# Immunization Delivery Costs in Low- and Middle-Income Countries

## A descriptive analysis, gap analysis, and summary of immunization delivery unit costs in the literature

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# ABBREVIATIONS

| | |
|---|---|
| **AEFI** | Adverse event following immunization |
| **BCG** | Bacille Calmette-Guerin vaccine |
| **DT** | Diphtheria and tetanus toxoids, pediatric formulation |
| **DTaP** | Diphtheria and tetanus toxoids and acellular pertussis vaccine, pediatric formulation |
| **DTP** | Diphtheria and tetanus toxoids and whole-cell pertussis vaccine, pediatric formulation |
| **FIC** | Fully immunized child or full immunization of a vaccine (depending on context) |
| **HepB** | Hepatitis B vaccine |
| **Hib** | Haemophilus influenzae type b |
| **HPV** | Human papillomavirus |
| **ICAN** | Immunization Costing Action Network |
| **IDC** | Immunization delivery cost |
| **IDCC** | Immunization Delivery Cost Catalogue |
| **IPV** | Inactivated poliovirus vaccine |
| **JE** | Japanese encephalitis |
| **LMIC** | Low- and middle-income country |
| **MMR** | Measles-Mumps-Rubella |
| **MR** | Measles-Rubella vaccine |
| **NUVI** | New and underutilized vaccine introduction |
| **OCV** | Oral cholera vaccine |
| **OPV** | Oral poliovirus vaccine |
| **PCV** | Pneumococcal conjugate vaccine |
| **SIA** | Supplementary immunization activity |
| **Td** | Tetanus and diphtheria vaccine, adult/adolescent formulation |
| **TT** | Tetanus toxoid |
| **USD** | U.S. dollar ($) |
| **YF** | Yellow fever |

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This systematic review was conducted by ThinkWell and supported by the Bill & Melinda Gates Foundation.

## WHAT IS THE PURPOSE OF THIS REPORT?

This report is intended to summarize the evidence on immunization delivery costs and to dig deeper into the variation in, and drivers of, costs across country contexts and immunization delivery strategies. The intended audience is national and sub-national planners and policymakers, researchers, and international partners supporting country immunization and health system policy.

## WHAT IS THE IMMUNIZATION DELIVERY COST CATALOGUE (IDCC)?

The Immunization Delivery Cost Catalogue (IDCC) comprises the tools (Microsoft Excel workbook and web tool) created from the systematic review. The IDCC houses the most comprehensive, current, and standardized global evidence on the cost of delivering vaccines in low- and middle-income countries.

Access the online IDCC at **immunizationeconomics.org/ican-idcc.**

### Research Question

The systematic review aimed to answer the question: What are the unit costs of vaccine delivery across different low- and middle-income countries (LMICs) and through a variety of delivery strategies?

**Helping you answer questions like:**

What is the cost per girl for HPV vaccination in schools?

OR

What is the cost per dose to deliver vaccines in health facilities in Sub-Saharan Africa?

**Who is it for?**

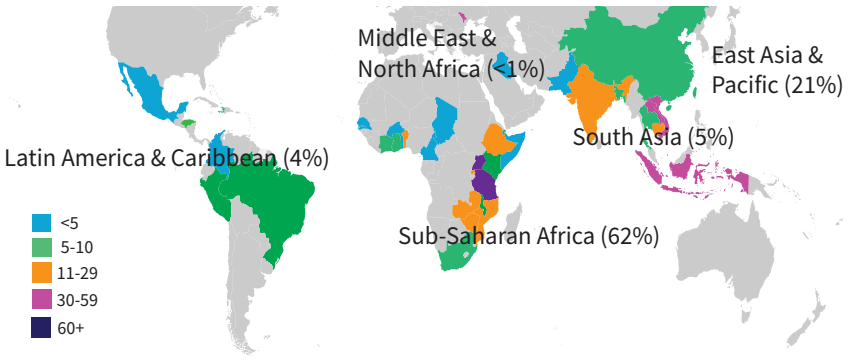
National and sub-national planners and policymakers, researchers, and international partners supporting country immunization and health system policy. Data may be useful for budgeting, planning, policymaking, research, advocacy, and beyond.

**How to access it?**

The catalogue is available online or in an Excel workbook. Other materials also available on website: summary report, methodology note, user guides, how-to videos.

## GEOGRAPHIC SPREAD

(# and % of unit costs)

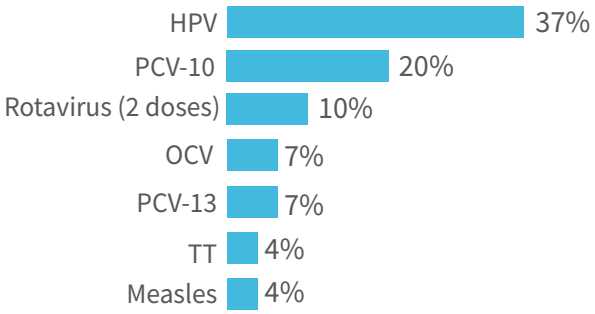



**68**
DATA SOURCES

**666**
IMMUNIZATION DELIVERY UNIT COSTS

## INCLUDED VACCINES

(% of single vaccine unit costs)

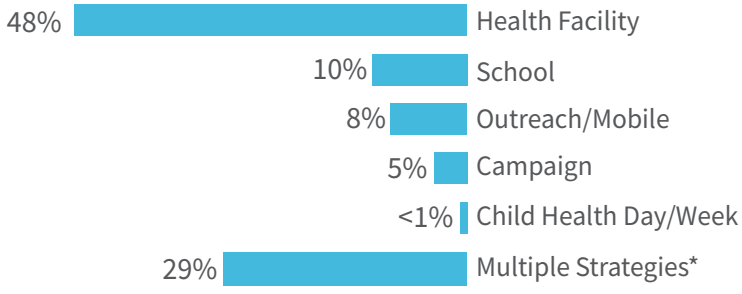



Each of the following single vaccines represent 2% or fewer unit costs: PCV-7; Rotavirus (3 doses); Meningococcal; HepB; OPV; BCG; DTP; DTP-HepB-Hib; DTwP-HepB; JE; Td; and Yellow Fever.

**61%** of the unit costs are for single vaccines. Of the single vaccines, most unit cost estimates are for **HPV** and **PCV-10**.

## DELIVERY STRATEGIES

(% of unit costs)




*Refers to a combination of two or more delivery strategies.

**Almost half** of unit costs are for vaccines delivered at a health facility.


# I. INTRODUCTION

The Immunization Costing Action Network (ICAN), led by ThinkWell and John Snow, Inc. (JSI), is a research and learning community supported by the Bill & Melinda Gates Foundation (BMGF) with the aim of increasing the visibility, availability, understanding, and use of evidence on the cost of delivering vaccines.

Under the ICAN, ThinkWell conducted a systematic review to compile and analyze the evidence base on immunization delivery costs (IDCs) in low- and middle-income countries (LMICs). The Immunization Delivery Cost Catalogue (IDCC), available as an interactive Microsoft Excel workbook and searchable web tool, allows for comparability across numerous articles/reports (resources) and the variety of settings captured by the systematic review, with cost data presented in 2016 U.S. dollars.

This report briefly describes the systematic review and then presents a descriptive and gap analysis of findings on immunization delivery costs (IDCs). Additional tools and products, including a detailed methodology note and user guides, are accessible at **http://immunizationeconomics.org/ican.** These resources are intended to help with interpretation of the systematic review and to dig deeper into the variation in and drivers of IDCs across country contexts and delivery strategies.

Beyond the global level analytics, ICAN conducted research studies on IDCs in India, Indonesia, Tanzania, and Vietnam, as well as facilitated cross-country learning on the common problems of costing immunization delivery and using evidence to inform advocacy efforts, routine planning and budgeting, and policy and program decision making. ICAN is also developing a methodological guide and costing tool to support the costing of vaccination campaigns.

## THE NEED FOR ACCESSIBLE IMMUNIZATION DELIVERY COST EVIDENCE

As LMICs drive toward achieving high and equitable coverage of life-saving vaccines and largely transition from donor- to self-funded immunization programs, the availability of sustainable, equitable, and predictable financing for vaccine delivery is essential. Over the last two decades, great strides have been made in expanding the coverage of routine and new vaccines, in part through better understanding of the cost of vaccination delivery. However, gaps in cost evidence remain.

Realistic and reliable IDC evidence that is available at the right time and in the right format would help countries better advocate, plan, budget, and make programmatic decisions. Translation of cost evidence into policy, programming, and financing at national and sub-national levels is challenging. Cost data are fragmented and of variable quality, and can be difficult for policymakers, program planners, and other global and country-level stakeholders to understand and use. In an era of transitioning donor aid, the use of cost evidence in these processes, rather than historical funding levels or cost norms, is essential to ensuring that immunization programs mobilize adequate resources to meet coverage goals, address challenges of health equity, effectively manage the introduction of new vaccines, and achieve efficiencies through health system integration.

## ICAN DEFINITION OF IMMUNIZATION DELIVERY COSTS

The costs associated with delivering immunizations to target populations, exclusive of vaccine costs. *Delivery costs may include any or all of the following cost categories:**

- Paid human resources
- Volunteer human resources
- Per diem and travel allowances
- Cold chain equipment and their over-heads (e.g. energy, maintenance, repairs)
- Vehicles, transport, and fuel
- Program management
- Training and capacity building
- Social mobilization and advocacy
- Adverse event following immunization (AEFI) and disease surveillance
- Buildings, utilities, other overhead, and shared costs
- Vaccine supplies (e.g. safety boxes, diluents, reconstitution syringes)
- Waste management
- Other supplies and recurrent costs
- Other non-vaccine costs

*Cost categories used in this review were developed based on a review of Brenzel 2014, University of Washington 2016, and WHO 2006.

Additionally, as new delivery strategies – such as campaigns or school-based delivery – are explored to help countries meet these goals and the introduction of new vaccines, the need for cost evidence to develop and support these programmatic and budget requests is key. However, it can be time consuming and expensive to conduct country-specific costing studies. It also can be difficult to access and interpret cost evidence from other countries and to translate these data so they are relevant for other settings. To address these challenges, ThinkWell embarked on a systematic review to make the available evidence globally accessible and easy to interpret. The systematic review aimed to answer a question frequently asked by global and country immunization stakeholders: What are the unit costs of vaccine delivery across different LMICs and through a variety of delivery strategies? The initial systematic review, or Phase I, was completed in early 2018. The review was refreshed in 2018 (Phase II) and 2019 (Phase III) to capture new content which is reflected in this report.

## PURPOSE OF THIS DOCUMENT

Past systematic reviews on this topic have consolidated only part of the costing evidence picture. They have focused on either (1) a subset of vaccines, (2) a subset of economic evaluations (e.g., only cost-effectiveness or cost-benefit studies), or (3) only the incremental costs of new vaccine introduction (NUVI). Given the latest published reviews and the large number of resources recently published on the topic of vaccine delivery costs, there was an expressed need to bring the evidence base up to date (De la Hoz-Restrepo et al. 2013; Levin et al. 2015; Mogasale et al. 2016; Ozawa et al. 2012). Our systematic review builds upon previous efforts, updating the evidence base while including IDC data that are not restricted to a particular vaccine, delivery strategy, type of cost analysis, or setting.

The review primarily targets country decision-makers: Expanded Programme on Immunization (EPI) managers, members of the National Immunization Technology Advisory Group (NITAG), and other country policymakers responsible for financing and planning at the national and the subnational levels. These decision-makers need to know what it costs to deliver a particular vaccine or range of vaccines in a particular context for budgeting the national immunization program or making a programmatic decision. Other target audiences include global and regional stakeholders, such as donors and development banks; other development partners; civil society organizations; and researchers. These groups may be interested in the systematic review and findings as reference data for making financing and resource allocation decisions or managing or supporting development programs, or for academic or applied research pursuits.

This report summarizes findings from the systematic review. First, the report presents a descriptive analysis of the dataset along with identified gaps in the evidence base. Second, the report presents an analysis of immunization delivery unit cost ranges (cost ranges) for vaccine delivery through a variety of strategies and in a variety of contexts.

Note: A full list of technical terms and definitions used in conjunction with the systematic review can be found in Annex 2.


स्वस्थ जीवन जिएं
बेटी बचाओ

## II. SYSTEMATIC REVIEW OVERVIEW

The systematic review methods are based on standard practices and were subject to external review and revision by immunization costing experts at multiple stages throughout the process. The entire process is depicted in Figure 1 and is briefly described in the section that follows. The process is explained in detail in our methodology note (ICAN 2019).

The systematic review includes peer-reviewed articles and grey literature that included primary data collection and estimation of IDCs published between January 2005 and March 2019.[1] The review was limited to LMICs, resulting in 68 articles/reports (resources) that present immunization delivery unit costs (i.e., cost per dose, per capita, per fully immunized child, per full immunization of a vaccine,[2] and

**FIGURE 1. Process for systematic review**


[1]The date range for the systematic review was selected to reflect the most recent data, vaccine delivery technologies, and established costing methods for the sake of greater comparability, and to limit the size of the search. There are some seminal costing studies conducted prior to 2005, but these were excluded to capture resources using the most up-to-date and accepted methods to increase comparability of results (Brenzel, 2013; Castañeda-Orjuela et al. 2013). Many cost-effectiveness studies utilize cost estimates from secondary sources, leading to their exclusion. The methodology note (**immunizationeconomics.org/ican-idcc-methodology**) includes a detailed description of the search inclusion and exclusion criteria.

[2]Full immunization of a vaccine refers to all required doses of a specific vaccine (e.g., two doses of oral cholera vaccine (OCV)). Fully immunized child refers to the provision of required vaccines to a specific group by a clear point in time (e.g., infants who received all doses of a vaccine in the schedule before reaching one year of age). We used the resource authors' definition of fully immunized child that was relevant for their studies, as opposed to a standard global definition, for example, of DTP3.

[3]See the methodology note at **immunizationeconomics.org/ican-idcc-methodology** for a detailed description of the quality assessment.

# Our systematic review of **68** resources resulted in a dataset with **over 600** immunization delivery unit costs.

per person in the target population). Information extracted from the resources includes the reported cost results, along with methodological and contextual information to help with comparison and their interpretation. All cost findings are also converted to a common year (2016) and currency (U.S. dollars [US$]) to ensure comparability across studies and different settings. The quality of each resource is assessed against a parsimonious set of quality criteria[3] that capture methodological rigor and reporting standards, uncertainty of results, and risk of bias and limitations. Annex 1 presents the list of resources that are included in the review and that inform the analyses presented in this report.

## III. DESCRIPTIVE FINDINGS AND GAP ANALYSIS

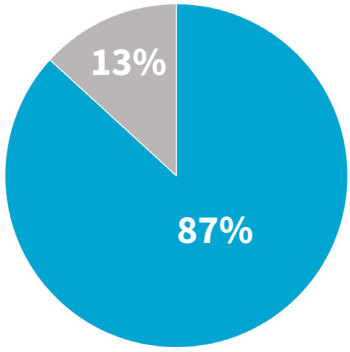
The IDCC dataset presents information extracted from the resources as reported by the authors, along with cost information both as reported by the authors and then converted by us to 2016 US$. The cost data include immunization delivery unit costs (i.e., cost per capita, per dose, per full immunization of a vaccine, per fully immunized child, or per person in the target population). The IDCC dataset includes additional detail to help with interpretation of those costs, including information on study design, vaccines costed, delivery strategy, type of costs, and so on.

