Costs of delivering COVID-19 vaccine in 92 AMC countries

Updated estimates from COVAX Working Group on delivery costs

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1 Executive summary

This report presents broad estimates of the costs of delivering COVID-19 vaccines to approximately 20% of the population in the 92 Advance Market Commitment (AMC) countries. It is assumed that the existing health system will be leveraged, and only additional resources are included - defined as financial costs. Importantly, the costs of health worker salaries are excluded from the estimates.

Total financial costs - including country, regional, and global level costs - amount to US$ 2.018 billion, equivalent to US$ 1.66 per dose supplied and US$ 3.70 per person vaccinated with two doses (after accounting for vaccine wastage).

Technical assistance and global and regional costs amount to 15% of total costs. In-country outreach and fixed site delivery comprises 57% of total costs. In-country, up-front costs, such as cold chain installation and training, comprise 28% of the total.

2 Introduction

Delivery of COVID-19 vaccines will pose unique challenges due to the urgency of achieving population immunity, targeting of non-traditional population groups, and administration of novel vaccines. Information on costs of vaccine delivery is essential for effective planning, budgeting and fundraising for the vaccine pillar of the Access to Covid-19 Tools (ACT) Accelerator[1]. A multi-organizational working group was established in early September 2020 with the task of estimating the costs of delivering COVID-19 vaccines in the 92 Advance Market Commitment (AMC) countries. The first, rapid estimates generated by the group were disseminated at the end of September 2020. This document describes updated cost estimates based on feedback received. The new estimates are based on more thorough approximations of unit costs for some of the cost categories and inclusion of global and regional activities as well as technical assistance. The differences between the previous and the updated estimates are explained in section 4.6. The most important explanation for higher total costs compared to the previous estimates is an increase in the number of doses expected to be delivered in the 92 AMC economies during 2021.

The cost estimates have been developed to facilitate planning, budgeting and fundraising at global level. Costs of COVID-19 vaccine delivery vary between countries due to price differences, diverse health system structures and divergent vaccine delivery strategies. The costs per dose estimates in this document are broad, benchmark values, which should not be used for detailed planning and budgeting in individual countries. A COVID-19 vaccine introduction and deployment costing tool has been developed for planning and budgeting within countries[2].

[1] https://www.who.int/initiatives/act-accelerator

[2] COVID-19 vaccine introduction and deployment costing (CVIC): https://www.who.int/publications/i/item/10665337553

3 COVID-19 vaccination scenario

The aim was to estimate the incremental costs of delivering COVID-19 vaccines to health care workers (HCWs), elderly and other groups, amounting to up to 20% of the population in the 92 AMC countries. Delivery costs are defined as costs associated with administering the vaccine exclusive of vaccine supplies[3]. In our analysis, syringes and safety boxes were also excluded, as these will be bundled with COVID-19 vaccines.

The costs estimated represent the additional health sector expenses needed for vaccine delivery when existing health systems components are leveraged, and costs are valued in financial terms. The viewpoint is the public health sector. Hence, resources already in place in the health system, such as health worker salaries, are not included. Costs of hiring additional health workers are not included either. Capital costs are not annualized, but the full costs allocated to year 2021. The estimates exclude costs of potential oversight and assurance of external funding, which may be necessitated in countries with weaker delivery systems or in fragile settings.

The scenario costed is summarized in Table 1. A vaccine that requires 2-8° cold storage was assumed. The costs of implementing ultra cold chain are not included, but have been estimated in a separate analysis for a relatively small target population, given that these vaccines will only comprise a small proportion of the overall COVAX facility portfolio of vaccines.

A total of two billion vaccine doses have been secured for COVAX participating countries for delivery during 2021[4]. Of these, 1,319 million doses are expected to be allocated to the 92 AMC countries, including 50 million doses for a humanitarian buffer and 50 million doses for a contingency buffer. The remaining doses will be allocated to self-financing countries (Figure 1). Delivery of the 100 million buffer doses are excluded from the cost analysis. Hence, costs of delivering a total of 1,219 billion vaccine doses to the 92 AMC countries are estimated.

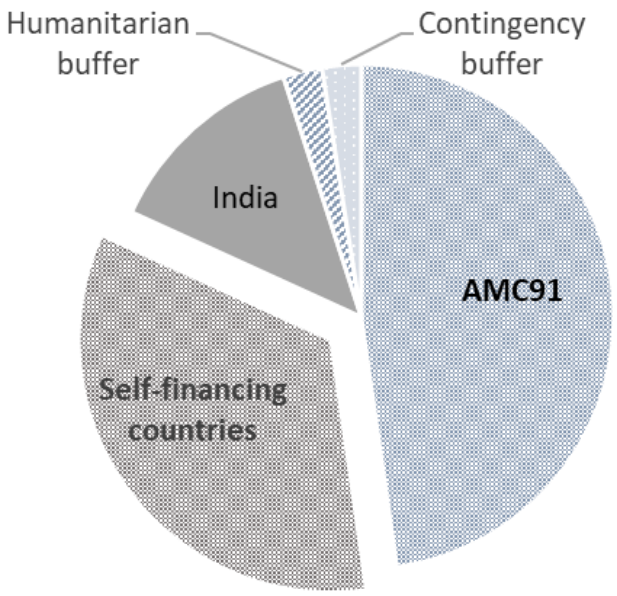
Table 1: COVID-19 vaccine scenario for delivery cost estimates

Countries included	92 AMC countries
Population target groups	Core health care workers Elderly
Number of doses in schedule	2 doses per person
Vaccine cold chain requirement	2-8°
Vaccine vial size	10 doses
Vaccine wastage	10%
Percent of population aimed to be vaccinated, excluding India	20%
Proportion of donor-funded AMC doses allocated to India	20%
Percent of population aimed to be vaccinated in India	9.47%
Number of vaccine doses for AMC91	955.2 million
Number of vaccine doses for India	263.8 million
Total number of vaccine doses supplied	1,219 million
Timeframe	2021
Strategy for reaching core health care workers	Fixed site
Strategy for reaching the elderly	Outreach

[3] Vaughan K, Ozaltin A, Mallow M, Moi F, Wilkason C, Stone J, Brenzel L. The costs of delivering vaccines in low- and middle-income countries: Findings from a systematic review. Vaccine X. 2019 Jul 15;2

[4] https://www.who.int/news/item/18-12-2020-covax-announces-additional-deals-to-access-promising-covid-19-vaccine-candidates-plans-global-rollout-starting-q1-2021

Figure 1: Distribution of 2 billion Covid-19 vaccine doses from COVAX



It was assumed that countries will first prioritize vaccination of HCWs and subsequently the elderly, defined as people above 65 years. The subsequent target group was assumed to be people between 50 and 64 years, followed by the population less than 50 years of age. These are simplifying assumptions based broadly on the SAGE values allocation framework[5]. Preliminary insights from COVAX vaccine request forms show that while almost all countries list HCWs as the initial target population, 20 out of 82 countries subsequently prioritize groups such as the police, security forces or government officials over elderly and those with co-morbidities[6].

It was assumed that HCWs would be reached through fixed site delivery while the elderly would be reached via outreach services. As HCWs are already based at health facilities, fixed site delivery is considered the most sensible strategy for reaching this group. Outreach services was deemed the most feasible delivery strategy for reaching the elderly because there will be no registration systems available in most settings to notify people about how to attend vaccination services.

