]	562,400	$26.6	$47.33

* Per child under 5.
† In two out of three scenarios that vary hospitalization rates.

FIG.1 AVERAGE COST OF HOSPITALIZATION DUE TO ROTAVIRUS GASTROENTERITIS



*For secondary hospital care only.

COSTS OF ROTAVIRUS ILLNESS TO FAMILIES

In many countries, a case of rotavirus, especially one requiring hospitalization, can have a major and even devastating financial impact on families. These costs include direct out-of-pocket (OOP) payments for medical care, transportation, lodging and other expenses, as well as losses in income due to caregivers having to miss work to care for the child.

Out-of-pocket expenditures

OOP payments can especially be high in urban areas, where many severe cases of rotavirus—including among the poor—are treated in expensive public teaching hospitals serving as referral centers and in private facilities. The average OOP expenses borne by families of patients treated at three urban public hospitals in Libya represented about 25% of a typical family's monthly income when medical as well as other costs such as transportation were included.[12]

While direct household expenditures for hospitalized care of rotavirus in studies in Africa tended to be considerably lower, one study showed that Kenyan families similarly paid nearly one-quarter of their household monthly income in OOP costs.[3]

Despite the potentially devastating financial impact on families, few studies have directly quantified the impact on households in terms of catastrophic health expenditures and medical impoverishment. However, studies from Malaysia—where many people, including the poor, seek health care for diarrhea in the private sector—demonstrate the impact that medical expenses for rotavirus can have on lower income households. For families of patients treated for acute gastroenteritis, including rotavirus, at a large public-sector teaching hospital in Kuala Lumpur, the average OOP costs ($101) in the poorest income group represented 23% of the total monthly household income, while the average OOP costs for the wealthiest group ($120) represented only 6% of their average monthly income.[13] These OOP payments were considered catastrophic (exceeding 10% of the monthly household income) for 86% percent of those in the lowest-income quintile, 48% of those in the second-lowest quintile, and one-third of all households in the study. The poorest households, in fact, paid in absolute dollar amounts more than any other income groups, on average, except the wealthiest.

A study in Malaysia shows that OOP payments for a rotavirus episode (mainly for hospital care) were considered catastrophic to 16% of families in the lowest income group (quintile) and 18% of families in the second poorest income group.[14] Seven percent of families in the poorest quintile became impoverished as a result of rotavirus-related expenses.

The indirect costs of lost wages

Wages lost due to one or both parents or other caregivers having to miss work due to a child's rotavirus illness—known as "indirect costs"—compound the economic burden for many families. The mean number of working days lost due to rotavirus in a child (hospitalized and outpatient cases combined) was more than nine days in Vietnam, while it ranged from 2.3 to 6.4 days in seven West European countries.[15] In the Malaysian hospital study in Kuala Lumpur, lost wages accounted for nearly half ($107) of the average total costs ($222) incurred by households for a rotavirus hospitalization.[13]

Jacqueline Wambui with her two daughters outside their home in Kangemi, Nairobi,on Sunday, June 26, 2016.

FIG.2 AVERAGE COSTS OF ROTAVIRUS HOSPITALIZATION TO FAMILIES AS A PERCENTAGE OF NATIONAL MONTHLY HOUSEHOLD INCOME*

Direct medical | Direct non-medical | Indirect (lost wages)

Country	Treatment hospital Total cost (US$)	% of income
Malaysia[13]	Urban teaching hospital $222.00	18%
Uganda[17]	Public, NGO & private hospitals $15.60	10%
Libya[12]	3 urban public hospitals $191.00	32%
Kenya[3]	Rural hospitals (median) $19.86	24%

*Mean costs unless otherwise indicated.