The descriptive and gap analysis describes the evidence on immunization delivery unit costs by focusing on three categories:

- Spread/scope of the evidence
- Methods/reporting
- Quality

## SPREAD OF EVIDENCE ON IMMUNIZATION DELIVERY UNIT COST FINDINGS

### SOURCES OF IMMUNIZATION DELIVERY UNIT COST FINDINGS




Of the 68 resources, 59 (87%) are peer-reviewed articles and 9 (13%) are grey literature reports.


The majority of immunization delivery unit costs (559, or 84%) come from resources published from 2014 through 2019.


Over a quarter (188, or 28%) of the unit costs come from the EPI Costing and Financing Project (EPIC), a multi-country immunization costing and financing project supported by the Bill & Melinda Gates Foundation.[4]

### GEOGRAPHIC SCOPE OF IMMUNIZATION DELIVERY UNIT COST FINDINGS

***Country***

The over 600 immunization delivery unit costs include IDC data from a total of 37 LMICs (Figure 2). The largest number of unit costs (21%) come from Tanzania. Seven countries (Tanzania, Uganda, Vietnam, Moldova, Benin, Lao PDR, and Indonesia) contributed nearly two-thirds of the unit costs (65%) in the dataset. For seven countries (Burkina Faso, Chad, Iraq, Mexico, Togo, Pakistan, Senegal), there exist two or fewer unit costs.

***Country region***

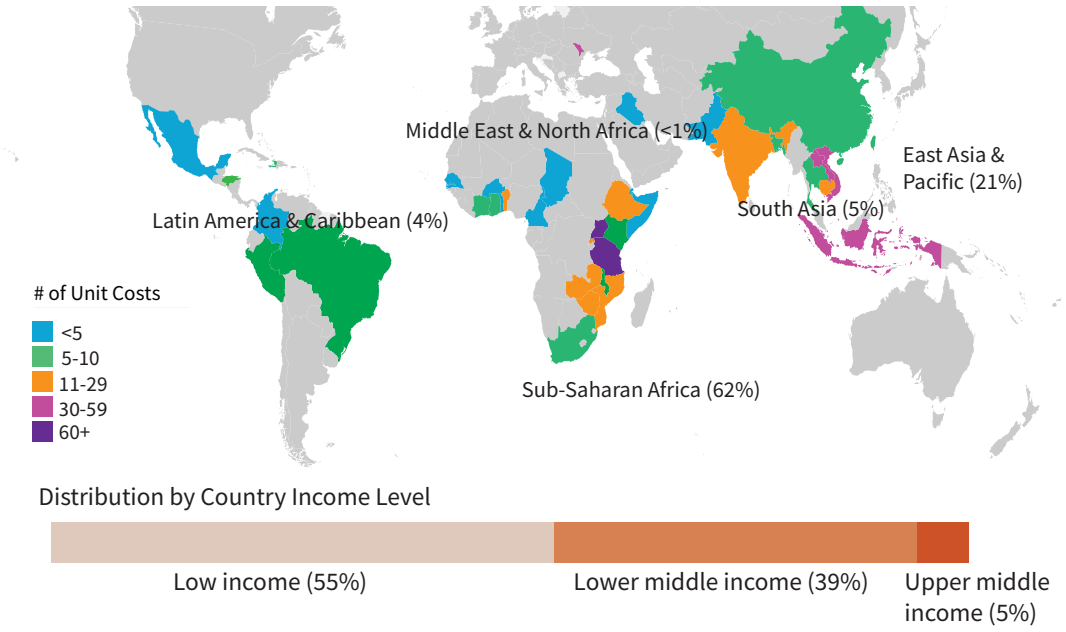
Sub-Saharan Africa accounts for almost two-thirds of all immunization delivery unit cost findings and East Asia and Pacific for one-fifth. There are fewer than 45 unit costs each for all other regions, including Europe and Central Asia (44), South Asia (32), Latin America and the Caribbean (29), and the Middle East and North Africa (2) (Figure 2).

***Country income level***

Over half of the unit costs (55%) are from low-income countries, and one-third (39%) are from lower-middle-income countries. Only 5% of the unit costs are from upper-middle-income countries (Figure 2).

[4] **http://www.immunizationeconomics.org/epic.**

## FIGURE 2. Geographic scope of immunization delivery unit cost findings




| Country | Unit Costs (#) |
|---|---|
| Tanzania | 141 |
| Uganda | 91 |
| Vietnam | 45 |
| Moldova | 44 |
| Benin | 42 |
| Lao PDR | 36 |
| Indonesia | 34 |
| Zambia | 25 |
| Rwanda | 24 |
| Zimbabwe | 22 |
| India | 19 |
| Cambodia | 16 |
| Ethoipia | 14 |
| Mozambique | 11 |
| Ghana | 8 |
| Cote d'Ivoire | 7 |
| Honduras | 7 |
| Bangladesh | 7 |
| South Africa | 6 |

| Country | Unit Costs (#) |
|---|---|
| Haiti | 6 |
| China | 6 |
| Thailand | 6 |
| Brazil | 5 |
| Bhutan | 5 |
| Kenya | 5 |
| Peru | 5 |
| Malawi | 5 |
| Cameroon | 4 |
| Colombia | 4 |
| The Gambia | 4 |
| Burkina Faso | 2 |
| Chad | 2 |
| Iraq | 2 |
| Mexico | 2 |
| Togo | 2 |
| Pakistan | 1 |
| Senegal | 1 |

Note: Country regions and income levels use the World Bank classification. The analysis aims for consistency with the context of each resource included in the review, matching the year for which the costing data were reported with the country's regional and income classification of that same year. If the costing year was not reported, the year of the intervention was used. If that was also not available, the publication year of the resource was used.

**Gap analysis**:

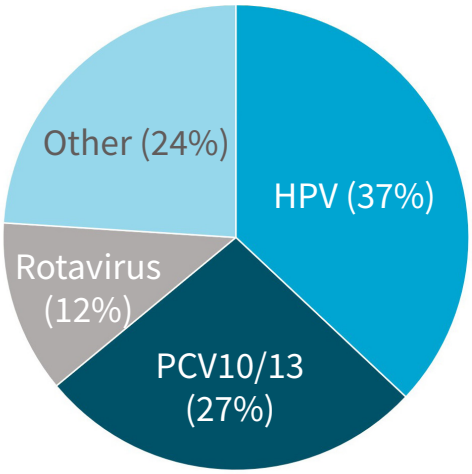
There is no IDC data from the overwhelming majority of LMICs (100 countries, 73%). Evidence is limited from all regions other than Sub-Saharan Africa and East Asia and the Pacific. Considering country income level, the greatest need for cost data is from upper-middle income countries.

## VACCINES COSTED

### *Single Vaccines*

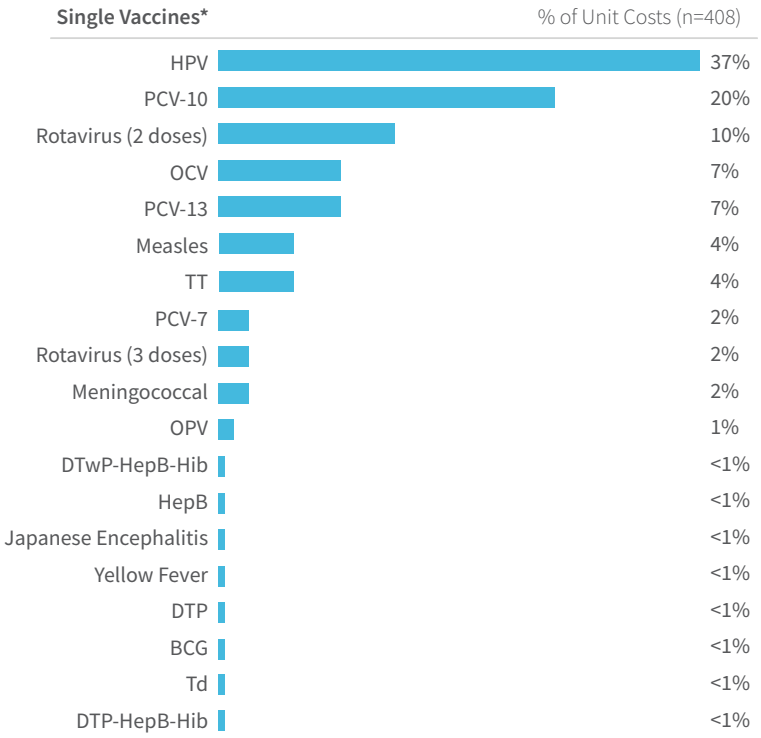

Nearly two-thirds of the immunization delivery unit costs are costs for single vaccines (Figure 3).


Of the costs for single vaccines, 82% are in the context of new vaccine introduction.




Of the single vaccines, most immunization delivery unit costs are for HPV (37%), PCV (27%), and Rotavirus (12%).

**FIGURE 3. Distribution of immunization delivery unit cost findings for single vaccines**




*BCG = Bacillus Calmette-Guérin; DTP = Diphtheria and tetanus toxoids and whole-cell pertussis vaccine, pediatric formulation; HepB = Hepatitis B; Hib = Haemophilus influenzae type b; HPV = Human Papillomavirus; JE = Japanese Encephalitis; OCV = Oral Cholera Vaccine; OPV = Oral Polio Vaccine; PCV = Pneumococcal Conjugate Vaccine (7-, 10-, or 13-valent); TT = Tetanus Toxoid; Td = Tetanus and diphtheria vaccine, adult/adolescent formulation.

Note: Percentages do not sum to 100% due to rounding. There were no resources with immunization delivery unit costs for Inactivated Poliovirus Vaccine (IPV).

### *Multiple vaccines and vaccine schedules*


Just under 40% of the immunization delivery unit costs are associated with delivery of more than one vaccine or a schedule of vaccines (Figure 4).


Of the schedules of more than one vaccine, nearly three-quarters (74%) of the unit costs are from schedules that contain between five and eight contacts with the health system (Figure 5).

Note: The unit costs associated with multiple vaccines or schedules of vaccines represent between two and ten contacts with the health system. Unlike the number of costed antigens, which only describes which antigens are administered, the number of contacts with the health system reflects co-administration, which may result in delivery cost savings. For example, a schedule including BCG, Measles, DTP-HepB-Hib, OPV, and YF includes five antigens and five contacts with the health system (i.e., contacts are approximately birth, 2 months, 4 months, 6 months, and 9 months).

**FIGURE 4. Antigens costed for multiple vaccines and vaccine schedules**

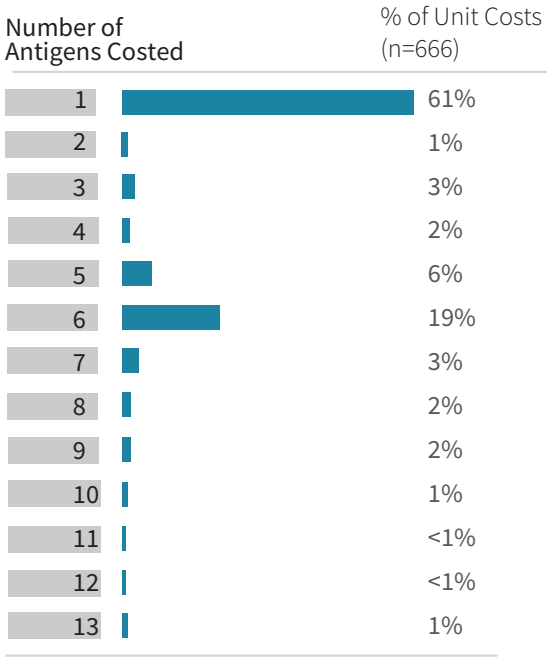
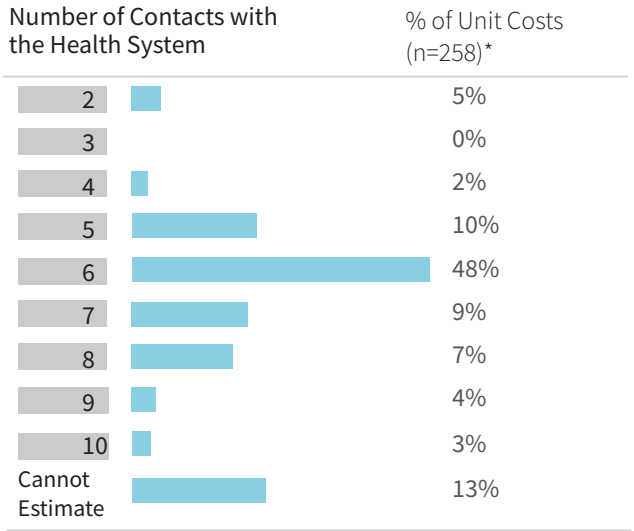



**FIGURE 5. Contacts with the health system for multiple vaccines and vaccine schedules**




*Number of unit costs only including between four and ten contacts with the health system.

Note: Percentages do not sum to 100% due to rounding. "Cannot estimate" means that the number of contacts with the health system could not be determined because of lack of information about vaccination timing (for example, in the case of vaccines for high-risk groups or those given only in outbreak situations) or due to limitations in the write-up of the resource.

**Gap analysis**:

Except for PCV, HPV, and Rotavirus, limited immunization delivery unit cost data exist on all other single vaccines. For unit costs reporting on multiple vaccines or vaccine schedules, there is high variability in antigens and number of contacts with the health system, making it challenging to compare across them.

## DELIVERY STRATEGIES

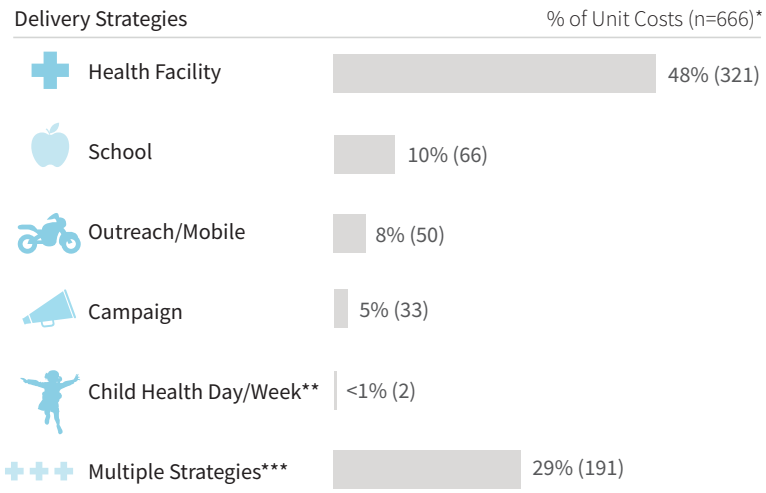
321 345

Almost half of the unit costs pertain to health facility delivery,[5] reflecting the predominant delivery of vaccines at fixed sites.

66 600

There are also a substantial number of unit costs for school-based delivery (10%), all published since 2010 and 78% focused on HPV introduction.