Coverage rates were assumed as 90% for HCWs and 80% for the other target groups. The number of core HCWs in each of the 92 countries were derived from the WHO National Health Workforce Accounts (NHWA)[7]. In this database, core HCWs consist of medical doctors, nursing personnel, midwifery, dentists and pharmacists. The number of core HCWs in the 92 countries is around 14.9 million people, ranging from 0.25% of the population in Gavi eligible countries to 0.54% in non-Gavi eligible AMC countries. It should be noted that community health workers are not included

[5] WHO SAGE values framework for the allocation and prioritization of COVID-19 vaccination, 14 September 2020 https://apps.who.int/iris/bitstream/handle/10665/334299/WHO-2019-nCoV-SAGE_Framework-Allocation_and_prioritization-2020.1-eng.pdf?sequence=1&isAllowed=y

[6] Preliminary insights from COVAX vaccine request forms show that while almost all countries list HCWs as the initial target population, 20 out of 82 countries subsequently prioritized groups such as the police, security forces or government officials over elderly and those with co-morbidities (Source: Presentation to COVAX Core Coordination Meeting (CCM) on 16th December 2020

[7] https://apps.who.int/nhwaportal/Home/Welcome?ReturnUrl=%2Fnhwaportal%2FHome%2FIndex

in the database, so the numbers of HCWs targeted for COVID-19 vaccination is likely an underestimate. This could lead to overestimation of costs because HCWs are likely less costly to vaccinate than other population groups because they are easier to locate. The total population of the 92 economies is almost 4 billion people (Table 2).

Table 2: Size of population groups in the 92 AMC economies (2021)

	Core HCWs	People 65+	People 50-64 years	Population <50 years old	Total
Gavi eligible (n=57)	4,597,161	73,263,345	162,799,204	1,611,430,171	**1,852,089,881**
India	6,646,648	94,361,715	180,495,957	1,111,853,439	**1,393,357,759**
Gavi transitioned (n=12)	1,869,054	31,023,294	58,930,267	315,714,620	**407,537,235**
Non-Gavi (n=22)	1,764,337	20,314,269	38,830,771	265,619,599	**326,528,977**
Total (n=92)	**14,877,200**	**218,962,623**	**441,056,199**	**3,304,617,829**	**3,979,513,852**
Percent of total	**0.37%**	**5.50%**	**11.08%**	**83.04%**	**100%**

4 Assumptions and methods for cost estimates

Costs of COVID-19 vaccine delivery for the 92 AMC countries were estimated at global, regional and country levels. While most costs will be incurred within countries during deployment preparations and for administering the vaccine, important activities are necessary at global and regional levels. Global and regional activities included were:

- Technical Assistance
- Innovations (smart vaccination certificates, traceability solutions, real-time monitoring, digital micro-planning, digital tools for safety monitoring)
- Pharmacovigilance activities at regional and global levels
- Post-introduction evaluations

4.1 Country-level delivery costs

A total of 13 cost categories were included for country-level delivery costs (Table 3). Syringes and safety boxes will be bundled with the COVID-19 vaccines, so these were not included in the delivery cost estimates. Unit costs were scaled to total costs by either multiplying by number of vaccine doses, number of health facilities in the respective country, or assuming total costs per country (Table 3). The number of health facilities per country were gathered from either the Global Health Observatory database[8] or from Gavi applications for the Cold Chain Equipment Optimization Platform (CCEOP). When comparing with local knowledge, it was apparent that both data sources seemed to underestimate the number of health facilities. We therefore used the source with the highest number of health facilities for a country.

[8] Global Health Observatory indicator views, https://apps.who.int/gho/data/node.imr

Table 3: Costs categories included in delivery cost estimates

	Cost category	Scaling factor
1	Planning and coordination	Country
2	Training	Facility
3	Social mobilization	Facility and country
4	Cold chain equipment (2-8°)	Dose
5	Cold chain recurrent	Dose
6	Pharmacovigilance	Facility and country
7	Vaccination certificates	Dose
8	Protective Personal Equipment (PPE) for health care workers	Dose
9	Hand hygiene for health care workers and vaccine recipients	Facility and dose
10	Vaccine transport	Dose
11	Waste management	Dose
12	Per diem for outreach service delivery and supervision	Dose
13	Transportation for outreach services	Dose

An important data source for unit costs was the Immunization Delivery Cost Catalogue (IDCC)[9]. This database stores resources on vaccine delivery costs in low- and middle-income countries (LMICs) from a large, systematic review of published and unpublished studies available since 2005. Data from IDCC were complemented with information from vaccination campaign budgets and Human Papilloma Virus (HPV) vaccine introduction budgets. Cold chain equipment costs were derived from the PATH Installed Base and Forecast Model. All costs were inflated to 2020 values. Unit costs assumptions for each of the categories are seen in Table 4. Details of data sources and assumptions for each of the cost categories are included in Annex 1.

As an example, transportation costs for outreach will decrease with the number of doses delivered in an outreach session. Since many data points were derived from studies and budgets campaigns targeting infants, where sometimes as many as 100-200 doses could be delivered on a given day, the number of doses delivered were adjusted to reflect the most likely number of doses administered when targeting health care workers and the elderly. It was assumed that 50 doses would be delivered per session at fixed sites and 30 doses per outreach session.

Fixed costs are defined as items that do not vary substantially by the number of doses delivered, such as planning and coordination. Variable costs vary with the number of vaccine doses delivered.

Unit costs vary between countries because of different salary levels and prices of goods, while the costs of tradable goods, such as cold chain equipment, are generally relatively similar across countries. Unit costs related to non-tradeable items were adjusted in the analysis as follows. Four cost categories were adjusted according to purchasing power parity (PPP): (i) training, (ii) vaccine transport, (iii) per diems and (iv) transportation for outreach. The methodology developed by Portnoy and colleagues for adjusting unit costs for PPP was used[10]. For social media listening, country-specific salaries were used to adjust the estimates. Country-specific water tariffs for costs of infection prevention and control were used.

[9] http://immunizationeconomics.org/ican-idcc

[10] Portnoy A, Vaughan K, Clarke-Deelder E, Suharlim C, Resch SC, Brenzel L, Menzies NA. Producing Standardized Country-Level Immunization Delivery Unit Cost Estimates. Pharmacoeconomics. 2020 Sep;38(9):995-1005.

Table 4: Unit cost assumptions (US$)

	Variable costs		Fixed costs			Adjusted for PPP or country specific prices
Cost category	**Facility delivery per dose**	**Outreach per dose**	**Per facility**	**Per country**	**Per large/conflict country**	
Planning and coordination				590,000	800,000	No
Training*			62.79			Yes
Social mobilization:						
Community awareness			750.00			No
Behavioral data				30,000	100,000	No
Social media listening				Country specific		Yes
Cold chain equipment (2-8°)				Country specific		Yes
Cold chain recurrent	0.01	0.01				No
Pharmacovigilance			78.77			No
Vaccination certificates	0.03	0.03				No
PPE	0.07	0.11				No
Hand hygiene:						
Sanitizer	0.1	0.1				No
Water	Country specific					Yes
Soap		0.01				No
Buckets for outreach			12.46			No
Vaccine transport*	0.04	0.04				Yes
Waste management	0.044	0.044				No
Per diem for outreach*		1.39				Yes
Transportation for outreach*		0.49				Yes

*Costs adjusted according to PPP for each country. Estimates listed are median values across the data sources (details given in Annex 1)

4.2 Technical Assistance

Due to the urgency and complexity of COVID-19 vaccine roll-out, substantial technical assistance (TA) will be required in all 92 AMC economies. TA will be provided by several different organizations, including WHO, UNICEF, USAID and Centers for Disease Control. Financing for TA is needed at global, regional and country levels.