In Libya, lost income represented 7% of monthly income, increasing the total (direct and indirect) household costs of a rotavirus hospitalization to 32% of monthly income.[12]

In countries where government-funded health insurance pays for the majority of medical care costs, the bulk of household costs from a rotavirus episode are due to lost wages, which can still be significant. In Rwanda, where health insurance covered around 80% of direct medical costs for childhood diarrhea cases requiring hospitalization in one study, households still had to pay 65% of the total average cost of illness ($66 out of $101)—with lost wages making up almost two-thirds of these household costs.[18] In a Swedish study, lost wages of caretakers resulting from a child hospitalized with rotavirus averaged €1,621 (≈$1,800), making up 42% of the total costs to society of a hospitalized case and 94% of the costs borne by households.[5]

In addition, rotavirus cases treated at home and their associated costs are often not included in studies, constituting a "hidden burden" of the disease. A study in Malaysia estimated that home-treated cases cost Malaysian families more than $10 million in 2013 or 21% of total societal costs of the disease—nearly all of it due to lost wages.[2]

Ann Wambugo, with 8-month-old Shalom, farms tobacco in Kenya.

THE INCREASED BURDEN ON FAMILIES DUE TO SECONDARY ROTAVIRUS CASES

An additional burden that rotavirus can have on families is the transmission of the infection to other household members, leading to additional lost wages and treatment costs. These secondary cases are usually missing from economic studies of rotavirus and, if included, would increase the estimated value of vaccination.

Sweden

A Swedish study of children hospitalized with rotavirus found that in 31% of families, a caregiver also became ill with gastroenteritis—losing almost four days of work due to her or his own illness, and increasing the average number of working days lost in the entire study population from 4.2 days to 5.4 days.[5]

U.K. & Canada

In rotavirus studies in both the U.K and in Canada, around half of all families reported at least one other household member becoming ill with gastroenteritis near the time of the first identified case.[19,20] The risk of developing a secondary case in the Canadian study was highest (44%) among children under 2 years of age.[20]

A child and mother at a community center.

ROTAVIRUS VACCINE AFFORDABILITY

Country-level decision makers must decide whether or not rotavirus vaccines are affordable for their governments. Affordability can especially be a concern for countries not eligible for support from Gavi, the Vaccine Alliance, as well as in countries transitioning from Gavi support, since they must increase their costs for the vaccine significantly within a relatively short period of time. Current prices of rotavirus vaccines in several countries and regions are shown in Table 2.

Cost-effectiveness analyses (discussed in the next section) can also be used to estimate the break-even price of the vaccine. This is the price at which the savings in treatment costs are equal to the cost of the vaccination program, and below which vaccination becomes cost-saving (see Table 3 for estimated break-even prices in several countries). These estimates can be useful to countries when negotiating vaccine prices with manufacturers.

The addition of new, lower-cost vaccines from India to the global market may improve both the cost-effectiveness and affordability of rotavirus vaccination, especially in low- and middle-income countries.

TABLE 2 CURRENT PRICES OF ROTAVIRUS VACCINES

Country/region	Vaccine	Price per course (US$)
Full GAVI prices[21]	RotaTeq	$9.60
	ROTARIX	$4.58
	ROTAVAC	$2.55
	ROTASIIL	$2.85–4.65
Lower-middle-income countries in Eastern Mediterranean Region*[22]	RotaTeq	$10.71
PAHO[23]	ROTARIX	$13.00
Upper-middle-income countries in Western Pacific Region*[22]	ROTARIX	$14.70
Australia[24]	ROTARIX/RotaTeq	(estimated)[x] $94.53
U.S.[25]	ROTARIX/RotaTeq	(CDC price) $189.38–211.47 (private market) $241.90–248.67

*V3P database does not identify countries

TABLE 3 ESTIMATED BREAK-EVEN PRICES FOR ROTAVIRUS VACCINES

Country	Perspective	Break-even price per vaccine course (US$)
Kenya[3]	Health care system	$2.07
Bolivia[26]	Government	$7.62
New Zealand[27]	Government	$36.00
Saudi Arabia[11]	Societal	$47.50
Germany[4]	National health insurance	$67.00–71.61

THE VALUE OF THE ROTAVIRUS VACCINE

Many countries have conducted studies to estimate the impact and cost-effectiveness of rotavirus vaccine before making decisions about introducing it into their national immunization programs.