**FIGURE 6. Immunization delivery unit costs by delivery strategy**

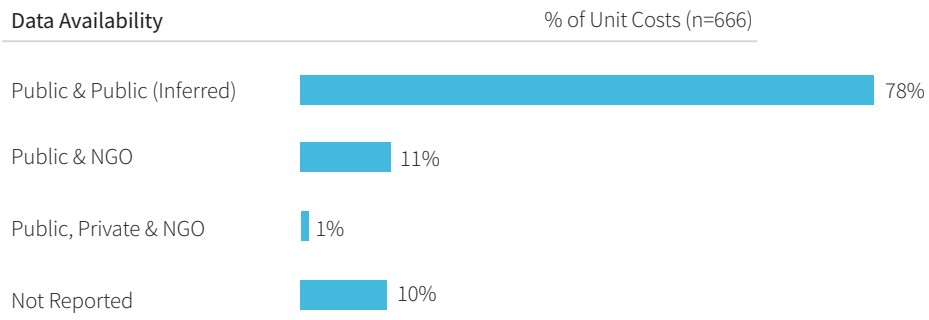



* Three resources are not shown in the figure as they did not report the delivery strategy(ies) used (<1%).
** Includes child health days/weeks or national immunization days/weeks.
*** Refers to a combination of two or more delivery strategies.

[5]Some delivery strategies reported by articles/reports as "health facility" may also include delivery via outreach/mobile or other strategies primarily due to how data are recorded by the health facility.

## DELIVERY SECTOR

### FIGURE 7. Immunization delivery unit costs by delivery sector




**Gap analysis:**

Limited data exist on the cost of delivery at private and NGO facilities.

## TARGET DELIVERY POPULATIONS

The immunization delivery costs cover a range of target delivery populations, from birth to older children/adolescents, to other groups, such as pregnant women.

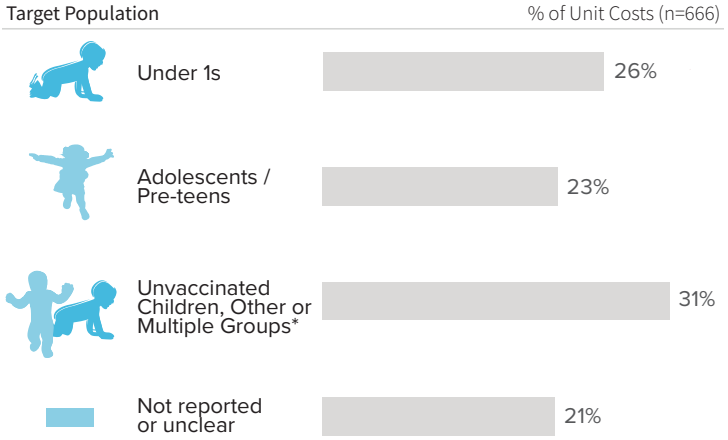
170 496

26% of the unit costs are for delivery to under ones (birth cohort, newborns, and infants).

152 514

23% of the unit costs are for delivery to adolescents/pre-teens, which includes 10-year-old girls and older children/adolescents (Figure 8).

**FIGURE 8. Target population for immunization delivery**




*The category "Other or multiple groups" includes a number of other age ranges (e.g., under 5s, 2- to 3-year-olds, 6 months to less than 10-year-olds, cholera high-risk individuals, hard-to-reach children, healthy non-pregnant individuals, and combinations of target populations).

**Gap analysis:**

More thorough reporting is needed to clearly identify the target delivery population, as it was unidentified for one-fifth (21%) of the unit costs.

## NEW VACCINE INTRODUCTIONS


Over half of the unit costs relate to new vaccine introduction.


Most (85%) of the unit costs on new vaccine introductions represent vaccines costed incrementally.


44% of unit costs on new vaccine introduction costed the introduction of HPV vaccine.

**TABLE 1. New vaccines costed incrementally for introduction**

| Vaccines | # of unit costs |
|---|---|
| **Incremental costs** | |
| HPV | 116 |
| PCV-10 | 81 |
| Rotavirus (2 doses) | 38 |
| PVC-13 | 27 |
| PCV-7 | 9 |
| Rotavirus (3 doses) | 8 |
| Measles | 5 |
| Measles; Rotavirus (2 doses); PCV-10 | 4 |
| Measles; Rotavirus (2 doses); PCV-13 | 4 |
| DTwP-HepB-Hib | 2 |
| DTP-HepB-Hib | 1 |
| OCV | 1 |
| **Total** | **296** |

**Gap analysis:**

There are limited data on the incremental costs of introducing vaccines other than the HPV, PCV, and Rotavirus vaccines.

## METHODS/REPORTING OF EVIDENCE ON IMMUNIZATION DELIVERY UNIT COSTS

### STUDY PERSPECTIVE

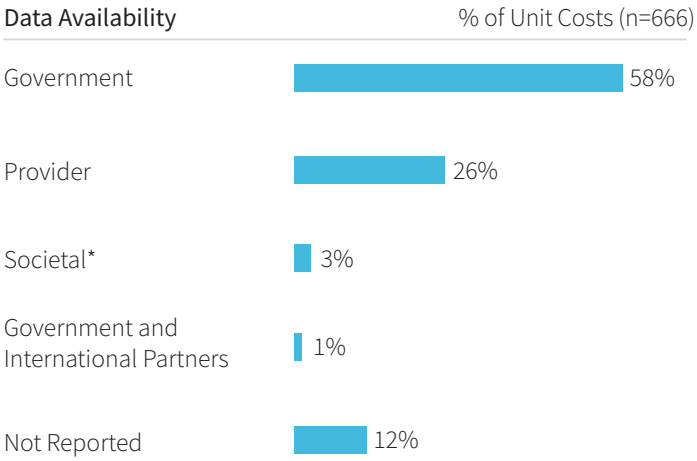
584 | 82

The study perspective taken is noted for 88% of unit costs.

558 | 108

The largest share of unit costs is from costing studies that took a government (58%) or provider perspective (26%) (Figure 9).

**FIGURE 9. Immunization costing study perspective**




*Perspective noted in the IDCC. In most cases, where societal perspective was reported by the resource, the methodology section clarified that in fact a government or provider perspective was taken.

**Gap analysis:**

The largest gap is the lack in reporting or inaccurate reporting of the perspective taken. Immunization delivery unit costs associated with an unreported perspective are likely to be government/provider. Unit costs associated with the societal perspective were defined as such by resource authors, but were often determined by the research team to be a government or provider perspective.

## STUDY DESIGN

469 197

Almost three-quarters (70%) of the unit costs are based on a retrospective study design, with just over one-quarter (26%) based on a prospective design. For the remaining 4% of unit costs, the study design was not reported.

## COST METHODOLOGY

528 138

Over three-quarters (79%) of immunization delivery unit costs were estimated using the ingredients or bottom-up approach. Nearly 10% are based on top-down, micro-costing or mixed approaches.

**Gap analysis:**

Clearer reporting that identifies the cost methodology used is needed as 11% of immunization delivery unit costs are from resources that did not report or did not clearly report on the cost methodology used.

## TYPES OF COSTS

Half of the estimates in the IDCC pertain to incremental immunization delivery unit costs, and 45% of the estimates represent full costs. Almost half (46%) of the unit costs represent economic costs, 41% financial costs, and only 8% fiscal costs. Most unit costs are incremental economic costs (23%), followed by full economic costs (23%), and then incremental financial costs (18%) (Table 2).

**Definitions**

- Economic costs: Financial outlays plus opportunity costs, such as heath worker time and any donated items such as vaccines
- Financial costs: Financial outlays, usually with straight-line depreciation of capital items
- Fiscal costs: Financial outlays, usually without depreciation of capital items
- Incremental costs: Additional costs associated with introducing a new vaccine or making a change in delivery.
- Full costs: The sum of all costs associated with vaccination delivery.

**TABLE 2. Type of cost by economic, financial, and fiscal costs**

| Type of Costing | Type of Unit Costs | | | | Total Unit Costs |
|---|---|---|---|---|---|
| | Economic | Financial | Fiscal | Not reported/ unclear | |
| **Full Costing** | 151 (49%) | 119 (44%) | 9 (16%) | 24 (69%) | 303 (45%) |
| **Incremental Costing** | 154 (50%) | 122 (45%) | 46 (84%) | 8 (31%) | 330 (50%) |
| **Not Reported** | 4 (1%) | 29 (11%) | 0 (0%) | 0 (0%) | 33 (5%) |
| **Total Unit Costs** | 309 (46%) | 270 (41%) | 55 (8%) | 26 (4%) | 666 (100%) |

Note: Percentages do not sum to 100% due to rounding.

**Gap analysis:**

For a considerable number of unit costs, the type of cost is unclear or is not reported in the resource. There are gaps in both financial and fiscal costs, which are likely most useful for country-level planners and policymakers.

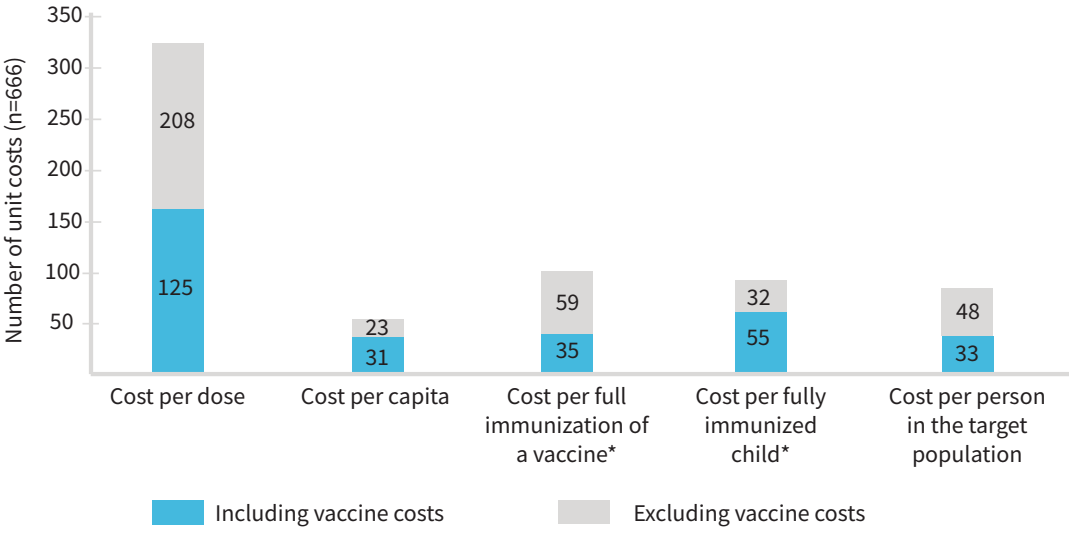
## IMMUNIZATION DELIVERY UNIT COSTS


Slightly more unit cost estimates in the IDCC exclude the vaccine cost (57%), compared to the estimates that include the vaccine cost (43%).

**Gap analysis:**

There are few studies that include an evaluation of the following cost categories:
(1) adverse event following immunization (AEFI) and disease surveillance costs; (2) buildings, utilities, other overheads and/ or shared costs; (3) per diem and travel allowances; (4) program management; and (5) waste management.[6]

**FIGURE 10. Typology of immunization delivery unit costs in dataset**




Cost per dose is the most frequently reported immunization delivery unit cost (50%), followed by cost per full immunization of a vaccine or fully immunized child[7] (30%), cost per person in the target population (12%), and cost per capita (8%).

*There are an additional eight unit costs including vaccine costs and eight unit costs excluding vaccine costs where authors did not define full immunization, so it is unclear if these represent cost per full immunization of a vaccine or cost per fully immunized child.

[6]Note that some cost categories, such as volunteer human resources and some shared costs, may be justifiably excluded in financial and fiscal cost analyses, so their exclusion from the immunization delivery unit cost estimates would not represent a gap.
[7]Full immunization of a vaccine refers to all required doses of a specific vaccine (e.g., two doses of oral cholera vaccine (OCV)). Fully immunized child refers to the provision of required vaccines to a specific group by a clear point in time (e.g., infants who received all doses of a vaccine in the schedule before reaching one year of age). We used the study authors' definition of fully immunized child that was relevant for their studies, as opposed to a standard global definition, for example, of DTP3.

## COST CATEGORIES

The majority of immunization delivery unit costs include the major cost drivers of vehicles, transport, and fuel (98%); cold chain equipment and overheads (89%); social mobilization and advocacy (83%); and paid human resources (81%) (Table 3). The most commonly included cost category was vehicles, transport, and fuel. In contrast, volunteer human resources and adverse event following immunization (AEFI) and disease surveillance were the least commonly included costs, included in only 29% and 45% of the unit costs, respectively.

Most immunization delivery unit costs (79%) include half of the cost categories (8 of 14 cost categories). Over half (58%) of unit costs include 10 or more cost categories. Nine percent of the unit costs are comprised of only supply chain costs (three to six cost categories of 14).

**TABLE 3. Cost category inclusion by costing type**

| Cost category | Economic (n=309) | Financial (n=270) | Fiscal (n=55) | Total (n=666) |
|---|---|---|---|---|
| **Paid HR** | 94% | 61% | 100% | 81% |
| **Volunteer HR** | 41% | 21% | 16% | 29% |
| **Per diem & travel allowances** | 72% | 74% | 56% | 72% |
| **Cold chain equipment & overheads** | 89% | 85% | 100% | 89% |
| **Vehicles, transport & fuel** | 99% | 96% | 100% | 98% |
| **Program management** | 59% | 70% | 35% | 60% |
| **Training & capacity building** | 79% | 80% | 89% | 79% |
| **Social mobilization & advocacy** | 77% | 93% | 89% | 83% |
| **AEFI and disease surveillance** | 41% | 54% | 16% | 45% |
| **Buildings, utilities, other overheads & shared costs** | 58% | 49% | 100% | 57% |
| **Vaccine supplies** | 72% | 67% | 76% | 70% |
| **Waste management** | 54% | 74% | 60% | 62% |

# IV. QUALITY ASSESSMENT OF EVIDENCE ON IMMUNIZATION DELIVERY UNIT COSTS

The quality of each resource was assessed on three dimensions: methodological rigor and reporting standards (8 items), uncertainty of results (3 items), and risk of bias and limitations (3 items) (Table 4). Each item was given an individual score of 1 (lowest), 2, or 3 (highest); for some items there was also a "not applicable" option.

Scores for all items were summed and averaged, excluding any "not applicable" answers, to produce a final score for each resource on the same 1 to 3 scale. The overall mean quality score across 64[8] resources is 2.3. For more information on the quality assessment, refer to the methodology note at immunizationeconomics.org/ican-idcc-methodology.

The two assessment categories with the highest mean score are "Contextual factors: are there any contextual factors related to the study setting that have not been accounted for in the results?" (3.0/3.0), meaning that resources that reported contextual factors took them into account in the results, and "Replicability: was the purpose of the study clearly defined?" (3.0/3.0). The category with the lowest score is "Data analysis strategy: were statistical tests used and confidence intervals reported?" (1.2/3.0), indicating that the overwhelming majority of resources did not report sufficient methodological detail in this area (Table 3).

**TABLE 4. Quality assessment scoring**

| Quality Attribute | Mean Score* |
|---|---|
| **Methodology and reporting** | |
| Quality of input data/data source | 2.5 |
| Sample strategy in relation to conclusion and generalizability | 2.7 |
| Data analysis strategy | 1.2 |
| Allocation of shared costs | 1.8 |
| Annualization of capital items | 1.9 |
| Replicability: methods | 2.2 |
| Replicability: study purpose | 3.0 |
| Reporting of results | 2.4 |
| Accuracy of reported findings: Does sum of capital and recurrent items match total? | 2.8 |
| Accuracy of reported findings: Does sum of cost categories match total? | 2.6 |
| **Uncertainty of results** | |
| Sensitivity analysis | 1.3 |
| Missing cost categories | 2.6 |
| Contextual factors | 3.0 |
| **Risk of bias/limitations** | |
| Author-stated limitations | 2.2 |
| Extractor-perceived limitations | 2.4 |
| **Overall Total** | **2.3** |

*Resources scoring n/a were not included in mean calculations.