The 13 vaccine delivery cost categories are closely interlinked, and TA is needed for all aspects of vaccine delivery. Planning and coordination should ensure that all activities and commodities are delivered coherently and in the right order. The vaccine can for instance not be administered until staff has been trained and the cold chain is in place. For commodity cost categories, such as cold chain and PPE, TA is needed for installment and in-country logistics.

Costs of TA was approximated as an additional percentage of delivery costs for each of the categories. Twenty percent of costs was assumed for activities that require updated or new systems and procedures: Planning and coordination, cold chain, training, social mobilization, pharmacovigilance, vaccine transport, and waste management. Ten percent was assumed for categories that largely consist of recurrent commodities: Vaccination certificates, PPE, and hand hygiene. Five percent was assumed for costs that are largely transactional: Cold chain recurrent, per diem and transportation for outreach.

4.3 Global and regional level costs

4.3.1 Pharmacovigilance

Since all COVID-19 vaccines are novel vaccines that have never been used in humans on a large scale, strong pharmacovigilance will be imperative. The WHO COVID-19 pharmacovigilance working group recommends that there should be a safety committee in each WHO region that meets frequently to assess all available data, both from routine safety surveillance and from studies. Members of these committees should be trained, and they should be paid for their time and expertise. The committees should be in place for at least one year after vaccine introduction.

At global level, it is desirable that country representatives are engaged during the pre-qualification stage of the various COVID-19 vaccines. The aim is to transfer expertise in pharmacovigilance to stakeholders in LMICs. The approximate, annual costs for ensuring strong engagement in pharmacovigilance amount to US$ 2.4 million (Table 5).

Table 5: Costs of global and regional pharmacovigilance activities

Activity	Quantity	Unit costs	Annual costs (US$)	Costs for three years (US$)
Regional safety committees	10	150,000	1,500,000	4,500,000
Country engagement in global pharmacovigilance activities	92	10,000	920,000	2,760,000
Total			**2,420,000**	**7,260,000**

4.3.2 Innovations

Five innovations are being accelerated to advance COVID-19 vaccine delivery (Table 6). Costs of implementing the innovations over the next three years were approximated by the respective COVAX innovation working groups. Total costs were estimated at US$ 77.9 million, with US$ 33.6 needed in 2021.

Table 6: Innovations planned for deployment during COVID-19 vaccine introduction (US$)

Innovation	Objective	Costs during 2021	Costs for three years
Smart vaccination certificates	To create interoperable standards for a global vaccine certificate system that allows for the diversity of solutions in countries to have trusted, cross-border data exchange	11,025,000	28,125,000
Traceability solution	To develop a traceability model that can be rapidly deployed at the global and country level to support supply chain security and vaccine safety	11,250,000	19,000,000
Real-time monitoring	To manage vaccination outreach and campaigns in "real time" with vaccination workers receiving daily guidance by SMS or WhatsApp on which communities they are to visit, their targets for number of people to be vaccinated, and updates on whether the target in a community has been met	3,440,000	9,267,500
Digital micro-planning	To introduce a set of decision-making steps and tools, such as GIS, spatial analysis, satellite imagery and artificial intelligence to optimize vaccine delivery through mapping of target populations, vaccination session planning, cold chain and logistics operations, supervision, recording, reporting and monitoring	6,699,167	18,787,500
Digital tools for safety monitoring	To either implement case-based safety data within DHIS2 or vigiflow management system for adverse event recording	1,200,000	2,700,000
Total		**33,614,167**	**77,880,000**

4.3.3 Post-introduction research evaluations

Post-introduction research evaluations are needed to assess effectiveness and impact, programmatic aspects, safety, costing and financing, as well as social and behavioral issues. A post-implementation evaluation taskforce with emphasis on LMICs has been established under the leadership of the WHO. The aim of the taskforce is to co-ordinate ongoing and planned evaluation activities and make linkages between focus areas.

Approximate costs for the study topics represented in the taskforce are seen in Table 7. It is not recommended that all countries undertake safety studies, but at least one study should be undertaken in each WHO subregion. It is for instance necessary to evaluate the safety of using the vaccine in children and during pregnancy.

For programmatic evaluations, it is expected that countries will conduct an early, rapid version of the post-introduction evaluation (PIE) that only addresses specific areas of concern (such as ultra cold chain or how to access certain target populations) and in addition also undertake a full PIE 6-12 months after introduction.

Total costs of post introduction evaluations amount to approximately US$ 13.4 million.

Table 7: Costs of post-introduction research studies of COVID-19 vaccine

Topic area	Number of studies	Cost per study (US$)	Total (US$)
Impact cohort studies	4	375,000	1,500,000
Vaccine effectiveness	15	75,000	1,125,000
Programmatic	100	35,000	3,500,000
Safety	30	150,000	4,500,000
Costs and financing	8	60,000	480,000
Social and behavioral	15	150,000	2,250,000
Total	172		**13,355,000**

5 Results

5.1 Number of people to be reached with COVID-19 vaccine

A total of 546.3 million people is predicted to be vaccinated with COVID-19 vaccine during 2021 (Table 8). This is equivalent to 8.52% of the population in India and 17% of the population in the remaining 91 economies. The population reached is less than 20% as targeted by COVAX due to the assumption of 10% vaccine wastage.

Core HCWs comprise 2.5% of the population reached, people aged 65 years and older comprise 32%, and people between 50 and 64 years comprise 42%. The demographic composition determines whether there are doses left for vaccinating the population less than 50 years. The following 16 countries have a relatively old population compared to the other countries and will not have vaccines left for vaccinating people less than 50 years: El Salvador, Fiji, Grenada, Guyana, India, Indonesia, Moldova, Morocco, Myanmar, North Korea, Saint Lucia, Saint Vincent, Sri Lanka, Tunisia, Ukraine and Vietnam.

Table 8: Number of people predicted to be vaccinated with two doses of COVID-19 vaccine during 2021 (coverage)

	HCWs	People 65+	People 50-64 years	Population <50 years old	Total
Gavi eligible (n=57)	4,137,445 (90%)	58,610,676 (80%)	125,013,809 (77%)	118,073,630 (7%)	**305,835,560 (17%)**
India	5,981,983 (90%)	75,489,372 (80%)	37,238,646 (21%)	(0%)	**118,710,001 (8%)**
Gavi transitioned (n=12)	1,682,149 (90%)	24,818,635 (80%)	37,024,751 (63%)	3,938,419 (1%)	**67,463,954 (17%)**
Non-Gavi (n=22)	1,587,903 (90%)	16,251,415 (80%)	29,896,964 (77%)	6,535,467 (2%)	**54,271,749 (17%)**
Total (n=92)	**13,389,480 (90%)**	**175,170,099 (80%)**	**229,174,171 (52%)**	**128,547,515 (4%)**	**546,281,265 (14%)**
Percent of total	**2.5%**	**32%**	**42%**	**24%**	

5.2 Country-level delivery costs

Total, country-level costs of delivering 1,219 million doses were estimated at US$ 1.722 billion (Table 9). **This is equivalent to US$ 1.41 per dose supplied and US$ 3.15 per person vaccinated with two doses** (after accounting for wastage). Upfront costs for activities and investments that need to be in place before vaccination can start total US$ 576 million.

