Immunization campaigns during the COVID-19 pandemic

A rapid analysis of the additional operational cost

BREAKING NEW GROUND

Version: 14 May 2020

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SUMMARY

The Immunization Costing Action Network (ICAN) has conducted an analysis of the potential additional operational cost of an immunization campaign held during the COVID-19 pandemic. Although most mass immunization campaigns have been suspended due to the COVID-19 pandemic, some campaigns will nevertheless need to go ahead, with additional precautionary measures in place to ensure the safety of health workers and the community. Based on data from 10 studies on the cost of conducting an immunization campaign, ICAN has estimated the added cost per dose of several potential measures and implications: personal protective equipment (PPE) for vaccination teams, extra staff to ensure physical distancing and triaging at campaign sites, additional per diems due to potential changes in delivery strategies, and estimates of an increase of certain operational cost components (such as additional social mobilization to offset vaccine hesitancy), with a low, medium and high scenarios for each.

The results of this analysis show that the operational cost of a campaign could increase by 3-17% with simple PPE for vaccination team members and hand washing stations, adding crowd controllers to vaccination teams to manage physical distancing and triaging at campaign sites could imply a 13-25% increase in the operational cost per dose, per diems associated with a longer campaign duration could result in a 8-32% increase, and impact on other operational aspects of the campaign, such as social mobilization and transport could increase the operational cost of a campaign by 40%. All protective measures and operational changes combined could increase the operational cost of a campaign by 36% in the low scenario up to 131% in the high scenario.

BACKGROUND

Although most preventive immunization campaigns have been suspended due to the COVID-19 pandemic, some outbreak responses will nevertheless need to go ahead, with additional precautionary measures in place to ensure the safety of health workers and the community. During the current COVID-19 pandemic, WHO's Strategic Advisory Group of Experts on Immunization advises countries to temporarily suspend any mass immunization campaigns in order to reduce the risk of spreading the virus.[1] As of the 28th of April, campaigns had been paused or postponed in 35 countries[2] to avert further spreading of COVID-19, and additional countries may have to postpone campaigns planned for later this year, affecting a total of more 117 million children.[3] Through periodic evaluations, countries will need to determine the necessity of further delays. In some circumstances, immunization campaigns will need to be conducted before the transmission of COVID-19 has fully diminished, for example in the case of an outbreak of a vaccine preventable disease. For those campaigns, guidance dictates that 'stringent measures are required to uphold standard and COVID-19 infection prevention and control, adequately handle injection waste, protect health workers and safeguard the public.' Because currently no estimates

exist regarding the costs associated with the implementation of such measures or other cost implications of conducting immunization campaigns in the context of COVID-19, ICAN has conducted an analysis to estimate the additional cost per dose of introducing a range of precautionary measures.

METHODOLOGY

The analysis used data reported in 10 campaign studies to calculate the additional cost of a number of potential operational changes due to COVID-19. The scenarios were developed based on a review of the literature on COVID-19 precautionary measures and data on campaigns conducted in similar settings. From the campaign costing studies, input data were extracted to calculate the increases of certain cost components under each of the scenarios. All cost estimates were converted to 2020 US dollars using World Bank exchange rates[4] and IMF inflation rates.[5] The results are reported both as a USD increments per dose, as well as a percentage increase from the original operational cost[i] estimates.

DATA

This analysis used data from 10 out of the 12 campaign costing studies in the Immunization Delivery Cost Catalogue (IDCC).[6] ICAN's IDCC is the result of a systematic review of over 17,000 resources that included immunization delivery costs (published and grey literature) published between January 2005 and March 2019. It includes over 600 unit costs from 68 resources and is the most comprehensive, current, and standardized global evidence on the cost of delivering vaccines in low and middle income countries. The database includes 17 unit costs from 12 studies reporting immunization campaign costs, which formed the starting point for this analysis. Two studies were excluded as one study only reported the cold chain cost per dose[7] and another did not separate the campaign costs into cost activities.[8] The full list of study references can be found in Follow-up analyses conducted by ThinkWell and the Harvard T.H. Chan School of Public Health will assess the cost implications for routine and routine outreach immunization service delivery.