These studies—which normally look at impact for one or more birth cohorts until they reach the age of 5 years—predict that across different epidemiological, geographic, and economic settings, rotavirus vaccination would prevent tens of thousands of cases for each birth cohort (Table 4). The studies also estimate thousands of deaths per birth cohort prevented in high-mortality countries, such as Pakistan and Uganda, while treatment cost savings would run into the tens of millions of dollars in higher-income countries, much of it due to fewer hospitalizations. These are the savings in treatment costs before the cost of the vaccination program is considered.

To measure the cost-effectiveness of vaccines, these studies also estimate the difference in the costs with and without rotavirus vaccination (the costs of the vaccine program minus the cost savings from fewer cases to treat) and divide these "incremental costs" by health outcome measures, such as deaths, cases or disability-adjusted life-years (DALYs). DALYs quantify the healthy years lost because of premature death due to the disease and the time lost due to illness or disability. The lower the cost per DALY averted, the more cost-effective a vaccine is. If countries do not have their own benchmark to determine whether an intervention is cost-effective in their particular context, they often define an intervention as cost-effective if its cost per DALY averted is less than the country's gross domestic product (GDP) per capita.

Most economic studies of rotavirus vaccines conducted in countries throughout the world and at different levels of development have found rotavirus vaccination to be cost-effective. This is true even under the assumption that Gavi-supported countries pay the full Gavi price for the vaccine (with no subsidies) and wealthier countries pay prevailing market prices. The cost-effectiveness ratios of rotavirus vaccination in low-income, high-mortality countries, such as Afghanistan and Pakistan, are a small fraction (1/7 or 1/8) of their GDP per capita—making the vaccines highly cost-effective.[28,29] This is despite the lower efficacy of the vaccines in these settings. In low-mortality, higher-income countries, such as Turkey and Argentina, the costs per DALY are still well under half of the GDP per capita. Visit rotacouncil.org to learn about rotavirus vaccine cost-effectiveness in a range of countries.[9,30]

Gunjan Baruah, with her parents, after getting her vaccination against rotavirus at Assam Medical College in Dibrugarh, India.

TABLE 4 ECONOMIC IMPACT OF ROTAVIRUS VACCINATION FROM THE GOVERNMENT PERSPECTIVE FOR BIRTH COHORT UNTIL AGE 5

Country income level	Country	Size of birth cohort	Cases prevented	Hospitalizations prevented	Deaths prevented	Total treatment costs averted
Low-income	Afghanistan*[28]	1,500,000	120,000	4,900	1,197	$135,000
	Malawi**[31]	650,000	51,300	7,800	431	$400,000
	Uganda**[17]	1,500,000	146,200	12,145	2,666	$298,000
Lower-middle-income	Indonesia[8]	4,200,000	451,789	117,110	5,450	$5,100,000
	Bangladesh*[32]	3,000,000	390,000	45,000	390	$700,000
	Pakistan[29]	4,800,000	1,200,000	43,000	6,700	$1,600,000
	Ghana**[33]	870,000	111,707	8,000	447	$317,000
Upper-middle-income	Turkey[9]	1,250,000	No data	43,000	Not analyzed	$15,200,000/yr
	Iran*[34]	1,300,000	3,500,000	114,000	27	$28,000,000
High-income	Germany[4]	650,000	206,000 –242,000	18,000	Not analyzed	$42,000,000

*Average of results for 10 birth cohorts
**Average of results for 20 birth cohorts

Assumed vaccine efficacy against severe or hospitalized rotavirus:
- 48% (first year) in Bangladesh and Pakistan;
- 53% (against rotavirus infections) in Afghanistan;
- 64–67% in Malawi, Ghana and Uganda (wanes over time);
- 84% in Indonesia;
- 84–90% in Turkey; and
- 96–98% in Germany (wanes over time).