Three cost categories comprise 63% of total costs: per diem for outreach (33%), social mobilization (18%) and transportation for outreach (12%).

Table 9: In-country costs of delivering 1,219 million COVID-19 vaccine doses (US$)

Cost category	Upfront	Recurring		Total	Percent of total
		Facility	Outreach		
Planning and coordination	68,350,000			68,350,000	4%
Training	16,636,305			16,636,305	1%
Social mobilization	316,256,959			316,256,959	18%
Cold chain equipment (2-8°)	137,935,484			137,935,484	8%
Cold chain recurrent		3,154,155	8,991,480	12,145,636	1%
Pharmacovigilance	32,118,038			32,118,038	2%
Vaccination certificates		9,462,466	26,974,441	36,436,907	2%
PPE		22,079,088	98,906,283	120,985,371	7%
Hand hygiene	5,080,715	31,541,555	98,906,283	135,528,552	8%
Vaccine transport		6,926,325	16,329,953	23,256,279	1%
Waste management		13,878,284	39,562,513	53,440,797	3%
Per diem for outreach			567,465,884	567,465,884	33%
Transportation for outreach			200,041,930	200,041,930	12%
Total	**576,377,501**	**86,894,562**	**1,058,734,348**	**1,722,006,412**	**100%**
Percent of total	33%	5%	61%	100%	

5.3 Technical Assistance

Technical Assistance is approximated at US$ 198 million, equivalent to US$ 0.16 per vaccine dose supplied (Table 10).

Table 10: Global, regional and country-level Technical Assistance

Cost category	Delivery costs	Percent of value needed for TA	TA (US$)
Planning and coordination	68,350,000	20%	13,670,000
Training	16,636,305	20%	3,327,261
Social mobilization	316,256,959	20%	63,251,392
Cold chain equipment (2-8°)	137,935,484	20%	27,587,097
Cold chain recurrent	12,145,636	5%	607,281
Pharmacovigilance	32,118,038	20%	6,423,608
Vaccination certificates	36,436,907	10%	3,892,025
PPE	120,985,371	10%	12,023,148
Hand hygiene	135,528,552	10%	13,576,190
Vaccine transport	23,256,279	20%	4,991,906
Waste management	53,440,797	20%	10,688,148
Per diem for outreach	567,465,884	5%	28,271,910
Transportation for outreach	200,041,930	5%	9,990,596
Total	**1,722,006,412**		**198,300,560**

5.4 Global and regional level costs

Global and regional level costs amount to approximately US$ 99 million over three years (Table 11).

Table 11: Global and regional level costs (US$)

Activity	Costs in 2021	Total costs (three years)	Percent of total
Innovations	33,614,167	77,880,000	79%
Post-introduction evaluations	4,451,667	13,355,000	7%
Pharmacovigilance	2,420,000	7,260,000	14%
Total	**40,485,833**	**98,495,000**	**100%**

5.5 Total costs

Total financial costs - including country, regional, and global level costs - amount to US$ 2.018 billion, equivalent to **US$ 1.66 per dose supplied and US$ 3.70 per person vaccinated** with two doses (Table 12) (after accounting for wastage). The costs per dose supplied was calculated by dividing total costs with total number of doses supplied (1.219 billion doses). The costs per person vaccinated with two doses were estimated by dividing total costs by 546,281,265 people

vaccinated. Hence, the number of doses delivered are 1,092,562,529. The difference between doses supplied and doses delivered is explained by the assumed 10% vaccine wastage rate.

Technical assistance and global and regional costs amount to 15% of total costs. In-country outreach and fixed site delivery comprises 57% of total costs and in-country up-front costs comprise 28% of the total (Table 13 and Figure 3).

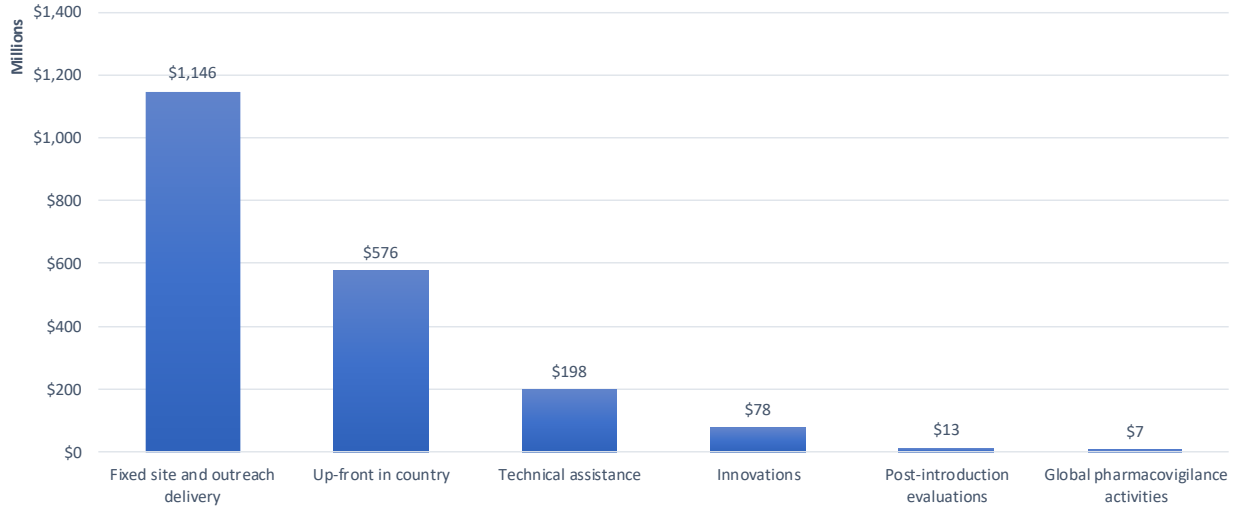
Table 12: Total costs according to Gavi eligibility country groupings (US$)

	Total (US$ millions)	US$ per dose supplied	US$ per person vaccinated with 2 doses	Percent of total
Gavi eligible (n= 57)	951	1.39	3.11	55%
India	283	1.07	2.39	16%
Gavi transitioned (n=12)	250	1.66	3.70	13%
Non-Gavi (n=22)	238	1.97	4.39	14%
Technical Assistance	198	0.16	0.36	10%
Global and regional	98	0.08	0.18	5%
Total	**2,019**	**1.66**	**3.70**	**100%**

Table 13: Total costs according to cost category

Category	Total (US$ millions)	Percent of total
Fixed site and outreach delivery	1,146	57%
Up-front in country	576	28%
Technical assistance	198	10%
Innovations	78	4%
Post-introduction evaluations	13	1%
Global pharmacovigilance activities	7	0.4%
Total	**2,019**	**100%**

Figure 3: Costs of COVID-19 vaccine delivery in 92 AMC economies during 2021



5.6 Limitations

Unit costs for in-country delivery were based on best available data for each of the different cost categories, as described in Annex 1. COVID-19 vaccine will however be delivered to different population groups and in different manners than the studies and budgets of which the approximations are based upon. Moreover, delivery strategies are uncertain and expected to vary between countries. There are thus substantial uncertainties and the unit cost estimates should be viewed as broad approximations with wide confidence intervals. To improve the evidence on costs, it will be important to gather data alongside vaccine introductions in countries representing different settings.