[i] Operational costs or immunization delivery costs are defined as the costs associated with delivering immunizations to target populations, exclusive of vaccine costs.

Annex A. Seven of the ten remaining studies costed oral cholera vaccine (OCV) campaigns, and the remaining three were meningitis A, measles and YF campaign costing studies. None of the studies co-delivered other vaccines or health interventions. Three of the ten campaigns were reactive, while the other seven were planned campaigns. The scope of the costs reported in the studies differed: three studies only reported the incremental cost of the campaign,[ii] six studies reported only the full costs[iii] and one study reported both. Financial costs were reported in four studies[iv], economic costs were reported in five[v], and for two studies the type of cost was unclear.[vi]

From each study, relevant data were extracted including the number of vaccination days, vaccination posts, total number of vaccination team members and team size, the size of the target population and the number of doses delivered. In some cases, not all of these data were reported, or not in the format required for the analysis, so that assumptions had to be made. The number of vaccinators per team was not always explicitly stated and in these scenarios, it was either assumed that the skilled health workers in a team were the vaccinators, an assumption was made based on team size and the number of doses delivered per hour or an assumption made based on team size i.e. that two of the eight team members were vaccinators.

SCENARIOS & ASSUMPTIONS

The analysis evaluates the impact of four scenarios of potential operational changes to immunization campaigns that would have incremental fiscal cost implications. The scenarios and the cost assumptions used for these are based on closely related guidance and protocols from WHO,[9 10 11 12 13 14 15 16] measures put in place for campaigns held while the Western African Ebola epidemic was winding down in 2015, data from the polio, measles and cholera campaigns held in Kivu in 2019 during the Ebola outbreak and from the measles campaign held in Kinshasa in April 2020 in the context of COVID-19. The four scenarios describe individual effects, and have been modelled separately first, and afterwards, for the studies for which it was possible, have been included in an analysis of combined effects.

The first set of scenarios estimates the additional cost of requirements to ensure the safety of health workers and the target population during an immunization campaign are based on existing WHO guidance and protocols. While awaiting the release of WHO's guidance on the required precautionary measures specific to immunization campaigns held during the COVID-19 pandemic, the scenarios are based on existing related protocols. The low scenario is based on WHO's forthcoming guidance on prioritization of outbreak response vaccination campaigns in the context of the COVID-19 pandemic, which indicates that vaccinators do not need to wear gloves unless the skin of the patient is not intact, and that the use of masks not currently considered a requirement, though vaccinators could consider extended medical mask use in areas with widespread community transmission, meaning that they would wear the same masks throughout the vaccination period.[9] The COVID-19 Risk Communication Package For Healthcare Facilities[17] recommends masks even for triaging staff at facilities, which is why it has been included for all vaccinating and non-vaccinating team members. The medium scenario adds gloves to

[ii] Additional cost required for the intervention (campaign), compared to the baseline cost (routine immunization program/broader health system).

[iii] The sum of all costs associated with the campaign implementation, including the use of routine resources.

[iv] Financial outlays, usually with straight-line depreciation of capital items.

[v] Financial outlays, with discounted annualization of capital items, plus opportunity costs such as volunteer time and any donated items such as vaccines.

[vi] Evidence on what it costs to conduct a campaign is limited and due to the different methods used, is hard to compare. To address this, ICAN is developing methodological guidance on costing campaigns, through an iterative process of 2-3 country studies: http://immunizationeconomics.org/ican-standardizing-campaign-costing

that, which vaccinators used and change for each beneficiary during post-Ebola immunization campaigns in Libera[18] [19] and Sierra Leone in 2015.[20] The high scenario also includes the use of goggles and gowns for vaccinators, based on WHO's protocol on the rational use of personal protective equipment (PPE),[10] which indicates its use around patients without respiratory symptoms should depend on a risk assessment, and the list of Priority Medical Devices in the context of COVID-19[11] specifies gowns, goggles and/or face shields as part of the supplies required even for triaging. The high scenario also assumes team members would change mask twice per day, as guidance indicates to replace masks as soon as they become damp with a new, dry mask.[14] The unit prices for PPE supplies used in this analysis equal those used in the WHO COVID-19 Essential Supplies Forecasting Tool (ESFT).[21] Prices are exclusive of shipment costs.