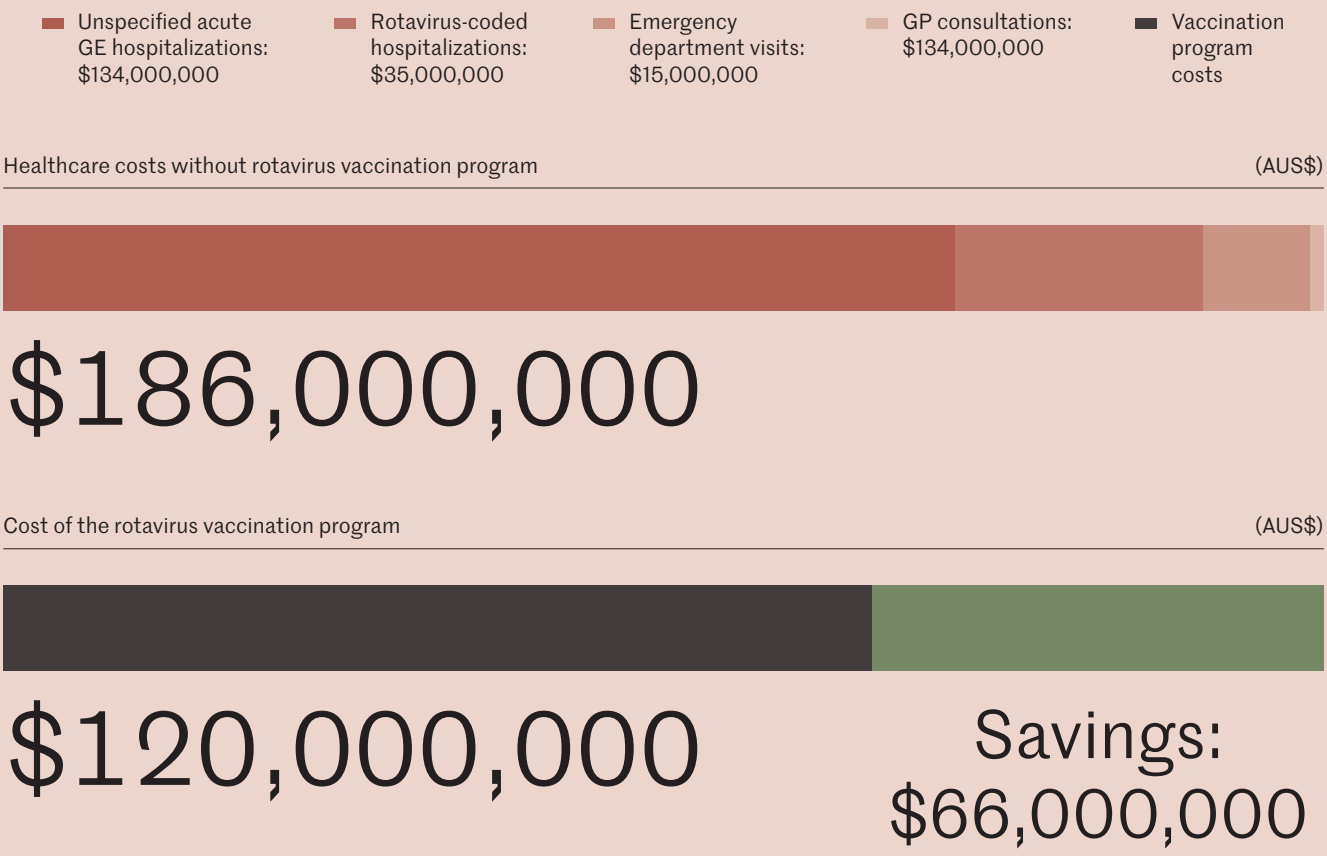
Estimated coverage rates:
- 77% in Afghanistan;
- 94–95% in Indonesia and Bangladesh; and
- 80–89% in all other countries.

Outcomes and costs were discounted each year in all studies.