[8]One resource of the 68 was a dataset and personal communication with the EPIC costing team. This was not included in the quality assessment. There were three resources from Phase III that did not undergo quality assessment because the review team participated in the writing of the grey literature reports, introducing a conflict of interest.

**Gap analysis**:

Much better methods reporting is needed, particularly with regard to data analysis strategy and sensitivity analyses.

# V. IMMUNIZATION DELIVERY UNIT COST RANGES

The analyses on the 2016 US$ immunization delivery unit costs (cost per dose, per capita, per full immunization of a vaccine or fully immunized child, per person in the target population) led to the development of immunization delivery cost ranges (cost ranges) for specific vaccines, by different delivery strategies, and for different country contexts. To generate the most robust estimates, results are based on four or more comparable immunization delivery unit costs. Results are primarily presented as cost ranges, rather than as single point estimates, to emphasize the variability in costing results related to context, costing methods, and reporting. Delivery cost variation is important for potential users to consider. The IDCC can be explored further to determine underlying reasons for cost variation.

Cost ranges were generated according to the following five steps:

**1.** Identification of immunization delivery unit costs that are methodologically and contextually similar, based on seven or eight mandatory comparability criteria, considering type of cost, delivery platform and scale and other factors (Annex 3).

**2.** Checking comparability of unit costs against an additional set of methods, vaccine delivery and contextual criteria.

**3.** Calculation of cost ranges for combinations of four or more comparable immunization delivery unit costs with associated descriptive statistics, including the range (minimum and maximum), mean, median, and 25th and 75th percentile estimates.

**4.** Validation of cost ranges with a panel of immunization costing experts.

**5.** Preparation of methodological notes to facilitate interpretation.

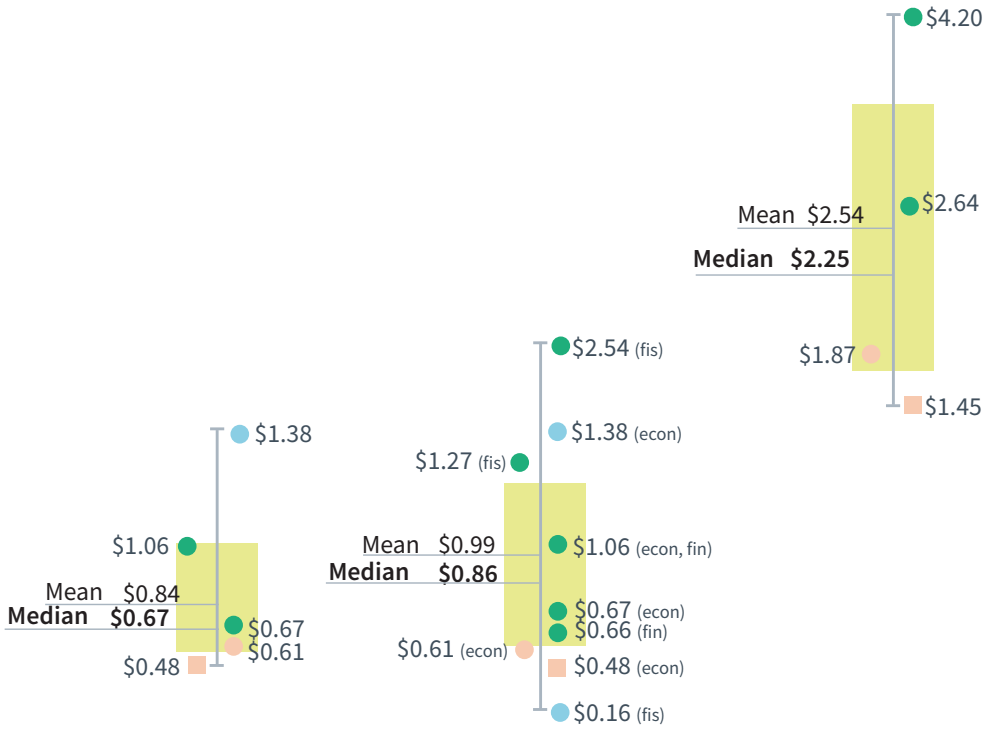
The methods for each step are described in detail in the companion methodology note at **immunizationeconomics.org/ican-idcc-methodology.**

# IMMUNIZATION DELIVERY UNIT COST ESTIMATES

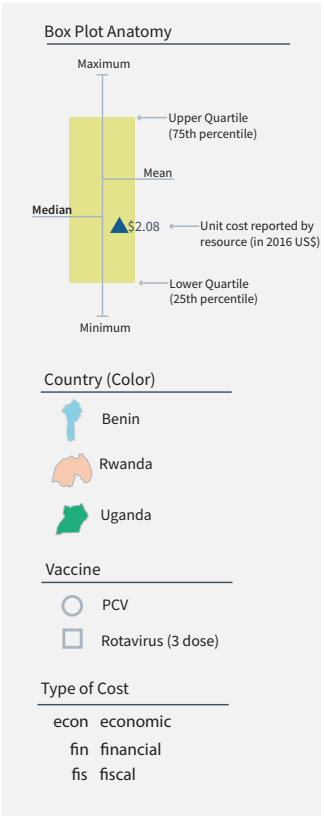
The four figures depicting the nine immunization delivery unit cost ranges (cost ranges) are displayed alongside the accompanying tables on the next pages (pp. 29-36). Annex 4 explains how to interpret these figures.

## IMMUNIZATION DELIVERY UNIT COST RANGES 1-3

### Incremental delivery cost for single, newly introduced vaccines, excluding vaccine cost (2016 US$)




KEY




| UNIT COST (excluding vaccine cost) | Economic cost per dose - incremental cost | Economic, financial and fiscal cost per dose - incremental cost | Economic cost per full immunization of a vaccine (3 doses) |
|---|---|---|---|
| DELIVERY STRATEGY | Health facility<br>Routine delivery, not SIA | | |
| OTHER COST DETAILS | Includes both introduction/startup costs and recurrent/ongoing costs | | |

## ADDITIONAL DETAIL: INCREMENTAL COST FOR SINGLE, NEWLY INTRODUCED VACCINES (EXCLUDING VACCINE COSTS) (2016 US$)

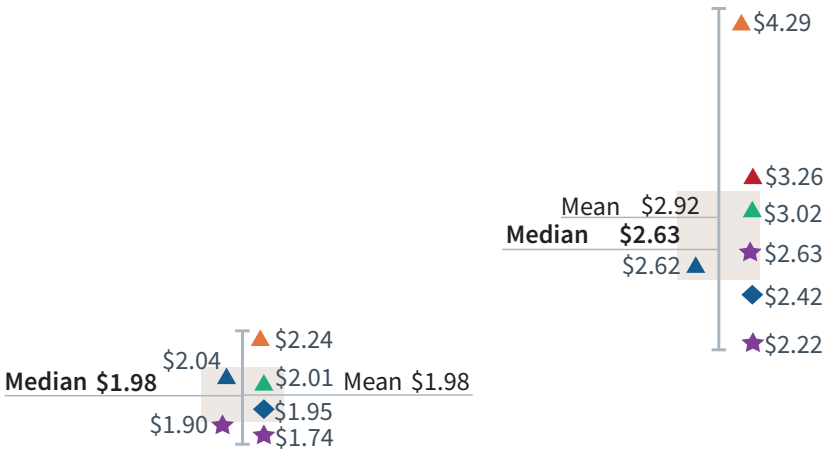
| No. | Countries | Vaccines costed | Delivery strategy (platform) | Delivery sector | Delivery scale | Other notes for interpretation | Quality score of resources | No. of cost categories (of 14)** | Type of unit cost+ | Individual immunization delivery unit costs | Immunization delivery cost range (2016 US$) | Descriptive statistics (2016 US$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Benin, Rwanda, Uganda | PCV7/10/13 & Rotavirus (3 dose) | Health facility (fixed site)<br><br>(Routine delivery, not SIA) | Public sector and NGO | National | The Rwanda unit costs are based on a sample of 3 facilities, while the other estimates had samples of 49 facilities | 2.1-2.7 | 10-12<br><br>(all major cost categories included) | Economic cost per dose | $0.48 (Rota, Rwanda)[1]<br>$0.61 (PCV, Rwanda)[1]<br>$0.67 (PCV, Uganda)[2]<br>$1.06 (PCV, Uganda)[2]<br>$1.38 (PCV, Benin)[3] | $0.48 - $1.38 | Mean: $0.84<br>25th percentile: $0.61<br>**Median: $0.67**<br>75th percentile: $1.06 |
| **2** | Benin, Rwanda, Uganda | PCV7/10/13 & Rotavirus (3 dose) | Health facility (fixed site)<br><br>(Routine delivery, not SIA) | Public, public and NGO, not reported | National | The Uganda unit costs come from a single source | 2.5-2.7 | 8-12<br><br>(all major cost categories included) | Economic, financial, and fiscal cost per dose | $0.16 (PCV, Benin, fis.)[3]<br>$0.48 (Rota 3 dose, Rwanda, econ.)[1]<br>$0.61 (PCV, Rwanda, econ.)[1]<br>$0.66 (PCV, Uganda, fin.)[2]<br>$0.67 (PCV, Uganda, econ.)[2]<br>$1.06 (PCV, Uganda, econ.)[2]<br>$1.06 (PCV, Uganda, fin.)[2]<br>$1.27 (PCV, Uganda, fis.)[2]<br>$1.38 (PCV, Benin, econ.)[3]<br>$2.54 (PCV, Uganda, fis.)[2] | $0.16 - $2.54 | Mean: $0.99<br>25th percentile: $0.62<br>**Median: $0.86**<br>75th percentile: $1.22 |
| **3** | Rwanda, Uganda | PCV7/10 & Rotavirus (3 dose) | Health facility (fixed site)<br><br>(Routine delivery, not SIA) | Public sector, public sector and NGO | National | The Rwanda unit costs are based on a sample of 3 facilities, while the other estimates had samples of 49 facilities | 2.1-2.7 | 10-12<br><br>(all major cost categories included) | Economic cost per full immunization of a vaccine (3 doses) | $1.45 (Rota, Rwanda)[1]<br>$1.87 (PCV, Rwanda)[1]<br>$2.64 (PCV, Uganda)[2]<br>$4.20 (PCV, Uganda)[2] | $1.45 - $4.20 | Mean: $2.54<br>25th percentile: $1.77<br>**Median: $2.25**<br>75th percentile: $3.03 |

*The quality of each article/report was assessed using a checklist developed by the ICAN research team. The quality scores across all articles/reports ranged from 1.6 to 2.8, with an average (mean) score of 2.3.
**The ICAN research team considered paid HR; cold chain equipment and overheads; vehicles, transport, and fuel; and training and capacity building to be the major cost categories.
+ Includes both introduction/startup costs and recurrent/ongoing costs.

References:
[1]Ngabo, F., Levin, A., Wang, S. A., Gatera, M., Rugambwa, C., Kayonga, C., … Hutubessy, R. (2015). **A cost comparison of introducing and delivering pneumococcal, rotavirus and human papillomavirus vaccines in Rwanda. Vaccine, 33(51), 7357–7363. https://doi.org/10.1016/j.vaccine.2015.10.022**
[2]Guthrie, T., Zikusooka, C., Kwesiga, B., Abewe, C., Lagony, S., Schutte, C., … Kinghorn, A. (2014). **Costing and Financing Analyses of Routine Immunization in Uganda.**
[3] **AMP. (2014). Costing and financing analyses of routine immunization and new vaccine introduction in Benin Final Report.**

## IMMUNIZATION DELIVERY UNIT COST RANGES 4-5

### Incremental delivery cost for introducing HPV vaccine to an existing schedule, excluding vaccine cost (2016 US$)

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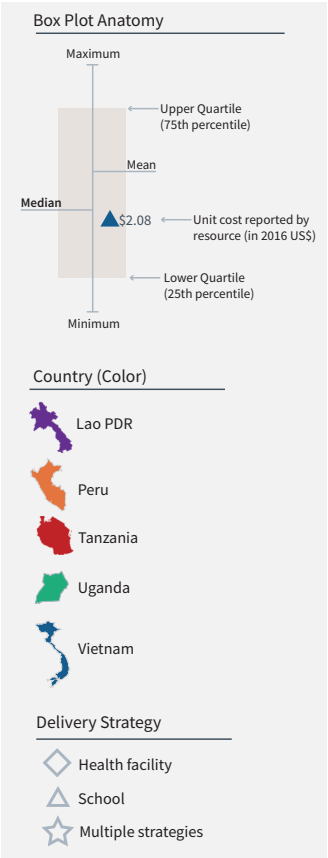



| UNIT COST (excluding vaccine cost) | Financial cost per dose - incremental cost | Economic cost per dose - incremental cost |
|---|---|---|
| DELIVERY STRATEGY | Health facility, school and multiple strategies (i.e., two or more delivery strategies)<br>Routine delivery, not SIA<br>Costs are related to pilot/project delivery | |
| OTHER COST DETAILS | Includes both introduction/startup costs and recurrent/ongoing costs | |

## ADDITIONAL DETAIL: INCREMENTAL COST FOR INTRODUCING HPV VACCINE (EXCLUDING VACCINE COSTS) (2016 US$)

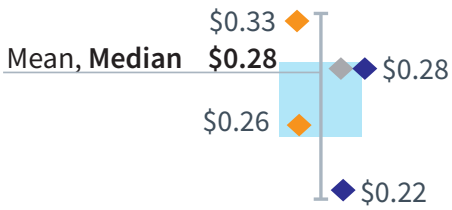
| No. | Countries | Vaccines costed | Delivery strategy (platform) | Delivery sector | Delivery scale | Other notes for interpretation | Quality score of resources* | No. of cost categories (of 14)** | Type of unit cost+ | Individual immunization delivery unit costs | Immunization delivery cost range (2016 US$) | Descriptive statistics (2016 US$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4** | Lao PDR, Peru, Tanzania, Uganda, Vietnam | HPV | Health facility, school and multiple strategies (i.e., two or more delivery strategies) | Public sector | Pilot/ project | Two resources were used to generate the cost range | 2.0-2.5 | 7-14 (all major cost categories included; some unit costs exclude cold chain) | Financial cost per dose | $1.74 (Lao PDR)[3]<br>$1.90 (Lao PDR)[3]<br>$1.95 (Vietnam)[1]<br>$2.01 (Uganda))[1]<br>$2.04 (Vietnam)[1]<br>$2.24 (Peru)[1] | $1.74 - $2.24 | Mean: $1.98<br>25th percentile: $1.91<br>**Median: $1.98**<br>75th percentile: $2.04 |
| **5** | | | (Routine delivery, not SIA) | | | Three resources were used to generate the cost range | 2.0-2.5 | 8-14 (all major cost categories included) | Economic cost per dose | $2.22 (Lao PDR)[3]<br>$2.42 (Vietnam)[1]<br>$2.62 (Vietnam)[1]<br>$2.63 (Lao PDR)[3]<br>$3.02 (Uganda)[1]<br>$3.26 (Tanzania)[2]<br>$4.29 (Peru)[1] | $2.22 - $4.29 | Mean: $2.92<br>25th percentile: $2.52<br>**Median: $2.63**<br>75th percentile: $3.14 |

*The quality of each article/report was assessed using a checklist developed by the ICAN research team. The quality scores across all articles/reports ranged from 1.6 to 2.8, with an average (mean) score of 2.3.
**The ICAN research team considered paid HR; cold chain equipment and overheads; vehicles, transport, and fuel; and training and capacity building to be the major cost categories.
+Includes both introduction/startup costs and recurrent/ongoing costs.