To account for the cost of added infection prevention and control (IPC) materials, all scenarios include handwashing stations for campaigns sites. For routine immunization services, WHO's forthcoming guidance on outbreak responses during COVID-19,[9] recommends to make multiple hand hygiene stations available (soap and water or alcohol-based hand rub) for staff and caretakers, including at entrance and exit points. In DRC, during the measles outbreak response campaign, a simple handwashing station (a bucket of soap and 12 units of soap) was installed at each site, [22] [23] and the low and medium scenario include two of them to accommodate both the entry and exit points of each vaccination post. The high scenario includes a more advanced handwashing station that includes tap and a basin. All prices are based on a WASH study in Kenya[24], and have been converted to USD2020. To show the potential range around some of these unit prices, Annex B shows a comparison of different prices for PPE and IPC supplies.

Table 1 – Scenario 1: infection prevention and control

1. Infection prevention and control: PPE for health workers & handwashing stations[vii]		
Low	Medium	High
– All vaccination team members receive one mask per day – One biohazard bag per team per day for disposal of PPE supplies – Simple hand washing station for each fixed vaccination post (2 x 60 liter bucket and 2 units of soap per post per day)	– Vaccinators receive one mask per day and one set of gloves per beneficiary – Other team members receive one mask and two sets of gloves per day – One biohazard bag per team per day for disposal of PPE supplies – Simple hand washing station for each fixed vaccination post (2 x 60 liter bucket and 2 units of soap per post per day)	– Vaccinators receive two masks and gown per day, one set of reusable goggles per campaign, and one set of gloves per beneficiary – Other team members receive two masks and two sets of gloves per day – One biohazard bag per team per day for disposal of PPE supplies – Hand washing station for each vaccination post (2 x 60 liter bucket, stand, basin and 2 units of soap per post per day)

Vaccination teams may require additional support to maintain physical distancing, triage beneficiaries, and ensure adequate hand washing practices are observed. Campaigns usually gather large crowds of people, and ensuring physical distancing at campaign sites will be challenging. Additionally, triaging beneficiaries and temperature checking at vaccination sites may also be required. WHO recommends to secure an outdoor large space where persons can be separated by at least 1 meter, to incorporate a designated triaging area, and to have a referral system in place for suspected cases.**Error! Bookmark not defined.** At fixed sites in DRC, in addition to the regular five vaccination team members (two vaccinators, a person responsible for tallying, a crowd controller and a social mobilizer), two staff are added dedicated to screening and monitoring the handwashing station.[22] The second set of scenarios looks at the cost implications of adding staff at vaccination sites to help out with such activities. The scenarios both assume that such additional staff would require a level of training comparable to that of community health workers, and that they would be paid per diems equal to that of the lowest vaccination team member. Where data on the lowest level of per diems was not available, an average was used. The estimations are unrelated to the number of crowd controllers that may have already been a part of the vaccination teams, and implications on regular salaries are not included.