Only financial costs have been estimated. This is especially a limitation regarding the costs of human resources because salary costs are not included. It is likely that counties will need to recruit additional staff to be able to administer the large volume of vaccines and these costs are not included.

5.7 Comparison with previous estimates

In the preliminary analysis distributed at the end of September 2020, total costs were estimated at US$ 1.5 billion for delivering 1,050 billion doses, equivalent to US$ 1.41 per dose delivered and US$ 3.02 per person vaccinated with two doses. The costs have now increased to US$ 2 billion. In the present, updated analysis, the number of doses predicted to be delivered in 2021 has according to COVAX plans and predictions increased to 1,219 million doses. This increase drives the rise in the global cost estimate. Costs per dose in the updated analysis is US$ 1.66 compared to the previous US$ 1.41 per dose. The increase is explained by the inclusion of regional and global costs in the form of technical assistance, innovations, pharmacovigilance and post-delivery evaluations. The costs per dose of in-country delivery has not changed – it remained at US$ 1.41 per dose despite changes in data and assumptions.

Annex 1: Assumptions and data sources for country-level delivery cost categories

A. Planning and coordination

Given the higher expected costs of COVID-19 vaccine introduction compared to previous new vaccine introductions, we relied on planning and coordination costs from an analysis of Gavi Technical Assistance for national HPV vaccine introduction in seven countries during 2019: Côte d'Ivoire, the Gambia, Kenya, Liberia, Malawi, Solomon Islands, and Zambia. Specifically, we assumed the median value across these seven countries as the default assumption, and the maximum value across the seven countries as the assumption for countries with a population size greater than 10 million or with major conflict zones. AMC countries with a population size less than 10 million categorized with major conflict zones are Central African Republic, Eritrea, Guinea-Bissau and West Bank and Gaza (Table A4).

Table A4: Planning and co-ordination costs for COVID-19 vaccine introduction

Activity	Default per country	>10 million people or conflict country
Planning & coordination	US$ 590,000	US$ 800,000

B. Training

Due to the pandemic, health worker training in preparation for COVID-19 vaccine introduction is expected to partly rely on virtual methods. The WHO has prepared a comprehensive curriculum with training materials that can be delivered either online or by an instructor as part of in-person training. If training is delivered in person, numbers may have to be restricted to ensure social distancing.

Virtual training is likely less expensive than in-person training since health workers do not have to travel to the training venue, and there are no expenses for rental of conference rooms, refreshments, etc. Costs of virtual training mainly consist of establishing online systems at the national level and ensuring that health workers have access to computers and/or smart phones. However, national coordination costs may increase.

Since there is not yet any data available on methods used for health worker training, we based costs on previous new vaccine introductions even though these were solely using in-person training. This could be an over-estimate of training costs for COVID-19 vaccine. However, since the vaccine will target a new population group and since introduction needs to take place at unprecedented speed, training of staff is an essential activity and it is imperative that the budget is adequate. The estimates will be updated when more information on training modalities and its costs become available.

Cost data were gathered from vaccination campaigns and new vaccine introduction budgets (Table A5). Example budget items were per diem, transport, refreshments, and venue rentals. The costs of training were converted from national (or subnational) amounts to per facility estimates, assuming that training costs would scale with the number of facilities in a given country. The number of health facilities per country was derived from the Global Health Observatory or taken from the respective article.

The cost per facility ranged from US$0.49 based on a new vaccine introduction study in Côte d'Ivoire to US$4,640 per facility in Solomon Islands. No correlation could be identified between cost and size of the country, the size of the campaign, type of vaccine or region. Therefore, a crude median across all available data was used, reducing the impact of outliers and resulting in a median of US$ 63 per health facility. This value was used as a *scaling factor* for extrapolation of existing data to all 92 countries. The costs include training at all levels; not just in health facilities.

Table A5: Cost per facility for training

Data source	Cost per facility (US$ 2020)
Polio house to house campaign budgets	
Benin	183
Mali	37
Papua New Guinea	68
South Sudan	59
Syria	58
Influenza vaccine studies	
Malawi, targeting pregnant women	170
Campaign budgets	
Ethiopia, yellow fever campaign	4
India, measles-rubella campaign	172
Sierra Leone, measles-rubella catch-up campaign	240
IDCC campaign costing literature	
Bangladesh, oral cholera vaccine	67
Benin, measles	72
Burkina Faso, meningitis A	2
Ethiopia, oral cholera vaccine campaign	214
New vaccine introduction costing studies	
Bhutan, PCV10	274
Rwanda, PCV7	47
Rwanda, Rota	28
Rwanda, HPV	95
Uganda, PCV10	54
HPV budgets	
Cote d'Ivoire	0.49
Kenya	52
Liberia	50
Malawi	84
Solomon Islands	1,288
Median: US$ 63	

C. Social mobilization

The costs of social mobilization activities include three components:

1. Behavioral and social data collection
2. Social listening
3. Social mobilization activities associated with prior 'new vaccine introductions'

As components (1) and (2) were not costed in prior analyses of new vaccine introductions, we gathered information from experts at WHO, UNICEF, BMGF, Common Thread and Johns Hopkins University. For behavioral and social data collection, the WHO recommends a sample size of 400 people for the immunization survey instrument that is currently being pilot tested at a likely cost of US$ 80 per interview. Hence, we assumed a cost of US$ 30,000 per country on average as the default assumption. For countries with a population size greater than 10 million or with major conflict zones, we assumed a cost of $100,000, as either a larger sample size or higher cost per interview would be expected. Countries with a population size less than 10 million categorized with major conflict zones are Central African Republic, Eritrea, Guinea-Bissau and West Bank and Gaza.

For social listening, following consultation with the Johns Hopkins Center for Communication Programs, we assumed that one monitoring and evaluation (M&E) level officer would be required to monitor social media, off line media, data from helplines and other community feedback mechanism, analyze data and produce reports, which would systematically feed into the programme to inform communication strategies, advocacy agenda and programme response. Two M&E level officers were assumed required in countries with a population size greater than ten million or with major conflict zones. Health care worker wages were estimated as multiples of GDP using estimation from a paper by Serie *et al*[14] that reports salaries for three groups; medical doctors, nurses and midwives, and other health care workers. We used an average of the multiple for the latter two groups.

Social mobilization for supporting new vaccine introduction include social mapping at community level to identify priority population to be vaccinated, influencers, and their profiles; production and dissemination of message content, mass media and print material; community engagement activities, such as dialogue at community level, interpersonal communication at household level through social mobilisers and CSO engagement, mobilization of youth groups, men and women group, community based organization and religious leaders. This also includes capacity building of frontline workers on social and behavior change communication and costs for monitoring and supervision of communication and community engagement activities.