References:
[1]Levin, C. E., Van Minh, H., Odaga, J., Rout, S. S., Ngoc, D. N. T., Menezes, L., … LaMontagne, D. S. (2013). **Delivery cost of human papillomavirus vaccination of young adolescent girls in Peru, Uganda and Vietnam.** Bulletin of the World Health Organization, 91(8), 585–592. https://doi.org/10.2471/BLT.12.113837
[2]Quentin, W., Terris-Prestholt, F., Changalucha, J., Soteli, S., Edmunds, W. J., Hutubessy, R., … Watson-Jones, D. (2012). **Costs of delivering human papillomavirus vaccination to schoolgirls in Mwanza Region, Tanzania.** BMC Medicine, 10 (November 2011). https://doi.org/10.1186/1741-7015-10-137
[3]Riewpaiboon A, Pathammavong C, Fox K, Hutubessy R. (2019). **Cost analysis of pilot school-based HPV vaccination program in two provinces of Lao PDR.** DOI: 10.29090/psa.2019.01.017.0052.

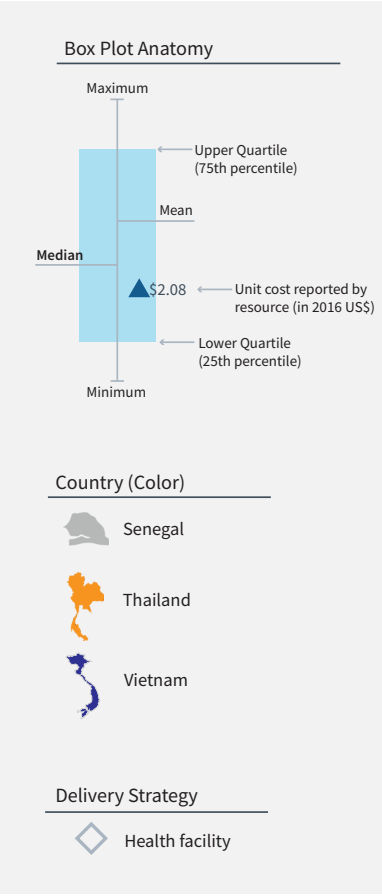
## IMMUNIZATION DELIVERY UNIT COST RANGE 6

### Supply chain delivery cost for a schedule of vaccines, excluding vaccine cost (2016 US$)




| | |
|---|---|
| UNIT COST (excluding vaccine cost) | Economic cost per dose |
| DELIVERY STRATEGY | Health facility<br><br>Routine delivery, not SIA |
| OTHER COST DETAILS | Supply chain only costs<br><br>Includes both introduction/startup costs and recurrent/ongoing costs |

KEY



## ADDITIONAL DETAIL: SUPPLY CHAIN DELIVERY COST FOR A SCHEDULE OF VACCINES (EXCLUDING VACCINE COSTS) (2016 US$)

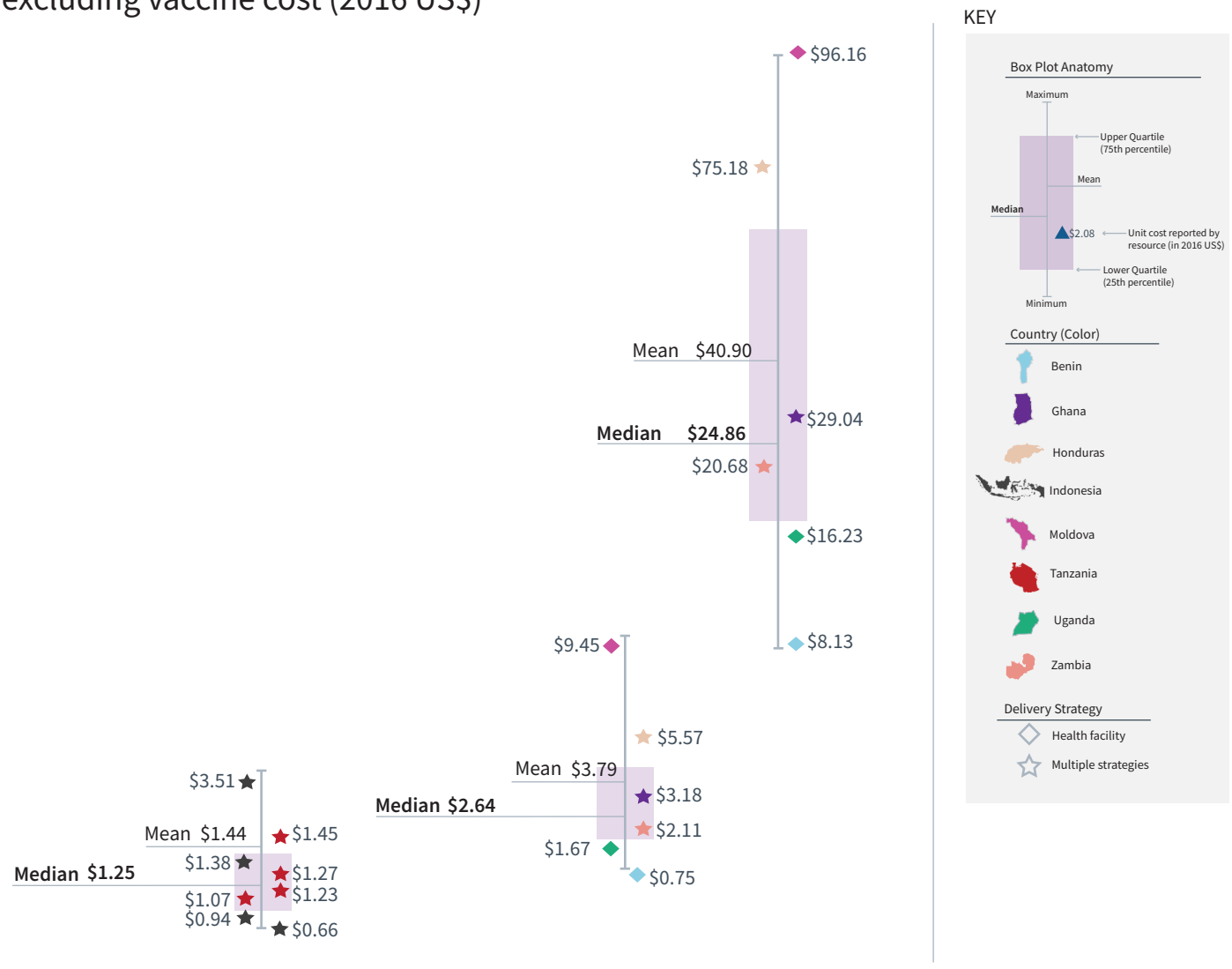
| No. | Countries | Vaccines costed | Delivery strategy (platform) | Delivery sector | Delivery scale | Other notes for interpretation | Quality score of resources* | No. of cost categories (of 14) | Type of unit cost+ | Individual immunization delivery unit costs | Immunization delivery cost range (2016 US$) | Descriptive statistics (2016 US$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6** | Senegal, Thailand, Vietnam | Vaccination schedules containing 6-7 antigens | Health facility (Routine delivery, not SIA) | Public sector | National | Supply chain only costs | 2.2-2.6 | All supply chain only unit costs with 3-5 cost categories | Economic cost per dose | $0.22 (Vietnam, 6 antigens)[3]<br>$0.26 (Thailand, 7 antigens)[1]<br>$0.28 (Vietnam, 6 antigens)[3]<br>$0.28 (Senegal, 6 antigens)[2]<br>$0.33 (Thailand, 7 antigens)[1] | $0.22 - $0.33 | Mean: $0.28<br>25th percentile: $0.26<br>**Median: $0.28**<br>75th percentile: $0.28 |

Note: This cost range combines unit cost data representing different schedules with different numbers of antigens and doses.
*The quality of each article/report was assessed using a checklist developed by the ICAN research team. The quality scores across all articles/reports ranged from 1.6 to 2.8, with an average (mean) score of 2.3.
+Includes both introduction/startup costs and recurrent/ongoing costs. Unit costs are full costs, not incremental.

References:
[1]PATH, World Health Organisation, Health Systems Research Institute, & Mahidol University. (2011). **An Assessment of Vaccine Supply Chain and Logistics Systems in Thailand.** Path, (September), 1–58.
[2]PATH. (2013). **Optimize: Senegal Report.**
[3]Mvundura, M., Kien, V. D., Nga, N. T., Robertson, J., Van Cuong, N., Tung, H. T., … Levin, C. (2014). **How much does it cost to get a dose of vaccine to the service delivery location: Empirical evidence from Vietnam's Expanded Program on Immunization.** Vaccine, 32(7), 834–838. https://doi.org/10.1016/j.vaccine.2013.12.029

## IMMUNIZATION DELIVERY UNIT COST RANGES 7-9

### Delivery cost for a schedule of vaccines, excluding vaccine cost (2016 US$)




| UNIT COST (excluding vaccine cost) | Financial cost per dose | Economic cost per dose | Economic cost per fully immunized child (defined as children who have received DTP3) |
|---|---|---|---|
| DELIVERY STRATEGY | Multiple strategies (i.e., two or more delivery strategies)<br>Routine delivery, not SIA | Health facility & multiple strategies (i.e., two or more delivery strategies)<br>Routine delivery, not SIA | Health facility & multiple strategies (i.e., two or more delivery strategies)<br>Routine delivery, not SIA |
| OTHER COST DETAILS | Includes facility-level only recurrent/ongoing costs | Includes both introduction/ startup costs and recurrent/ongoing costs at facility-level only | Includes both introduction/startup costs and recurrent/ongoing costs at facility-level only |

## ADDITIONAL DETAIL: DELIVERY COST TO DELIVER A SCHEDULE OF VACCINES (EXCLUDING VACCINE COST) (2016 US$)

| No. | Countries | Vaccines costed | Delivery strategy (platform) | Delivery sector | Delivery scale | Other notes for interpretation | Quality score of resources** | No. of cost categories (of 14)§ | Type of unit cost+ | Individual immunization delivery unit costs | Immunization delivery cost range (2016 US$) | Descriptive statistics (2016 US$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7** | Indonesia, Tanzania | Vaccination schedules containing 5-6 antigens for under 18 month olds | Health facility<br><br>(Routine delivery, not SIA) | Public sector | National | Only facility-level costs are included (i.e., above-facility costs excluded)<br><br>The unit costs are for different schedules, representing different numbers of antigens and doses | N/A* | 13<br><br>(all major cost categories included) | Financial cost per dose | $0.66 (Indonesia)[1]<br>$0.94 (Indonesia)[1]<br>$1.07 (Tanzania)[2]<br>$1.23 (Tanzania)[2]<br>$1.27 (Tanzania)[2]<br>$1.38 (Indonesia)[1]<br>$1.45 (Tanzania)[2]<br>$3.51 (Indonesia)[1] | $0.66 - $3.51 | Mean: $1.44<br>25th percentile: $1.04<br>**Median: $1.25**<br>75th percentile: $1.40 |
| **8** | Benin, Ghana, Honduras, Moldova, Uganda, Zambia | Schedules of 4-8 antigens for under 1-year-olds | Health facility (fixed site) & multiple strategies (two or more delivery strate-gies)<br><br>(Routine delivery, not SIA) | Public sector | National | | 2.5 - 2.8 | 11-13<br><br>(all major cost categories included) | Economic cost per dose | $0.75 (Benin, health facility (hf))[3, 4]<br>$1.67 (Uganda, hf)[5]<br>$2.11 (Zambia, multiple strategies (mult strat))[4, 6]<br>$3.18 (Ghana, mult strat)[4, 7]<br>$5.57 (Honduras, mult strat)[4, 8]<br>$9.45 (Moldova, hf)[4, 9] | $0.75 - $9.45 | Mean: $3.79<br>25th percentile: $1.78<br>**Median: $2.64**<br>75th percentile: $4.97 |
| **9** | | | | | | | | | Economic cost per fully immunized child (defined as children who have received DTP3) | $8.13 (Benin, hf)[3, 4]<br>$16.23 (Uganda, hf)[5]<br>$20.68 (Zambia, mult strat)[4, 6]<br>$29.04 (Ghana, mult strat)[4, 7]<br>$75.18 (Honduras, mult strat)[4, 8]<br>$96.16 (Moldova, hf)[4, 9] | $8.13 - $96.16 | Mean: $40.90<br>25th percentile: $17.34<br>**Median: $24.86**<br>75th percentile: $63.64 |

Note: This cost range combines unit cost data representing different schedules with different numbers of antigens and doses.

*The review team participated in the writing of the grey literature reports from which these unit costs were extracted, introducing a conflict of interest.

**The quality of each article/report was assessed using a checklist developed by the ICAN research team. The quality scores across all articles/reports ranged from 1.6 to 2.8, with an average (mean) score of 2.3.

§The ICAN research team considered paid HR, cold chain equipment and overheads, vehicles, transport, and fuel, and training and capacity building to be the major cost categories.

+ Includes both introduction/startup costs and recurrent/ongoing costs. Unit costs are full costs, not incremental.


References:

[1]Immunization Costing Action Network (ICAN). 2019. The Cost of Delivering Vaccines Using Different Delivery Strategies in High Coverage Areas in Indonesia. Washington, DC: ThinkWell.

[2]Immunization Costing Action Network (ICAN). 2019. The Costs of Different Vaccine Delivery Strategies to Reach Children Up to 18 Months in Rural and Urban Areas in Tanzania. Washington, DC: ThinkWell.

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[6]Schütte, C., Chansa, C., Marinda, E., Guthrie, T. A., Banda, S., Nombewu, Z., … Kinghorn, A. **2015. Cost analysis of routine immunisation in Zambia.** Vaccine 33(S1): A47–A52. https://doi.org/10.1016/j.vaccine.2014.12.040

[7]Le Gargasson, J. B., Nyonator, F. K., Adibo, M., Gessner, B. D., & Colombini, A. 2015. **Costs of routine immunization and the introduction of new and underutilized vaccines in Ghana.** Vaccine 33(S1):A40–A46.

[8]Pan American Health Organization. 2014. **Comprehensive costing and financial flows analysis of the national immunization program in Honduras**, 2011.

[9]Goguadze, K., Chikovani, I., Gaberi, C., Maceira, D., Uchaneishvili, M., Chkhaidze, N., and Gotsadze, G. 2015. **Costs of routine immunization services in Moldova: Findings of a facility-based costing study**. Vaccine 33(S1):A60–A65. https://doi.org/10.1016/j.vaccine.2014.12.034

# VII. CONCLUSIONS

This systematic review has responded to the need for compiled, analyzed evidence on IDCs in LMICs. It goes beyond past attempts that looked only at a subset of vaccines, a subset of economic evaluations, or costs of new vaccine introduction only, considering over 17,000 resources on the topic. Ultimately, it draws from 68 resources on IDC data without focusing solely on a particular vaccine, delivery strategy, type of cost analysis, or setting. This produced a dataset of over 600 immunization delivery unit costs (i.e., cost per capita, per dose, per full immunization of a vaccine, per fully immunized child, or per person in the target population), now available in the Immunization Delivery Cost Catalogue (IDCC) at **immunizationeconomics.org/ican-idcc**, all presented in 2016 US dollars for easy referencing and use.