Table 2 – Scenario 2: additional staff at vaccination sites

2. Additional staff at vaccination sites	
Low	High
– One additional triager/crowd controller per vaccination team to ensure physical distancing is observed	– One triager and one crowd controller per vaccination team to ensure physical distancing is observed

[vii] Please note that this in addition to all regular immunization campaign protocols regarding e.g. injection safety and waste management

– One mask per person per day (as per scenario 1) – One infrared thermometer per vaccination team	– Two masks and two sets of gloves per person per day (as per scenario 1) – One infrared thermometer per vaccination team

Increased infection prevention and control measures, together with potential changes in delivery strategies may require the campaign to be completed over a longer period of time, and thus an increase in per diems for health workers. Campaigns targeting school-aged children usually recognize school-based delivery as the most time and cost-efficient strategy, and targets for such days are high. For example, for the measles-rubella catch-up campaign conducted in India, operational guidelines estimated that a team could vaccinate 200 children per day in schools, compared to 150 during outreach to villages and hard-to-reach areas, and 50-100 at temporary fixed sites.[25] If schools have closed down, the campaign may take several more days to achieve its total target. Additionally, physical distancing measures may slow down the process at vaccination sites, resulting in lower coverage per day. The third set of scenarios estimates the costs of additional labor costs and per diems for health workers due to the extended duration of the campaign, assuming that a reduction in coverage cannot be compensated for by further extending the number of hours worked each day. An alternative potential cause for an increase in per diems could be to compensate for the increased risk that health workers are exposed to while participating in a campaign during the pandemic.

Table 3 – Scenario 3: campaign extension

3. Extended duration of the campaign & additional health worker per diems	
Low	High
– Assuming an extended duration of the campaign due to a reduction of the daily coverage levels to 80% of what was actually achieved	– Assuming an extended duration of the campaign due to a reduction of the daily coverage levels to 50% of what was actually achieved (i.e. what if the campaign took twice as long)

The fourth and final category of scenarios models an increase of certain components of the operational cost of the campaign, such as additional social mobilization efforts to offset vaccine hesitancy, communication on IPC requirements at vaccination sites and additional transport costs associated with a change in delivery strategy. This scenario assumes a cost increase of all activities and items that could reasonably be impacted by an extension of the campaign duration, a change in delivery strategy or other operational changes due to COVID-19. WHO guidance on outreach recommends expanding the number of sites to reduce the number of people to be vaccinated per site and day or exploring alternative immunization strategies such as implementation of door to door vaccination to avoid excessive gathering at the vaccination points. Covering a larger number of vaccination sites to reduce the number of people per site or additional outreach sessions may require additional travel costs. Another example is the additional need for social mobilization for the campaign as the presence of COVID-19 may lead to vaccine hesitancy and a lower turnout. Lessons learned from the Ebola countries show that a reduction in demand for immunization services, a distrust in the health system and a fear for seeking healthcare are likely in the case of a disease outbreak,[26] [27] which must be countered with extra awareness campaigns. Using the cost categories as reported by the campaign costing studies, such components were isolated and increased. Examples included micro-planning, local transportation of staff and vaccines within the targeted area, social mobilization costs, supervision and vaccine storage fees. As the analysis assumes that the target for the campaign would not change, the costs that were assumed to remain fixed included

vaccination-related supplies, international shipment and insurance fees, stationery, etc. Staff salaries and per diems were also excluded in order to avoid duplication when aggregating the effect of scenarios 3 and 4.

Table 4 – Scenario 4: increase in operational cost components

4. An increase of certain components of the operational cost of the campaign		
Low	Medium	High
– An increase of 25% of all cost components affected by an extension of the campaign	– An increase of 50% of all cost components affected by an extension of the campaign	– An increase of 100% of all cost components affected by an extension of the campaign

The 10 campaign costing studies were included in each scenario for which they reported sufficiently detailed data. Nine studies could be used for the infection prevention and control estimates (number 1). For the scenarios on adding crowd controllers (number 2), four studies had sufficient data, and for the staff cost increases (number 3), five studies could be included. Seven studies were used to estimate the impact of an increase in certain operational costs (number 4). Three studies could be used for all scenarios and were included in the estimates of the cumulative costs.