We utilized estimates from the Immunization Delivery Cost Catalogue[11,12,13] and Gavi's analysis on technical assistance for seven countries introducing HPV vaccine in 2019: Côte d'Ivoire, the Gambia, Kenya, Liberia, Malawi, Solomon Islands, and Zambia. We doubled the costs of mass media dissemination (TV/radio ads) and community advocacy/sensitization as recommended by the COVID-19 vaccine Social Mobilization working group. We assumed that these costs scaled

[11] Ngabo F, et al. (2015). A cost comparison of introducing and delivering pneumococcal, rotavirus and human papillomavirus vaccines in Rwanda. Vaccine, 33(51), 7357–7363

[12] Guthrie T, et al. (2014). Costing and Financing Analyses of Routine Immunization in Uganda.

[13] Dorji K, et al. (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.

on a per-facility rather than per-country level. This resulted in a cost of US$ 750 per health facility (Table A6).

Table A6: Social mobilization costs of COVID-19 vaccine introduction (US$)

Unit	Activity	Default country-level cost	Cost in countries with population > 10 million / conflict zones
Country	Behavioral and social data collection	30,000	100,000
Country	Social media listening (annual cost of 1-2 M&E officers)	Varies according to country[14]	Varies according to country
Facility	Social mobilization 'new vaccine introduction' activities	750	750

D. Cold chain equipment

The PATH Installed Base and Forecast model includes country-specific data on spare capacity in national, regional and district cold stores as well as in health facilities. Capacity is measured in liters. The data on cold chain capacity has been gathered from Gavi CCEOP applications and from WHO/UNICEF databases. Data from district cold stores or health facilities are available from 48 countries (predominantly Gavi-eligible) while national and regional level storage capacity data are only available from 35 and 36 countries, respectively.

Capacity data from the Gavi eligible countries show that the biggest needs are at national and regional levels. Due to recent CCEOP investments, most Gavi eligible countries have enough spare capacity in district cold stores and in health facilities. Capacity data from non-Gavi eligible AMC countries is more limited, particularly at the district and health facility levels.

For countries where capacity data is available, cold chain costs are estimated based on the difference between existing capacity and required capacity. For Gavi eligible countries with no capacity data available and for the non-Gavi eligible AMC countries, it was assumed that there is no spare capacity at the national and regional levels, and therefore full expansion is needed to accommodate COVID-19 vaccine introduction. National and regional levels will be the main storage hubs for COVID-19 vaccines and so it was assumed that countries will need the full expansion of capacity at these levels. We assumed that only a certain proportion of district level stores will be equipped with new cold chain equipment. This proportion is currently assumed to be 20%. We assumed that no countries need to add capacity at facility level in order to store COVID-19 vaccines.

It was assumed that there should be a 25% reserve capacity in 2-8°C refrigerators. Two ice pack freezers were assumed per region. For the 20% of districts with assumed expansion, we assumed one ice pack freezer per store.

The types of equipment assumed to be purchased to ensure cold chain expansion is summarized in Table A7. Unit prices from the COVAX cold chain equipment application form was used. An average was taken across unit prices and service bundle costs for the different brands of equipment.

[14] Serje J, Bertram MY, Brindley C, Lauer JA. Global health worker salary estimates: an econometric analysis of global earnings data. Cost Eff Resour Alloc. 2018 Mar 9;16:10

The need for cold chain expansion depends on the frequency of vaccine deliveries; the more annual deliveries, the less need for cold chain expansion. The annual number of shipments from vaccine manufacturer to country was assumed to be four. Similarly, four, annual deliveries were assumed from national to regional levels.

Table A7: Cold chain equipment purchased for expansion (US$)

Equipment	Net volume per unit	Unit cost	Service bundle cost	Total costs
National level				
Walk-in cold room	3,030 L – 9,500 L	25,000	18,750	**43,750**
Regional level				
Ice lined refrigerator (large)	200 L	1,813	1,000	**2,813**
Freezer for ice pack preparations	200 L	562	1,000	**1,562**
District level				
Ice lined refrigerator (large)	200 L	1,813	1,000	**2,813**
Solar direct drive refrigerator (large)	200 L	4,826	1,689	**6,515**
Freezer for ice pack preparations	200 L	562	1,000	**1,562**

E. Pharmacovigilance surveillance

The WHO has issued guidelines for establishing safety surveillance systems in countries using COVID-19 vaccines[15]. The minimum requirements for all countries are:

a) All facilities must have an adverse event reporting form. This can either be a paper format or digital (costs of digital is included in the global/regional innovation costs)
b) Training of facility staff in adverse event assessment and reporting
c) System to enable facilities to report adverse events to national level
d) National database to capture adverse event data reported by facilities
e) Continuous data entry into the national database
f) Regular analysis of adverse event data
g) Communication strategy for reacting to real and perceived adverse events
h) Website for publishing data
i) National AEFI committee

Costs of establishing the system include recruitment of staff and training. Each country needs to have a core number of people responsible for pharmacovigilance. Training material that can be used by countries has been developed by WHO. A standard database format capturing adverse event reporting has also been developed by WHO and distributed to approximately 100 countries.

The Roll Back Malaria Initiative recommended in 2008 that a national pharmacovigilance programme for anti-malarial drugs should cost between US$ 150,000 and US$ 250,000 for start-up with recurrent costs of around US$ 50,000 per year[16,17]. In 2019 USD, this amounts to around $205,500 to $342,600 for start-up and $68,500 in recurrent costs per year, which is the assumption we used for COVID-19 vaccine in each country. Stergachis *et al*. (2009) analyzed funding requests

[15] https://www.who.int/vaccine_safety/committee/Module_Establishing_surveillance_systems.pdf?ua=1

[16] Stergachis A, Bartlein RJ, Dodoo A, Nwokike J, Kachur SP. A situational analysis of pharmacovigilance plans in the Global Fund Malaria and U.S. President's Malaria Initiative proposals. Malar J. 2010 May 30;9:148

[17] Babigumira JB, Stergachis A, Choi HL, Dodoo A, Nwokike J, Garrison LP Jr. A framework for assessing the economic value of pharmacovigilance in low- and middle-income countries. Drug Saf. 2014 Mar;37(3):127-34

to the President's Malaria Initiative for pharmacovigilance activities, which ranged from US$ 33,333 in Madagascar to US$ 133,333 in Mali on an annual basis. On a per facility, the median for all seven countries analysed amounted to US$ 58.82 annually, which equal US$ 78.80 in 2019 values (Table A8).

For comparison, Table A9 shows data extracted from IDCC and campaign budgets on AEFI management or surveillance as part of routine immunization services or vaccination campaigns. Over 50% of AEFI surveillance costs during the measles-rubella Sierra Leone campaign were incurred at district level, the vast majority of which were for per diems and travel allowances.