This summary report has described the evidence in terms of its spread/scope, methods/reporting, and quality. It has also presented an analysis of cost ranges for vaccine delivery through a variety of strategies and in a variety of contexts.

In terms of the spread/scope of the evidence, the analysis has shown that an increasing number of resources on IDCs have been being published in recent years, thanks to several large immunization costing projects.

Unit costs are available from only 37 countries, primarily low income, and the overwhelming majority are for health facility-based delivery, despite the widespread use of outreach/mobile strategies and vaccination campaigns. Our review has also shown that we know relatively little about the costs of delivering single vaccines other than HPV, PCV and Rotavirus. We also know little about the cost of delivering multiple vaccines in a schedule, as schedules are difficult to compare as they are diverse in composition and are comprised of a number of antigens.

> Data are available for 37 countries in every region and income group, with Sub-Saharan Africa and low-income countries particularly well represented.

In low-income countries, the incremental cost per dose (excluding vaccine cost) to deliver single, newly introduced vaccines at health facilities ranged from $0.48 to $1.38 considering only economic costs. This contrasts with a range of $0.16 to $2.54 considering economic, financial and fiscal costs. The incremental cost for full immunization (i.e., 3 doses) of a vaccine ranged from $1.45 to $4.20 considering only economic costs.

Evidence indicates introducing HPV at schools on a pilot/project basis results in an incremental cost between $1.74 and $4.29 (the lower end of the range represents financial costs, whereas the higher end of the range corresponds with economic costs). Although there are limited immunization delivery unit costs for delivery via other delivery strategies, our analysis suggests that other strategies are more expensive than facility-based delivery.

There are few estimates available on the cost of the supply chain. The economic cost per dose of delivering vaccination schedules containing 6 to 7 antigens (excluding vaccine cost) ranged from $0.22 to $0.33.

The IDCC contains several cost estimates for delivering schedules of vaccines to children less than 18 months in health facilities. Results ranged from $0.66 to $3.51 per dose for delivering vaccination schedules of 5 to 6 antigens to children under 18 months of age (financial costs, facility-level only), to $0.75 to $9.45 per dose for delivering schedules of 4 to 8 antigens to children under 12 months of age (economic costs). The latter estimate equates to a cost per fully immunized child (defined by the study authors as children who have received DTP3) ranging from $8.13 to $96.16.

Methods and reporting on immunization delivery unit cost data need to be improved to allow users of the data to better understand how the study was conducted and the type of costs and cost categories included. Indeed, some of the variation shown in the IDCC may be more reflective of differences in methods and/or reporting rather than of actual cost differences.[9]

These findings should be useful for anyone interested in understanding the evidence base on IDCs, gaining inspiration for additional research in this area, or supporting countries in considering their IDC needs and comparing their costs to peers. This may include national and sub-national planners and policymakers, researchers, and international partners supporting country immunization and health system policy, planning, and financing.

There are additional tools and products, including a detailed methodology note and user guides, accessible at **http://immunizationeconomics.org/ican-idcc** to help with interpretation of the systematic review and to dig deeper into the variation in and drivers of IDCs across country contexts and delivery strategies.

[9]Unit costs may not be comparable because they use different costing methodologies, include different cost categories, represent different types of delivery (nationwide rollout versus pilot/project scale), and so on. See **http://immunizationeconomics.org/ican-idcc** for more details.

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Gotsadze, G., K. Goguadze, I. Chikovani, and D. Maceira. 2014. *Analyses of Costs and Financing of the Routine Immunization Program and New Vaccine Introduction in the Republic of Moldova Study Report*. Tbilisi, Georgia: Curatio Foundation.

Guthrie, T. et al. 2014. *Costing and Financing Analyses of Routine Immunization in Uganda*. Rivonia, South Africa: Heath & Development Africa.

ICAN / Immunization Costing Action Network. 2018. *Immunization Delivery Costs in Low- and Middle-income Countries  A methodology note for the systematic review, cost catalogue, and analytics.* Accessed May 23, 2018. **Immunizationeconomics.org/icanidccmethodologynote**.

Le Gargasson, J. et al. 2015. Costs of routine immunization and the introduction of new and underutilized vaccines in Ghana. *Vaccine* 33(S1):A40–A46.

Levin, C. et al. 2015. *Working paper for the convening on immunization delivery costs. Presentation at a meeting on immunization delivery costs*. October 14-15. Seattle, WA.

Mogasale, V. et al. 2016. Oral Cholera Vaccination Delivery Cost in Low- and Middle-Income Countries: An Analysis Based on Systematic Review. *PLoS Neglected Tropical Diseases* 10(12):e0005124.

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Schütte, C. et al. 2015. Cost analysis of routine immunisation in Zambia. *Vaccine* 33(S1): A47–A52. **https://www.sciencedirect.com/science/article/pii/S0264410X14016934**.

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# ANNEXES

## ANNEX 1. REFERENCES OF EXTRACTED ARTICLES/REPORTS

| Reference | Unit Costs | Countries | Vaccines Costed* |
|---|---|---|---|
| Al-lela, O. Q. B., Bahari, M. B., Al-abbassi, M. G., Salih, M. R. M., & Basher, A. Y. (2012). Estimation of immunization providers' activities cost, medication cost, and immunization dose errors cost in Iraq. *Vaccine*, 30(26), 3862–3866. **https://doi.org/10.1016/j.vaccine.2012.04.014** | 2 | Iraq | BCG, Measles, MMR, HepB, DTP, OPV |
| AMP. (2014). Costing and financing analyses of routine immunization and new vaccine introduction in Benin Final Report.** | 28[x] | Benin | BCG, Measles, DTP-HepB-Hib, OPV, PCV13, YF |
| Ayieko, P., Griffiths, U. K., Ndiritu, M., Moisi, J., Mugoya, I. K., Kamau, T., … Scott, J. A. G. (2013). Assessment of Health Benefits and Cost-Effectiveness of 10-Valent and 13-Valent Pneumococcal Conjugate Vaccination in Kenyan Children. *PLoS ONE*, 8(6), 1–10. **https://doi.org/10.1371/journal.pone.0067324** | 4 | Kenya | PCV10, PCV13 |
| Bem, J. and Stewart, E. "Vaccine Costing Analysis Preliminary Results." Presentation at the Pharmaceutical Fund and Supply Agency, Addis Ababa, Ethiopia, September 2015. | 7 | Ethiopia | OPV, Rotavirus, (2 doses), TT, PCV10, BCG, Measles, DTP |
| Bishai, D., Johns, B., Lefevre, A., & Nair, D. (2010). Cost effectiveness of measles eradication Final Report. Retrieved from **http://www.who.int/immunization/sage/1_Bishai_Economic_analysis.pdf** | 2 | Uganda | Measles |
| Brown, S. T., Schreiber, B., Cakouros, B. E., Wateska, A. R., Dicko, H. M., Connor, D. L., … Lee, B. Y. (2014). The benefits of redesigning Benin's vaccine supply chain. *Vaccine*, 32(32), 4097–4103. **https://doi.org/10.1016/j.vaccine.2014.04.090**** | 4 | Benin | BCG, Measles, TT, DTP-HepB-Hib, OPV, Rotavirus (2 doses), PCV13, YF |
| Cambodia MoH. (2018) Cambodia HPV vaccination demonstration project cost analysis. | 16 | Cambodia | HPV |
| Castañeda-Orjuela, C., Romero, M., Arce, P., Resch, S., Janusz, C. B., Toscano, C. M., & De la Hoz-Restrepo, F. (2013). Using standardized tools to improve immunization costing data for program planning: The cost of the Colombian Expanded Program on Immunization. *Vaccine*, 31(SUPPL.3), 72–79. **https://doi.org/10.1016/j.vaccine.2013.05.038†** | 4 | Columbia | BCG, MR, MMR, HepB, DTP, DT, Td, DTP-HepB-Hib, OPV, Rotavirus (2 doses), PCV7, YF, Influenza |

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|---|---|---|---|
| Cavailler, P., Lucas, M., Perroud, V., McChesney, M., Ampuero, S., Guérin, P. J., … Chaignat, C. L. (2006). Feasibility of a mass vaccination campaign using a two-dose oral cholera vaccine in an urban cholera-endemic setting in Mozambique. *Vaccine*, 24(22), 4890–4895. **https://doi.org/10.1016/j.vaccine.2005.10.006** | 1 | Mozambique | OCV |
| Chatterjee S, Das P, Nigam A, Nandi A, Brenzel L, Ray A, Haldar P, Aggarwal MK, Laxminarayan R. (2018) Variation in cost and performance of routine immunization service delivery in India. DOI: http://dx.doi.org/10.1136/bmjgh-2018-000794 | 3 | India | BCG, Measles, HepB, DTP, TT, OPV, JE |
| Chatterjee, S., Pant, M., Haldar, P., Aggarwal, M. K., & Laxminarayan, R. (2016). Current costs & projected financial needs of India's universal immunization programme. *Indian Journal of Medical Research,* 143(JUNE), 801–808. **https://doi.org/10.4103/0971-5916.192073** | 2 | India | BCG, Measles, HepB, DTP, DTP-Hib, OPV |
| Colombini, A., Badolo, O., Gessner, B. D., Jaillard, P., Seini, E., & Da Silva, A. (2011). Costs and impact of meningitis epidemics for the public health system in Burkina Faso. *Vaccine*, 29(33), 5474–5480. **https://doi.org/10.1016/j.vaccine.2011.05.058** | 2 | Burkina Faso | Meningococcal |
| Dorji, K., Phuntsho, S., Pempa, Kumluang, S., Khuntha, S., Kulpeng, W., … Teerawattananon, Y. (2018). Towards the introduction of pneumococcal conjugate vaccines in Bhutan: A cost-utility analysis to determine the optimal policy option. ***Vaccine,*** 36(13), 1757-65. **https://doi.org/10.1016/j.vaccine.2018.02.048** | 2 | Bhutan | PCV10, PCV13 |
| Douba, A., Dagnan, S. N., Zengbe-Acray, P., Aka, J., & Lépri-Aka N. (2006). Perception du Programme élargi de vaccination (PEV) dans le district sanitaire de Bouna (Nord-Est de la Côte d 'Ivoire). *Sante Publique*, 23(2), 113-121. | 5 | Côte d 'Ivoire | BCG, DTP-HepB, OPV |
| Ebong, C. E., & Levy, P. (2011). Impact of the introduction of new vaccines and vaccine wastage rate on the cost-effectiveness of routine EPI: Lessons from a descriptive study in a Cameroonian health district. *Cost Effectiveness and Resource Allocation*, 9, 1–8. **https://doi.org/10.1186/1478-7547-9-9** | 3 | Cameroon | BCG, Measles, DTP-HepB-Hib, OPV, YF |
| Goguadze, K., Chikovani, I., Gaberi, C., Maceira, D., Uchaneishvili, M., Chkhaidze, N., & Gotsadze, G. (2015). Costs of routine immunization services in Moldova: Findings of a facility-based costing study. *Vaccine*, 33(S1), A60–A65. **https://doi.org/10.1016/j.vaccine.2014.12.034** ** | 4 | Moldova | BCG, MMR, HepB, DTP-HepB-Hib, OPV |
| Gotsadze, G., Goguadze, K., Chikovani, I., & Maceira, D. (2014). Analyses of Costs and Financing of the Routine Immunization Program and New Vaccine Introduction in the Republic of Moldova Study Report. ** | 40 | Moldova | BCG, MMR, HepB, DTP, DT, Td, DTwP-Hib, DTP-HepB-Hib, OPV, Rotavirus (2 doses) |
| Griffiths, U. K., Hutton, G., & Das Dores Pascoal, E. (2005). The cost-effectiveness of introducing hepatitis B vaccine into infant immunization services in Mozambique. *Health Policy and Planning*, 20(1), 50–59. **https://doi.org/10.1093/heapol/czi006** | 3 | Mozambique | BCG, Measles, TT, OPV, HepB, DTP-HepB |

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| Griffiths, U. K., Korczak, V. S., Ayalew, D., & Yigzaw, A. (2009). Incremental system costs of introducing combined DTwP-hepatitis B-Hib vaccine into national immunization services in Ethiopia. *Vaccine*, 27(9), 1426–1432. **https://doi.org/10.1016/j.vaccine.2008.12.037** | 2 | Ethiopia | DTwP-HepB-Hib |
| Griffiths, U. K., Bozzani, F. M., Chansa, C., Kinghorn, A., Kalesha-Masumbu, P., Rudd, C., … Schutte, C. (2016). Costs of introducing pneumococcal, rotavirus and a second dose of measles vaccine into the Zambian immunisation programme: Are expansions sustainable? *Vaccine*, 34(35), 4213–4220. **https://doi.org/10.1016/j.vaccine.2016.06.050**** | 21 | Zambia | Measles, Rotavirus (2 doses), PCV10 |
| Griffiths, U. K., Santos, A. C., Nundy, N., Jacoby, E., & Matthias, D. (2011). Incremental costs of introducing jet injection technology for delivery of routine childhood vaccinations: Comparative analysis from Brazil, India, and South Africa. *Vaccine*, 29(5), 969–975. **https://doi.org/10.1016/j.vaccine.2010.11.038** | 15 | Brazil, India, South Africa | BCG, MMR, HepB, DTwP-Hib, YF, Measles, DT, TT, DTaP-Hib-IPV, PCV7, DTwP |
| Guthrie, T., Zikusooka, C., Kwesiga, B., Abewe, C., Lagony, S., Schutte, C., … Kinghorn, A. (2014). Costing and Financing Analyses of Routine Immunization in Uganda. Retrieved from **http://bit.ly/2CtYVKU** | 76[x] | Uganda | BCG, Measles, TT, DTP-HepB-Hib, OPV, PCV10 |
| Haidari, L. A., Wahl, B., Brown, S. T., Privor-Dumm, L., Wallman-Stokes, C., Gorham, K., … Lee, B. Y. (2015). One size does not fit all: The impact of primary vaccine container size on vaccine distribution and delivery. *Vaccine*, 33(28), 3242–3247. **https://doi.org/10.1016/j.vaccine.2015.04.018** *** | 2 | Benin | BCG, Measles, TT, DTP-HepB-Hib, OPV, Rotavirus (2 doses), PCV13, YF |
| Haidari, L. A., Brown, S. T., Ferguson, M., Bancroft, E., Spiker, M., Wilcox, A., … Lee, B. Y. (2016). The economic and operational value of using drones to transport vaccines. *Vaccine*, 34(34), 4062–4067. **https://doi.org/10.1016/j.vaccine.2016.06.022***** | 1 | Mozambique | BCG, Measles, TT, DTP-HepB-Hib, OPV, PCV10 |
| Haque, M., Waheed, M., & et al. (2016). The Pakistan Expanded Program on Immunization and the National Immunization Support Project. Retrieved from **http://documents.worldbank.org/curated/en/264971484109785001/pdf/111815-WP-PAKImmunizationEA-PUBLIC.pdf** | 1 | Pakistan | BCG, Measles, DTP, OPV |
| Hidle A, Gwati G, Abimbola T, Pallas SW, Hyde T, Petu A, McFarland D, and Manangazirab P. (2018) Cost of a human papillomavirus vaccination project, Zimbabwe. Bull World Health Organ. 2018 Dec 1; 96(12): 834–842. Published online 2018 Oct 17. doi: 10.2471/BLT.18.211904 | 22 | Zimbabwe | HPV |
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| Ilboudo PG, Le Gargasson JB. (2017) Delivery cost analysis of a reactive mass cholera vaccination campaign: a case study of Shanchol vaccine use in Lake Chilwa, Malawi. BMC Infect Dis. 2017 Dec 19;17(1):779. doi: 10.1186/s12879-017-2885-8. | 5 | Malawi | OCV |
| Immunization Costing Action Network (ICAN). 2019. The Cost of Delivering Vaccines Using Different Delivery Strategies in High Coverage Areas in Indonesia. Washington, DC: ThinkWell. | 32 | Indonesia | BCG, Measles, HepB, DT, Td, DTP-HepB-Hib, OPV |
| Immunization Costing Action Network (ICAN). 2019. The Cost of Preparation and Delivery of Td Vaccine to 7-Year-Old Children in Vietnam. Washington, DC: ThinkWell. | 18 | Vietnam | TT, Td |
| Immunization Costing Action Network (ICAN). 2019. The Costs of Different Vaccine Delivery Strategies to Reach Children Up to 18 Months in Rural and Urban Areas in Tanzania. Washington, DC: ThinkWell. | 104 | Tanzania | BCG, MR, DTP-HepB-Hib, OPV, Rotavirus (2 doses), PCV13 |
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| Kar, S. K., Sah, B., Patnaik, B., Kim, Y. H., Kerketta, A. S., Shin, S., … Wierzba, T. F. (2014). Mass Vaccination with a New, Less Expensive Oral Cholera Vaccine Using Public Health Infrastructure in India: The Odisha Model. *PLoS Neglected Tropical Diseases*, 8(2). **https://doi.org/10.1371/journal.pntd.0002629** | 3 | India | OCV |
| Kaucley, L., & Levy, P. (2015). Cost-effectiveness analysis of routine immunization and supplementary immunization activity for measles in a health district of Benin. *Cost Effectiveness and Resource Allocation*, 13(1), 14. **https://doi.org/10.1186/s12962-015-0039-7** | 6 | Benin | Measles |
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| Khan, I. A., Saha, A., Chowdhury, F., Khan, A. I., Uddin, M. J., Begum, Y. A., … Qadri, F. (2013). Coverage and cost of a large oral cholera vaccination program in a high-risk cholera endemic urban population in Dhaka, Bangladesh. *Vaccine*, 31(51), 6058–6064. **https://doi.org/10.1016/j.vaccine.2013.10.021** ††† | 3 | Bangladesh | OCV |