RESULTS

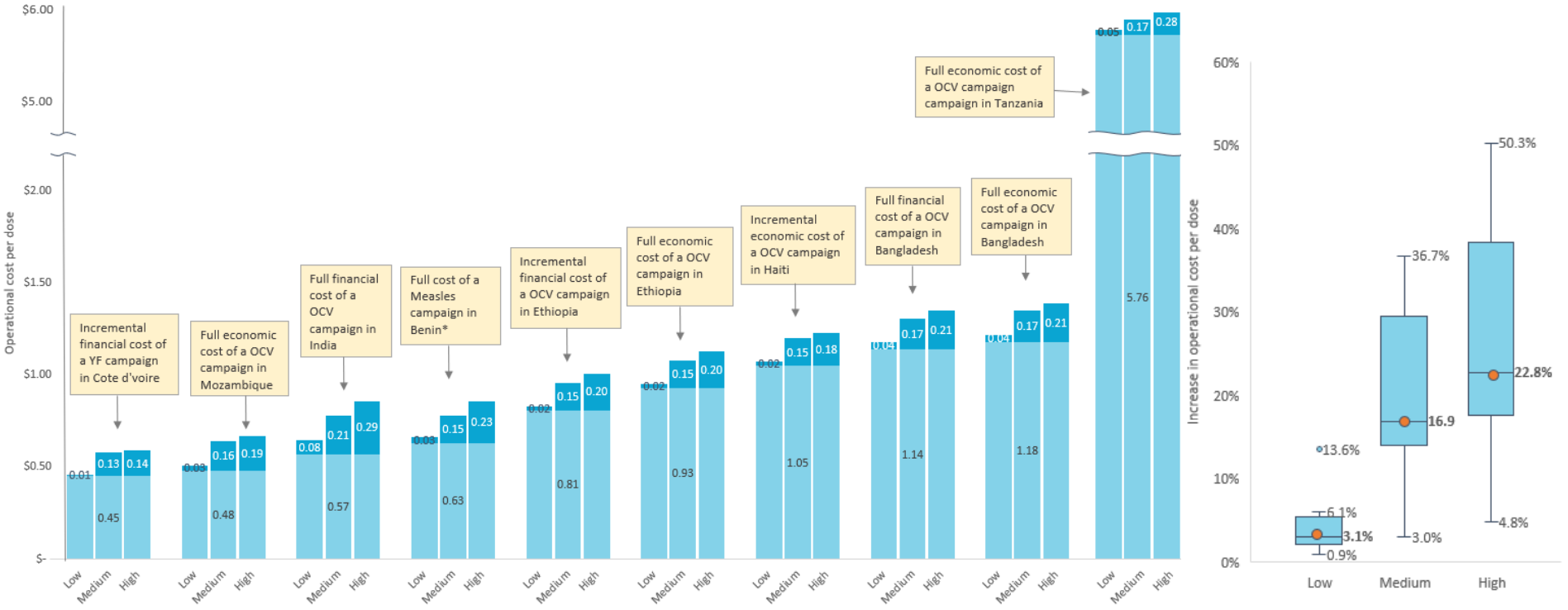
The results are shown in both absolute USD increments, as well as percentage increases compared to originally reported operational cost per dose. For each study, the graph shows what types of costs were included in the originally reported estimates (as explained in the Data section). Evidently, the percentage increase is higher for those settings where the original operational cost per dose was low. Some OCV studies reported the costs per fully immunized child as these campaigns administered two doses, and we have converted these results in cost per dose administered for comparability. The original amount per fully immunized person are shown in brackets. Due to the differences in the methodologies used for each of the campaign costing studies, and the lack of a sufficient number of comparable data points, it is not possible to develop pooled estimates from these results. No clear differences were observed between OCV campaigns and injectables, nor between planned and reactive campaigns, despite probable operational differences, which is likely the results of the small number of studies included. The full tables with the results of the analysis can be found in Annex C.

1. Additional infection prevention and control measures

Offering handwashing stations at campaign sites and masks for vaccinators could increase the operational cost of a campaign by US$0.01-0.08 per dose, adding gloves would increase this to US$0.13-0.21 per dose or up to US$0.29 per dose if vaccinators would have to wear goggles and gowns as well.