Table A8: Costs of pharmacovigilance for artemisinin-based combination therapy

Data source	PMI 2009 – US$ requested over 3 years	Single year per facility cost (2009 US$)
Ghana	110,000	7.19
Madagascar	100,000	5.56
Malawi	700,000	273.54
Mali	400,000	103.76
Mozambique	300,000	58.82
Rwanda	112,100	68.44
Uganda	290,000	14.74
Median (2009 US$):		58.82
Median (2019 US$):		**78.8**

Table A9: Costs of 'regular' AEFI surveillance as comparator (US$ 2020)

Data source	Cost per country	Cost per dose
Studies reporting on the cost of outreach services		
Indonesia	(not estimated)	0.01
Tanzania	(not estimated)	0.003
Campaign budget		
Sierra Leone, measles-rubella catch-up campaign	26,101	0.01
IDCC campaign costing literature		
Burkina Faso, Meningitis A campaign	5,921	0.001
Ethiopia, oral cholera vaccine campaign	(pilot)	0.02
India, oral cholera vaccine campaign	(pilot)	0.09
New vaccine introduction study		
China, Japanese encephalitis vaccine	(subnational)	0.02
Median:		**0.01**

F. Vaccination certificates

Unit costs of providing vaccination cards to beneficiaries were extracted from the sources listed in Table A10. Each of the campaigns included incurred costs or budgeted for providing a record of vaccination (in the form of a small card) to beneficiaries or for children to show to their parents. In the Mozambique OCV campaign, a vaccination card was issued during the first round of immunization and had to be presented before receiving a dose in the second round. Prior to the OCV campaign in Bangladesh, a census was conducted, and a bar-coded card was issued to eligible participants which was to be taken to the vaccination site. The median of all data points was US$ 0.03 per dose.

Table A10: Cost per dose of vaccine certificates

Data source	**Cost per dose (US$ 2020)**
Campaign budgets	
Ethiopia, yellow fever	0.16
India, measles-rubella campaign	0.08
Sierra Leone, measles-rubella catch-up campaign	0.03
IDCC campaign costing literature	
Bangladesh, oral cholera vaccine campaign	0.03
Mozambique, oral cholera vaccine campaign	0.02
Median: 0.03	

G. Personal protective equipment

In areas with widespread community transmission of COVID-19, or in areas where transmission is not well known or surveillance systems are weak, the WHO recommends extended use of medical masks during vaccination shifts[18,19]. Masks should be replaced as soon as they become damp. The use of gloves is only recommended if the skin of the beneficiary is not intact, which is the same recommendation as in settings without community transmission.

The cost of personal protective equipment (PPE) for health care workers were estimated using the methodology by Moi and colleagues[20]. Data on session and vaccination team sizes were derived from immunization costing studies in Indonesia and Tanzania. In Indonesia, around 20-30 children were usually covered in each outreach session by a team of 3-4 staff. In Tanzania, the team size was similar, but the session size was generally larger (30-40 children). Therefore, the session size

[18] WHO, UNICEF (2020). Community-based health care, including outreach and campaigns, in the context of the COVID-19 pandemic, Interim guidance, May 2020, World Health Organization and the United Nations Children's Fund (UNICEF), Licence: CC BY-NC-SA 3.0 IGO https://apps.who.int/iris/bitstream/handle/10665/331975/WHO-2019-nCoV-Comm_health_care-2020.1-eng.pdf?sequence=1&isAllowed=y

[19] WHO (2020). Framework for decision-making: implementation of mass vaccination campaigns in the context of COVID-19, Interim guidance, 22 May 2020 https://apps.who.int/iris/bitstream/handle/10665/332159/WHO-2019-nCoV-Framework_Mass_Vaccination-2020.1-eng.pdf?sequence=1&isAllowed=y

[20] Flavia Moi, Christina Banks, Laura Boonstoppel, The cost of routine immunization outreach in the context of COVID-19: estimates from Tanzania and Indonesia, ThinkWell, 20 July 2020

in all countries was assumed to be 30 beneficiaries per session. For fixed sites, the session size was assumed 50 beneficiaries per session. Vaccination teams were assumed to consist of 5 staff.

The following quantities of commodities were assumed:

- One mask per half day session (or two masks if the session took a full day) for each health worker on the vaccination team
- One biohazard waste bag per session (for used masks)
- Gloves not included.

Unit prices were gathered from the Emergency Global Supplies Catalogue (COVID-19)[21]. The price of one medical mask was USD 0.31 and the price of one biohazard bag was USD 0.17. Cost of international shipment of the commodities were not included. Estimates of costs per dose delivered are seen in Table A11.

Table A11: PPE costs per dose delivered (US$)

Cost category	Fixed site	Outreach
Masks for health workers	0.06	0.10
Biohazard bags for used masks	0.003	0.01
Total PPE cost per dose	**0.07**	**0.11**

H. Hand hygiene

It is recommended that hand sanitizer and handwashing stations with soap and water are available for use by recipients and their companions at all vaccination sites, and that health workers perform hand hygiene between administering each vaccine. The following quantities were assumed:

- 3 ml hand sanitizer before and after each vaccination for the beneficiary and the vaccinator each. Hence, a total of 12 ml of hand sanitizer per beneficiary.
- A simple hand washing station (2 x 60 L buckets with taps) to bring to outreach sites. Buckets assumed to have a useful life of six months.
- Beneficiary and vaccinator would wash their hands both before and after vaccination (4 x each beneficiary). Volume of water required for each handwash 0.25 liters
- Quantity of soap at outreach sites aligned with the assumptions for hand sanitizer at 12ml per beneficiary

Water usage was calculated following the method by Tan-Torres Edejer *et al*[22]. Costs were differentiated between sites that have access to piped water and areas that do not. The proportion of health facilities with access to running water was extracted from the WHO UNICEF JMP database[23]. For areas without piped water, water needs to be transported to the sites. It was assumed that if a facility had access to piped water, the outreach sites they serve would also have access, and if a facility did not have access to piped water, neither would the outreach sites. The most up

[21] WHO (2020). Emergency Global Supply Chain System (COVID-19), Catalogue as of 18.11.2020. https://www.who.int/publications-detail-redirect/emergency-global-supply-chain-system-(covid-19)-catalogue

[22] Tan-Torres Edejer, T., Hanssen, O., Mirelman, A., Verboom, P., Lolong, G., Watson, O.J., Boulanger, L.L., Soucat, A., Projected health-care resource needs for an effective response to COVID-19 in 73 low-income and middle-income countries: a modelling study, Lancet Global Health, September 9, 2020

[23] WHO UNICEF JMP database available from: https://washdata.org/. Accessed 27 October 2020.

to date water tariff for all countries was extracted from the IBNet Tariffs database and a multiplication factor of five was used to project the cost of water transported to sites without access to piped water, as provided by WHO WASH experts[24]. For 42 countries either the water price or the data on access to piped water were missing, and five countries were missing both. A median data point by country income classification was used for these countries.

Unit prices for the hand hygiene items are shown in Table A12. A breakdown of the cost per dose delivered and per facility is shown in Table A13.