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| Levin, C. E., Nelson, C. M., Widjaya, A., Moniaga, V., & Anwar, C. (2005). Costs of hepatitis B vaccine in a prefilled syringe in Indonesia. *Bulletin of the World Health Organization*, 83(3), 456–461. **https://www.sciencedirect.com/science/article/pii/S0264410X14016934** | 2 | Indonesia | HepB |
| Levin, C. E., Van Minh, H., Odaga, J., Rout, S. S., Ngoc, D. N. T., Menezes, L., … LaMontagne, D. S. (2013). Delivery cost of human papillomavirus vaccination of young adolescent girls in Peru, Uganda and Viet Nam. Bulletin of the *World Health Organization,* 91(8), 585–592. **https://doi.org/10.2471/BLT.12.113837** | 10 | Peru, Uganda, Vietnam | HPV |
| Levin, A., Wang, S. A., Levin, C., Tsu, V., & Hutubessy, R. (2014). Costs of introducing and delivering HPV vaccines in low and lower middle income countries: Inputs for GAVI policy on introduction grant support to countries. *PLoS ONE*, 9(6). **https://doi.org/10.1371/journal.pone.0101114** | 39 | Bhutan, India, Peru, Tanzania, Uganda, Vietnam | HPV |
| Lydon, P., Zipursky, S., Tevi-Benissan, C., Djingarey, M.H., Gbedonou, P., Youssouf, B.O., Zaffran, M. (2014). Economic benefits of keeping vaccines at ambient temperature during mass vaccination: the case of meningitis A vaccine in Chad. *Bulletin of the World Health Organization*, 92, 86-92. **http://dx.doi.org/10.2471/BLT.13.123471** | 2 | Chad | Meningococcal |
| Mascareñas, A., Salinas, J., Tasset-Tisseau, A., Mascareñas, C., & Khan, M. M. (2005). Polio immunization policy in Mexico: Economic assessment of current practice and future alternatives. *Public Health*, 119(6), 542–549. **https://doi.org/10.1016/j.puhe.2004.08.020** | 2 | Mexico | OPV |
| Minh, V. H., Nguyen, T. B. Y., Bao, G. K., Lan, H. D., Thuy, H. N., & Wright, P. (2008). Cost of providing the expanded programme on immunization: Findings from a facility-based study in Viet Nam, 2005. *Bulletin of the World Health Organization*, 86(6), 429–434. **https://doi.org/10.2471/BLT.07.045161** | 1 | Vietnam | HPV |
| Minh, V. H., Nguyen, T. B. Y., Bao, G. K., Lan, H. D., Thuy, H. N., & Wright, P. (2008). Cost of providing the expanded programme on immunization: Findings from a facility-based study in Viet Nam, 2005. Bulletin of the World Health Organization, 86(6), 429–434. **https://doi.org/10.2471/BLT.07.045161** | 12 | Vietnam | BCG, Measles, HepB, DTP, TT, OPV, JE |
| Moodley, I., Tathiah, N., & Sartorius, B. (2016). The costs of delivering human papillomavirus vaccination to Grade 4 learners in KwaZulu-Natal, South Africa. *South African Medical Journal = Suid-Afrikaanse Tydskrif Vir Geneeskunde*, 106(5), 60. **https://dx.doi.org/10.7196/SAMJ.2016.v106i5.9988** | 1 | South Africa | HPV |

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| Mvundura, M., Kien, V. D., Nga, N. T., Robertson, J., Van Cuong, N., Tung, H. T., … Levin, C. (2014). How much does it cost to get a dose of vaccine to the service delivery location: Empirical evidence from Vietnam's Expanded Program on Immunization. *Vaccine*, 32(7), 834–838. **https://doi.org/10.1016/j.vaccine.2013.12.029**‡ | 4 | Vietnam | BCG, Measles, HepB, DTwP, TT, OPV, DTP-HepB-Hib |
| Mvundura, M., Lorenson, K., Chweya, A., Kigadye, R., Bartholomew, K., Makame, M., … Kristensen, D. (2015). Estimating the costs of the vaccine supply chain and service delivery for selected districts in Kenya and Tanzania. *Vaccine*, 33(23), 2697–2703. **https://doi.org/10.1016/j.vaccine.2015.03.084** | 2 | Kenya, Tanzania | BCG, Measles, Td, DTP-HepB-Hib, OPV, PCV10, YF |
| Mvundura, M., Lydon, P., Gueye, A., Diaw, I.K., Landoh, D.E., Toi, B., … Kristensen, D. (2017). An economic evaluation of the controlled temperature chain approach for vaccine logistics: evidence from a study conducted during a meningitis A vaccine campaign in Togo. *The Pan African Medical Journal*, 27(Supp 3), 27. **doi:10.11604/pamj.supp.2017.27.3.12087** | 2 | Togo | Meningococcal |
| Ngabo, F., Levin, A., Wang, S. A., Gatera, M., Rugambwa, C., Kayonga, C., … Hutubessy, R. (2015). A cost comparison of introducing and delivering pneumococcal, rotavirus and human papillomavirus vaccines in Rwanda. *Vaccine*, 33(51), 7357–7363. **https://doi.org/10.1016/j.vaccine.2015.10.022** | 24 | Rwanda | PCV7, Rotavirus (3 doses), HPV |
| Pan American Health Organization. (2014). Comprehensive costing and financial flows analysis of the national immunization program in Honduras, 2011.** | 5[x] | Honduras | BCG, MMR, HepB, DTP, Td, DTP-HepB-Hib, OPV, IPV, Rotavirus (2 doses), PCV13, YF, Influenza |
| PATH. (2013). Optimize: Senegal Report. ‡ | 1 | Senegal | BCG, Measles, TT, DTwP-HepB-Hib, OPV, YF |
| PATH, World Health Organization, Health Systems Research Institute, & Mahidol University. (2011). An Assessment of Vaccine Supply Chain and Logistics Systems in Thailand. PATH (September), 1–58. ‡ | 2 | Thailand | BCG, Measles, MMR, HepB, DTP, OPV, JE |
| Quentin, W., Terris-Prestholt, F., Changalucha, J., Soteli, S., Edmunds, W. J., Hutubessy, R., … Watson-Jones, D. (2012). Costs of delivering human papillomavirus vaccination to schoolgirls in Mwanza Region, Tanzania. *BMC Medicine*, 10 (November 2011). **https://doi.org/10.1186/1741-7015-10-137** | 1 | Tanzania | HPV |

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|---|---|---|---|
| Riewpaiboon A, Pathammavong C, Fox K, Hutubessy R. (2019) Cost analysis of pilot school-based HPV vaccination program in two provinces of Lao PDR. DOI: 10.29090/psa.2019.01.017.0052 | 36 | Lao PDR | HPV |
| Riewpaiboon, A., Sooksriwong, C., Chaiyakunapruk, N., Tharmaphornpilas, P., Techathawat, S., Rookkapan, K., … Suraratdecha, C. (2015). Optimizing national immunization program supply chain management in Thailand: an economic analysis. *Public Health*, 129(7), 899-906. 1016/j.puhe.2015.04.016 | 4 | Thailand | BCG, Measles, MMR, HepB, DTP, DT, DTP-Hib, OPV, JE |
| Routh, J.A., Sreenivasan, N., Adhikari, B.B., Andrecy, L.L., Bernateau, M., Abimbola, T., … Mintz, E.D. (2017). Cost evaluation of a government-conducted oral cholera vaccination campaign - Haiti, 2013. T*he American Society of Tropical Medicine and Hygiene*, 97(4), 37-42. doi:10.4269/ajtmh.16-1023 | 6 | Haiti | OCV |
| Ruhago, G. M., Ngalesoni, F. N., Robberstad, B., & Norheim, O. F. (2015). Cost-effectiveness of live oral attenuated human rotavirus vaccine in Tanzania. *Cost Effectiveness and Resource Allocation*, 13(1), 1–12. **https://doi.org/10.1186/s12962-015-0033-0** | 3 | Tanzania | Rotavirus (2 doses) |
| Sarker, A. R., Islam, Z., Khan, I. A., Saha, A., Chowdhury, F., Khan, A. I., … Khan, J. A. M. (2015). Estimating the cost of cholera-vaccine delivery from the societal point of view: A case of introduction of cholera vaccine in Bangladesh. *Vaccine*, 33(38), 4916–4921. **https://doi.org/10.1016/j.vaccine.2015.07.042** ††† | 3 | Bangladesh | OCV |
| Schaetti, C., Weiss, M. G., Ali, S. M., Chaignat, C. L., Khatib, A. M., Reyburn, R., … Hutubessy, R. (2012). Costs of Illness Due to Cholera, Costs of Immunization and Cost-Effectiveness of an Oral Cholera Mass Vaccination Campaign in Zanzibar. P*LoS Neglected Tropical Diseases*, 6(10). **https://doi.org/10.1371/journal.pntd.0001844** | 2 | Tanzania | OCV |
| Schütte, C., Chansa, C., Marinda, E., Guthrie, T. A., Banda, S., Nombewu, Z., … Kinghorn, A. (2015). Cost analysis of routine immunisation in Zambia. *Vaccine,* 33(S1), A47–A52. **https://doi.org/10.1016/j.vaccine.2014.12.040**** | 4[x] | Zambia | BCG, Measles, DTP-HepB-Hib, OPV |

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|---|---|---|---|
| Sume, G. E., Fouda, A. A. B., Kobela, M., Nguelé, S., Emah, I., & Atem, P. (2013). A locally initiated and executed measles outbreak response immunization campaign in the nylon health district, Douala Cameroon 2011. *BMC Research Notes*, 6(1). **https://doi.org/10.1186/1756-0500-6-100** | 1 | Cameroon | Measles |
| Teshome, S., Desai, S., Kim, J.H., Belay, D., & Mogasale, V. (2018). Feasibility and costs of a targeted cholera vaccination campaign in Ethiopia. *Human Vaccines & Immunotherapeutics*. **https://doi.org/10.1080/21645515.2018.1460295** | 5 | Ethiopia | OCV |
| Usuf, E., Mackenzie, G., Lowe-Jallow, Y., Boye, B., Atherly, D., Suraratdecha, C., & Griffiths, U. K. (2014). Costs of vaccine delivery in the Gambia before and after, pentavalent and pneumococcal conjugate vaccine introductions. *Vaccine*, 32(17), 1975–1981. **https://doi.org/10.1016/j.vaccine.2014.01.045** | 4 | The Gambia | DTP-HepB-Hib, HepB, TT, OPV, YF, PCV7 |
| VillageReach. (2009). Comparison of Costs Incurred in Dedicated and Diffused Vaccine Logistics Systems, (October), 1–42. ‡‡‡ | 6 | Mozambique | BCG, Measles, TT, DTP-HepB, OPV |
| Yin, Z., Beeler Asay, G. R., Zhang, L., Li, Y., Zuo, S., Hutin, Y. J., … Jiang, F. (2012). An economic evaluation of the use of Japanese encephalitis vaccine in the expanded program of immunization of Guizhou province, China. *Vaccine*, 30(37), 5569–5577. **https://doi.org/10.1016/j.vaccine.2012.05.068** | 2 | China | JE |
| Yu, W., Lu, M., Wang, H., Rodewald, L., Ji, S., Ma, C., … Liu, Y. (2018). Routine immunization services costs and financing in China, 2015. *Vaccine*, 36(21), 3041-7. 10.1016/j.vaccine.2018.04.008 | 4 | China | BCG, MR, MMR, HepB, DTP, DT, OPV, IPV, JE, Meningococcal |
| Zengbe-Acray, P., Douba, A., Traore, Y., Dagnan, S., Attoh-Toure, H., & Ekra, D. (2009). Coûts de la riposte vaccinale contre la fièvre jaune à abidjan, 2001. *Sante Publique*, 21(4), 383–391. | 2 | Côte d 'Ivoire | YF |

[x]These resources were extracted with additional information provided by Suharlim, C. and Menzies, N. (2018). Personal communication.
*DT = Diphtheria and tetanus toxoids, pediatric formulation; DTaP = Diphtheria and tetanus toxoids and acellular pertussis vaccine, pediatric formulation; DTP = Diphtheria and tetanus toxoids and whole-cell pertussis vaccine, pediatric formulation; HepB = Hepatitis B Vaccine; Hib = Haemophilus influenzae type b; HPV = Human Papillomavirus; IPV = Inactivated Poliovirus Vaccine; JE = Japanese Encephalitis; MCV = Measles antigen-containing vaccines; MMR = Measles, Mumps & Rubella Vaccine; MR = Measles-rubella Vaccine; OPV = Oral Polio Vaccine; PCV = Pneumococcal Conjugate Vaccine; PCV7 = Pneumococcal Conjugate Vaccine (7-valent); PCV10 = Pneumococcal Conjugate Vaccine (10-valent); PCV13 = Pneumococcal Conjugate Vaccine (13-valent); Tetanus & diphtheria Vaccine, adult/adolescent formulation; TT = Tetanus Toxoid; YF = Yellow Fever
**Expanded Program on Immunization Costing (EPIC) Project
***Highly Extensible Resource for Modeling Event-driven Supply chains (HERMES) Framework
† ProVac Initiative
†† Cervical Cancer Prevention and Control Costing (C4P) tool demonstration for planning and costing nationwide HPV vaccination programs
††† Introduction of Cholera Vaccine in Bangladesh (ICVB)
‡ Project Optimize
‡‡ HPV Vaccines: Evidence for Impact project
‡‡‡ Project to Support PAV (EPI) to strengthen the management, reliability and quality of the health system in Mozambique