BEYOND EXPECTATIONS: ACTUAL ECONOMIC IMPACT OF ROTAVIRUS VACCINATION IN EARLY-INTRODUCING COUNTRIES

While most of the studies of the value of rotavirus vaccination are based on estimates—of reductions in disease incidence, savings in treatment costs and vaccination program costs—data on the real-life consequences of rotavirus vaccination programs from high-income countries are now coming in. In some cases, they show that the impact is greater than expected.

FIG.3 COST SAVINGS OVER SIX YEARS FOLLOWING INTRODUCTION OF ROTAVIRUS VACCINATION IN AUSTRALIA[24]



Australia

A 2007 study using national data on gastroenteritis cases presenting at hospitals, emergency departments and general practitioners' offices pre- and post-introduction of rotavirus vaccines finds the program to be cost-saving overall, which cost-effectiveness analyses did not predict.[24] Over six years (2007–12), the health care system prevented nearly A$186 million in treatment costs and paid A$120 million to provide the vaccine—for a cost savings of ≈A$66 million, or A$10.8 million per year (US$10.3 million). The unexpected cost savings were due in part to the indirect effects of vaccination—a reduction in rotavirus in older children, often diagnosed as unspecified gastroenteritis.

England

During the first year after rotavirus vaccine was introduced (in 2013), an estimated 87,000 rotavirus cases among children under age 5 were averted, including nearly 13,000 hospitalizations.[35] The estimated savings in treatment costs among children under 5 alone were £12.5 million (US$21.4 million)—68% of which were savings in hospitalization costs.

Finland

Five years after rotavirus vaccination was introduced (in 2009) and coverage of 91–93% was achieved, the annual incidence of rotavirus-confirmed hospitalizations in children under 5 declined 92% from pre-vaccination years and unspecified viral gastroenteritis hospitalizations fell 84%.[36] With an average cost of nearly €2,000 per hospitalization and €350 per outpatient hospital visit, the health care system saved, on average, an estimated €4.5 million (US$6.2 million) each year just from reductions in hospital-treated (inpatient and outpatient) cases. On the other hand, the rotavirus vaccination program cost €2.3 million per year (€38 per child). Thus, the program pays for itself at least two times over each year in hospital-based costs alone—the equivalent of €33 (US$45) per child in savings.

This compares to an earlier study before the vaccine was introduced that predicted no cost savings unless the cost of vaccination was less than $19.60 per child.[37]

HOW TO IMPROVE THE IMPACT AND COST-EFFECTIVENESS OF ROTAVIRUS VACCINATION

A global analysis found that improving the timeliness and coverage of rotavirus vaccination can substantially increase its impact and cost-effectiveness.[38]

The study estimated that if both doses of ROTARIX were always delivered on time (by ages 2 and 4 months, respectively), one-third more deaths would be prevented in low-income countries in Africa—achieving a 47% reduction compared to a 35% reduction with the current on-time performance of vaccination. The cost per DALY averted would decline 23% (from $61 to $47). Improving vaccination coverage to 90%, as well as the timing of vaccination, would increase the impact of vaccination on rotavirus-related deaths in low-income countries by nearly two-thirds (from the estimated 41% reduction with the current timing and coverage to 67%).

Adria Muste, 25, holds her baby and an infant immunization card in Ethiopia

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KEY FACTS

Costs

Health care systems and governments across the globe incur substantial costs from rotavirus illness each year. (See page 1)

Burden

Low income families, particularly in urban areas, often experience catastrophic expenditures due to a rotavirus hospitalization in low-income countries, and lost wages from a caregiver missing work further increases the economic burden of the illness across income levels. (See page 3)

Value

The vast majority of cost-effectiveness analyses conducted in countries across the world have found rotavirus vaccination to be a good value. The expanding number of vaccine products may help improve the affordability of rotavirus vaccines for low- and middle-income countries. (See page 7)

Benefits

Several studies in high-income countries following rotavirus vaccine introduction have found a greater than expected economic benefit from the vaccine—leading in some cases to cost savings after taking the vaccination program costs into account. (See page 8)

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