Table A12: Unit prices of hand hygiene supply costs

Item	US$	Source
Hand sanitizer (1 L)	8.30	WHO COVID-19 Essential Supplies Forecasting Tool (ESFT) version 2[25]
1 unit of soap (1 L)	0.90	WHO COVID-19 Essential Supplies Forecasting Tool (ESFT) version 2
60-liter bucket with tap (each)	6.23	Freedman et al.[26]
1 x m^3 water tariff	Differs per country	IBNet Tariffs database[24]

Table A13: Hand hygiene costs per dose delivered and per facility (US$)

Cost category	Fixed site (per dose)	Outreach (per dose)	Outreach (per facility)
Hand sanitizer	0.10	0.10	NA
Soap	NA	0.01	NA
Water	NA	Differs per country	NA
Buckets	NA	NA	12.46
Total: Hand hygiene cost per dose and per facility	***0.10***	***0.11-0.12***	***12.46***

I. Vaccine transport

The vaccine transport cost category captures the cost of storage and transport from national level to regions, districts and facilities, including per diems related to these activities. Cost data for vaccine storage and distribution extracted from sources are listed in Table A14. The median of the data points from the studies, excluding those which did not cover transport between multiple levels, was $0.04 per dose. In one study, it was not explicitly stated which levels of transport were covered by the cost given.

[24] IBNet Tariffs database available from: https://tariffs.ib-net.org/Compare?perPage=50. Accessed 27 October 2020.
[25] WHO (2020). WHO COVID-19 Essential Supplies Forecasting Tool (ESFT) version 2. https://www.who.int/docs/default-source/coronaviruse/covid-esft-v2-who-release-updated20200429-1650edt.xlsx?sfvrsn=6b46f7b0_2&download=true
[26] Freedman, M., Bennett, S.D., Rainey, R., Otieno, R. and Quick, R. (2017). Cost analysis of the implementation of portable handwashing and drinking water stations in rural Kenyan health facilities. Journal of Water, Sanitation and Hygiene for Development, 7(4), pp.659-664.

Table A14: Cost per dose of vaccine transport (US$ 2020)

Data source	Level of transport	Cost per country	Cost per dose
Studies reporting on the cost of outreach services			
Indonesia	Facility	(not estimated)	0.01
Tanzania	Facility	(not estimated)	0.01
Literature on influenza vaccination programs			
Albania, influenza vaccine, targeting health workers*	National to district	731 (health workers only)	0.05
Campaign budget data			
Sierra Leone, measles-rubella catch-up campaign*	National, district and facility	76,806	0.03
IDCC campaign costing literature			
Bangladesh, oral cholera vaccine campaign	Unclear	(pilot)	0.02
India, oral cholera vaccine campaign*	National, district and facility	(pilot)	0.04
New vaccine introduction and routine costing studies			
Bhutan, PCV10*	District to facility	1,426	0.03
Moldova, Rota*	National, district and facility	8,776	0.18
Vietnam, HepB and Japanese encephalitis vaccine	Facility	197 (sub national)	0.002
Median, excluding studies with partial cost: US$			**0.04**

* Included in median

J. Sharp waste management

To minimize risk to the communities, each vaccination team should practice on-site waste segregation and implement reverse logistics, where health care waste is taken back to the facility by the vaccination team to be disposed of properly along with other hazardous wastes[27].

Data on the costs of sharp waste management was taken from a study by Griffiths *et al* published in 2011[28]. Costs were inflated to 2020 values, giving a costs per dose of US$ 0.044.

K. Per diem for service delivery & supervision

It was assumed that per diems and allowances will be paid to health workers for service delivery, supervision and monitoring during outreach activities. Per diems for planning and coordination,

[27] WHO. Overview of technologies for the treatment of infectious and sharp waste from health care facilities. Geneva: World Health Organization; 2019, https://www.who.int/water_sanitation_health/publications/technologies-for-the-treatmentof-infectious-and-sharp-waste/en/

[28] Griffiths UK, Santos AC, Nundy N, Jacoby E, Matthias D. Incremental costs of introducing jet injection technology for delivery of routine childhood vaccinations: comparative analysis from Brazil, India, and South Africa. Vaccine. 2011 Jan 29;29(5):969-75

social mobilization and for training attendance were included in these respective categories. Per diem costs were extracted from data in the Immunization Delivery Cost Catalogue (IDCC) as well as campaign budgets.

The cost per dose of per diems was considerably less during vaccination campaigns compared to outreach sessions due to the larger number of vaccinations given during campaigns. Outreach sessions in Indonesia and Tanzania generally reach around 20-40 children, while a large campaign can reach up to 200 children per day. To gather information on the size of outreach sessions, literature on vaccination programs targeting the elderly (mainly PCV and influenza) in LMICs were reviewed. However, very few countries deliver such vaccines through outreach services. For the few countries that did, no detailed information could be found on the session size.

Given the limited supply, COVID-19 vaccines would need to be carefully distributed in a targeted manner to reach elderly and vulnerable populations, and session sizes would likely be relatively small. Campaigns usually target 100-200 children per day, and cost data for these studies were adjusted to assume a reduced target of 30 persons per day. Table A15 shows unit costs for each data source. The median of the data points from campaign budgets, outreach services, and IDCC campaign costing studies (adjusted to outreach session size) was US$ 1.39 per dose.

Table A15: Per diem cost per dose for service delivery, supervision and monitoring

Data source	**Cost per dose (US$ 2020)**
Polio house to house campaign budgets (with adjusted session size)	
Benin	1.23
Equatorial Guinea	1.39
Iraq – April 2019	2.18
Iraq – Sept 2019	2.28
Mali	0.74
Papua New Guinea	1.01
South Sudan	0.58
Syria	1.38
Studies reporting on costs of outreach services	
Indonesia	0.28
Tanzania	2.03
Campaign budgets	
DRC, measles follow-up campaign	0.65
Ethiopia, Yellow Fever campaign	1.82
Sierra Leone, measles-rubella catch-up campaign	0.82
IDCC campaign costing literature	
Benin – measles follow-up campaign	1.49
Cote d'Ivoire, yellow fever campaign	5.36
Ethiopia, oral cholera vaccine campaign	1.87
Median for adjusted session size: US$ 1.39	

L. Transportation for service delivery & supervision

When conducting vaccination activities that are not within walking distance of the facility, travel expenses will be incurred. Costs related to travel for the delivery of a COVID-19 vaccine (transport, fuel and vehicle maintenance) were included in this cost category and full costs (e.g. the capital cost of vehicles already owned by governments) were excluded where possible. Unit costs for this category were extracted from sources as detailed in Table A16.

An analysis was conducted to adjust OPV campaign, campaign budget data and IDCC campaign costing study transport costs per dose for a reduced target of 30 persons per day. The median of the data points from the outreach services, campaign budgets and IDCC campaign costing studies (adjusted to outreach session size where required) was $0.49 per dose.

Table A16: Transport cost per dose for service delivery, supervision and monitoring activities

Data source	**Cost per dose (US$ 2020)**
Polio house to house campaign budgets (with adjusted session size)	
Benin	0.18
Equatorial Guinea	2.71
Iraq – April 2019	2.18
Iraq – Sept 2019	2.21
Mali	0.48
Papua New Guinea	2.98
South Sudan	0.29
Syria	0.60
Studies reporting on the cost of routine outreach	
Indonesia	0.24
Tanzania	0.25
Campaign budget data	
DRC, measles follow-up campaign	0.12
Ethiopia, yellow fever campaign	0.18
Sierra Leone, measles-rubella catch-up campaign	0.50
IDCC campaign costing literature	
Bangladesh, oral cholera vaccine campaign	1.58
Median for adjusted session size: US$ 0.49	