## ANNEX 2. DEFINITIONS

| Term | Definition |
|---|---|
| --- | Reviewers could not find the indicated information in the article/report. For example, if a study does not discuss capital costs and their annualization, we have noted that methods for annualizing capital costs are "not reported" or "---". |
| Annualization | Costing method to spread the costs of items used for more than one year over the lifetime of the item. |
| Cannot estimate | Value cannot be calculated, due to missing/incomplete data or division by zero. |
| Cost category | Groupings of costs; also known as cost item, line item, etc. We used the following cost categories: Paid human resources, Volunteer human resources (economic costs only), Per diem and travel allowances, Cold chain equipment and their overheads (installation, energy, maintenance, repairs), Vehicles, transport and fuel, Program management, Training and capacity building, Social mobilization and advocacy, AEFI and disease surveillance, Buildings, utilities, other overheads and/or shared costs, Vaccines, Vaccine supplies, Waste management, Other supplies and recurrent costs, Other category costs. |
| Delivery cost | Frequently referred to at country level as "operational costs". The costs associated with delivering immunizations to target populations, exclusive of vaccine costs. Delivery costs may include any or all of the following items: paid and volunteer human resources and associated per diem and travel allowances, cold chain equipment and overheads, vehicles, transport and fuel, program management, training and capacity building, social mobilization and advocacy, adverse event following immunization (AEFI) and disease surveillance, buildings, utilities, other overheads and shared costs, vaccine supplies, waste management, other supplies and recurrent costs and other costs. We refer to these inputs as "cost categories"; some articles/reports refer to them as line items and/or activities. |
| Delivery strategy | How and where vaccines are delivered, such as through health facilities, outreach/mobile clinics (off-site delivery, generally to patients located more than a certain distance from a health facility; this delivery strategy may be called mobile in some countries, or outreach in others), schools, child health days/weeks or national immunization days/weeks, campaigns and multiple strategies (two or more of the aforementioned strategies). |
| Discount rate | The rate at which future costs are considered compared to those that occur in the present. |
| Economic cost | Financial outlays plus opportunity costs of health worker time and any donated items such as vaccines. |
| Financial cost | Financial outlays, usually with straight-line depreciation of capital items. |

| Term | Definition |
|---|---|
| Fiscal cost | Financial outlays, usually without depreciation of capital items. |
| Full/total | The sum of all costs associated with vaccination delivery. |
| Fully immunized child (FIC) | Full immunization of a vaccine or specifically defined by each article/report, but generally refers to provision of a certain number of doses of a specific vaccine(s) to a specific group and at a clear point in time, e.g., infants who received one dose of BCG; three doses each of OPV, DPT, and Hepatitis B vaccines; and one dose of measles vaccine before reaching one year of age. |
| Incremental | Additional costs associated with introducing a new vaccine or making a change in delivery. |
| Inferred | Not explicitly stated in the article/report but determined by the reviewers based on other information. |
| Not reported | Reviewers could not find the indicated information in the article/report. For example, if a study does not discuss capital costs and their annualization, we have noted that methods for annualizing capital costs are “not reported.” |
| Perspective | The point of view considered for costs (and benefits, if included), in a costing study; to whom the costs were incurred. Common perspectives include provider, government, healthcare, insurer and societal. |
| Quality assessment score | Indication of the quality of each article/report in the review, as assessed by the review team. Measured on three dimensions: methodological rigor and reporting standards (8 items), uncertainty of results (3 items) and risk of bias and limitations (3 items). Each item was given an individual score of 1 (lowest), 2, or 3 (highest); for some items there was also a “not applicable” option. Scores for all items were summed and averaged, excluding any “not applicable” answers, to produce a final score for each article/report on the same 1 to 3 scale. |
| Record | A record represents one or more unit costs with unique characteristics. While some articles/reports only report a single unit cost, most present multiple unit costs are calculated using different criteria (e.g., economic/financial/fiscal costs, full/incremental). |
| Record ID | Identifier for each row in the International Delivery Cost Catalogue (IDCC), representing unique unit cost(s) with a set of attributes, for example, economic, incremental costs of HPV delivery in schools. Many studies report multiple types of unit costs (e.g., financial, economic), so each is presented as a unique record ID. Record IDs including an underscore (_) are all from the same articles/reports. |
| Routine | Defined by WHO as "sustainable, reliable and timely interaction between the vaccine, those who deliver it and those who receive it to ensure every person is fully immunized against vaccine-preventable diseases" (cite WHO: http://www.who.int/immunization/diseases/poliomyelitis/endgame_objective2/routine_immunization/en/) |
| Shared costs | Delivery costs that are also used for non-immunization, for example vehicles that are used for outreach but also used for HIV. |

| Term | Definition |
|---|---|
| Standardized findings | Refers to the data extracted as part of the systematic review, presented in a standard format in the International Delivery Cost Catalogue (IDCC) with all costs brought to 2016 USD. |
| Supplementary immunization activity (SIA) | Strategy for delivering vaccination to children otherwise missed by routine immunization, or in response to a specific event, such as a disease outbreak. |
| Type of cost | Either financial, fiscal or economic; see definitions. |
| Type of costing | Differentiated between full or total costing and incremental costing; see definitions. |
| Unit cost | The cost of delivery of a single unit of immunization. The review includes four unit costs: per dose, per fully immunized child (FIC), per person in the target population, per capita. |

## ANNEX 3. METHODS CRITERIA FOR IDENTIFYING COMPARABLE UNIT COSTS

| Criteria | Options |
|---|---|
| **Mandatory Comparability Criteria** | |
| Type of costs* | Economic, financial, or fiscal costs |
| Type of costing | Full costing or incremental costing |
| Timeframe of costs | Introduction/startup costs, recurrent/ongoing costs, or both |
| Highest level of costs included | National, provincial, district, facility site, etc. |
| Supply chain only costs | Yes (includes supply chain only cost categories) or No (includes the broader set of cost categories) |
| Delivery platform | Routine, supplementary immunization activity (SIA), or both routine and SIA |
| Delivery scale | Pilot/project or full scale (We do not compare small-scale demonstration project costs with programs being implemented nation-wide, as cost estimates will likely vary due to economies of scale, etc.) |
| **Additional Comparability Criteria – Methods** | |
| Number of antigens costed | Between 1 and 13 |
| Number of sampled facilities | Number of facilities included in the sample |
| Perspective | Donor, government, provider, societal |
| Number of included cost categories | Total number of 15 total categories |
| **Additional Comparability Criteria – Vaccine delivery and context** | |
| Vaccines costed | HPV, Rotavirus (2 doses), multiple vaccines, etc. |
| Mode of administration | Oral or injectable (for single vaccines) |

* We also considered cost ranges without application of this variable, based on feedback from external reviewers.

| | |
|---|---|
| Number of contacts with the health system | Between 4 and 10 contacts that the immunization schedule requires with the health system (for unit costs reporting multiple vaccines and full costs) |
| Target delivery population | Birth cohort, infants, newborns, under 1s, older children/adolescents, unvaccinated children, 10-year-old girls, other (multiple choices), not reported or unclear |
| New vaccine introduction status | Yes or No |
| Vaccine delivery strategy | Health facility (fixed site), school, outreach, mobile, campaigns, national immunization day/week or child health day/week |
| Delivery sector | Public; Public and NGO; Public, Private and NGO; not reported |
| **Additional Comparability Criteria – Context** | |
| Country and number of countries costed | All countries for which data are available in the IDCC |
| Region | East Asia and the Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, South Asia, Sub-Saharan Africa |
| Country income level | Low income, Lower middle income, Upper middle income |
| Population size | < 10 million, 10 million to < 50 million, 50 million to <100 million, 100 million to <1 billion, 1 billion+ |
| Population density | <25 persons/$km^2$, 25 to <75 persons/$km^2$, 75 to <150 persons/$km^2$, 150 to <500 persons/$km^2$, 500+ persons/$km^2$ |
| Geographic setting | Rural, urban, mountainous, etc. |

## ANNEX 4. HOW TO INTERPRET IMMUNIZATION DELIVERY UNIT COST RANGES

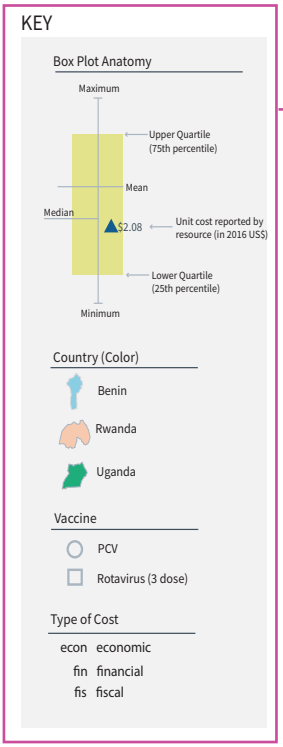
What does this **title** mean?

The **title** identifies the immunization delivery unit cost range(s) (e.g. pooled unit cost range(s)) depicted in the figure by type of costing (full/incremental), what type of vaccine(s) the range applies to (single, newly introduced vaccines, full schedules or specific vaccines such as HPV) and what costs are included (introduction/startup, recurrent/ongoing or both). The currency and year are also noted.

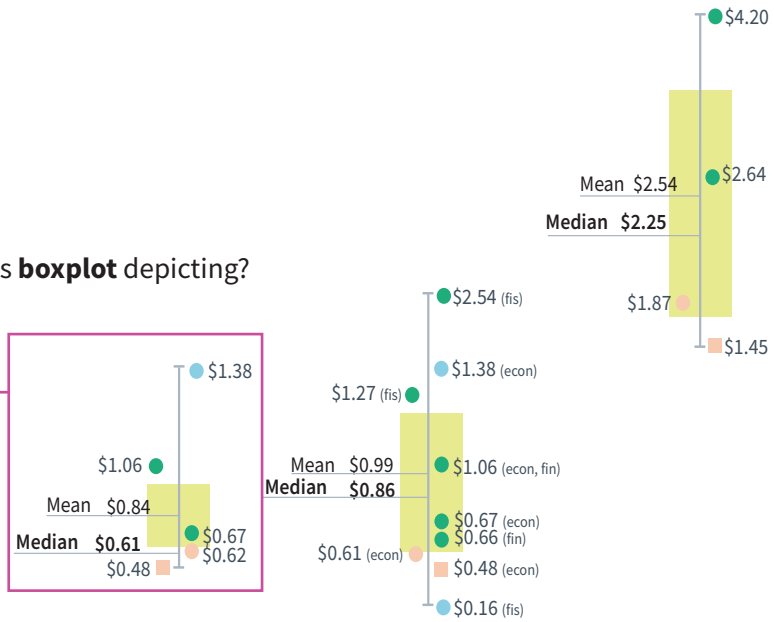
Incremental cost of single, newly introduced vaccines, excluding vaccine cost (2016 US$)

What is in **key**?

The **key** explains the box plot, the color coding and use of symbols in the figure




What is this **boxplot** depicting?




| | | | |
|---|---|---|---|
| UNIT COST (excluding vaccine cost) | Economic cost per dose | Economic, financial and fiscal cost per dose | Economic cost per full immunization of a vaccine (3 doses) |
| DELIVERY STRATEGY | Health facility (fixed site) (routine delivery, not SIA) | | |

Each **boxplot** figure depicts a pooled unit cost range. The symbols indicate individual unit costs that are part of the unit cost range. Bolded unit costs are the mean and median. Similar unit cost ranges are presented side-by-side to allow for easy identification of differences between the unit costs which may explain cost variation.

What is this **bottom section** presenting ?

The **bottom section** identifies the type of unit cost each box plot figure depicts and the delivery strategy(ies) represented by the individual unit costs used in the unit cost range.

This pooled unit cost range includes five individual immunization delivery unit costs, indicated by the colored symbols. They are:

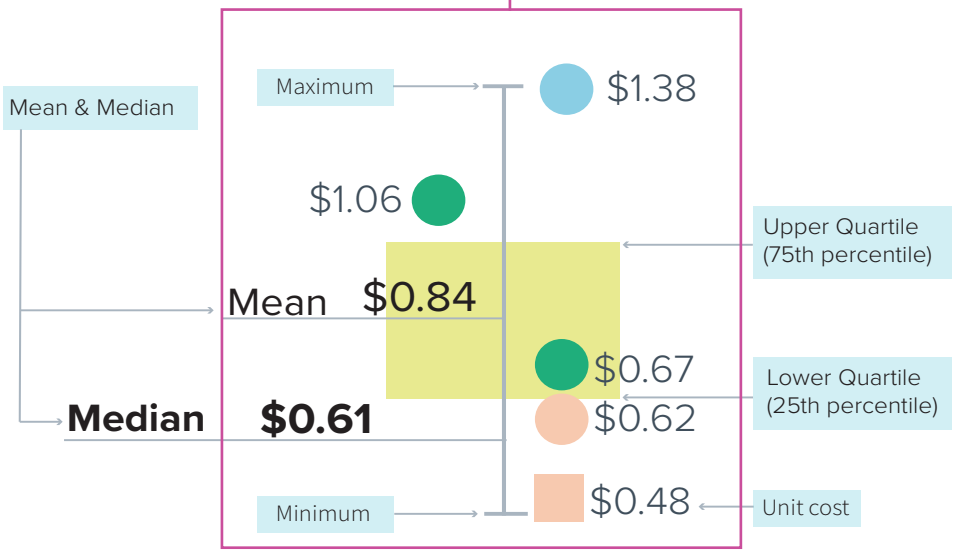
- $1.38 (blue circle, blue indicating the unit cost is from Benin, circle indicating it's for PCV vaccine)
- $1.06 (green circle, Uganda, PCV)
- $0.67 (green circle, Uganda, PCV)
- $0.62 (peach circle, Rwanda, PCV)
- $0.49 (peach square, Rwanda, Rotavirus (3 dose))

The mean is $0.84 and the median $0.67. The 25th and 75th percentile values are roughly indicated by the tan box. Please see table X for the exact values. The maximum individual unit cost estimate ($1.38) and minimum ($0.49) are indicated by the box plot end lines.

## Example Cost Range

### How to interpret the data points?

Text in the blue boxes defines the anatomy of the boxplot.




Shape signifies the vaccine type. Color denotes the country.

**EXAMPLE KEY**

Country (Color)

- Benin
- Rwanda
- Uganda

Vaccine Type

- Rotavirus (3 dose)
- PCV

| | |
|---|---|
| UNIT COST (excluding vaccine cost ) | Economic cost per dose |
| DELIVERY STRATEGY | Health facility (fixed site) (routine delivery, not SIA) |
| OTHER COST DETAILS | Includes both introduction/startup costs and recurrent/ongoing costs |

### How to interpret these results?

The **bottom section** shows cost range is the economic cost per dose, excluding vaccine cost. It's applicable for health facility (fixed site), routine delivery (not SIA).

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THINKWELL

Designed by: VISUALST