Figure 1 shows the results in USD when adding several levels of PPE for health workers and IPC measures, as well as the percentage increase compared to the originally reported operational cost. In the low scenario, the cost increase would only be 3%, while under the medium scenario, where health workers are equipped with masks and gloves only, the median increase in operational cost per dose is estimated at 17%.

Figure 1 – Scenario 1: additional infection prevention and control measures



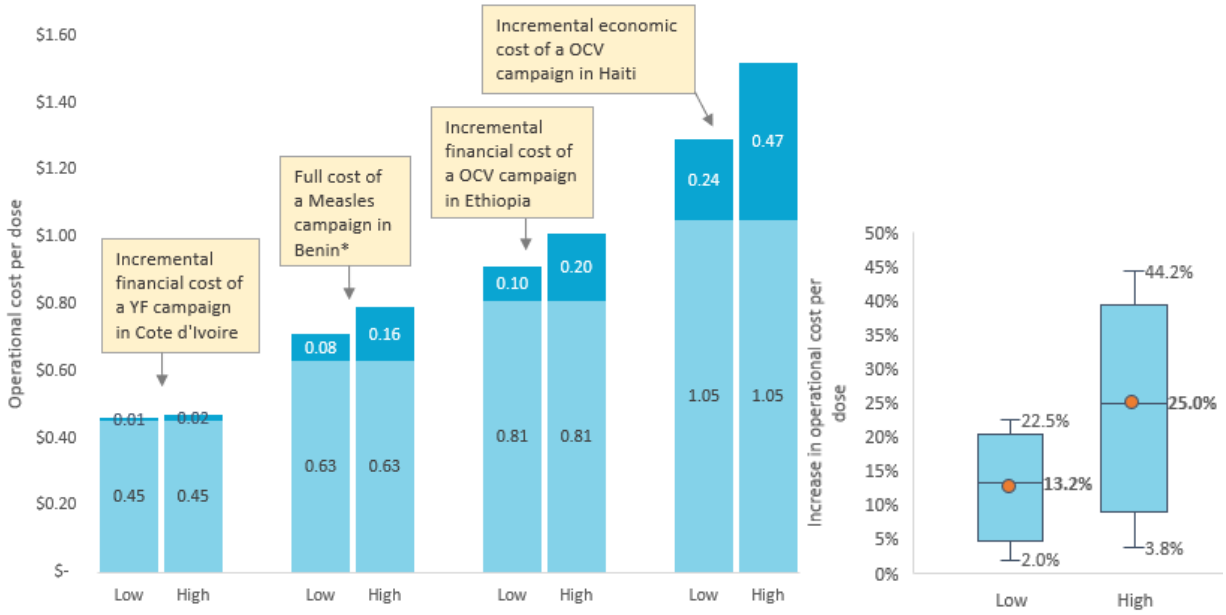
* It is unclear whether the costs reported in this study represented the financial or economic costs.

- **Low**: masks for all team members, simple hand washing stations, biohazard bag per day
- **Medium:** masks and gloves, simple hand washing stations, biohazard bag per day
- **High:** adding goggles and gowns for vaccinators, hand washing stations including stand and basin, biohazard bag per day

2. Additional staff at vaccination sites

Adding two team members to a vaccination team (high scenario) could increase the operational cost of the campaign by US$0.02-0.47, reflecting an increase in the operational cost of approximately 25%. The scenario assumes that crowd controllers would be added to existing teams (including masks in the low scenario, and in the high scenario gloves as well). The low scenario added one additional staff to each vaccination team (normally consisting of around five members) to ensure physical distancing is observed, to monitor the hand washing station and to manage the triaging process including temperature checking, which could increase the operational cost of the campaign by 13%. However, if the number of sites were reduced, and teams would be deployed at fewer locations at the same time, fewer crowd controllers may be needed, and the costs could be reduced.

Figure 2 – Scenario 2: additional staff at vaccination sites

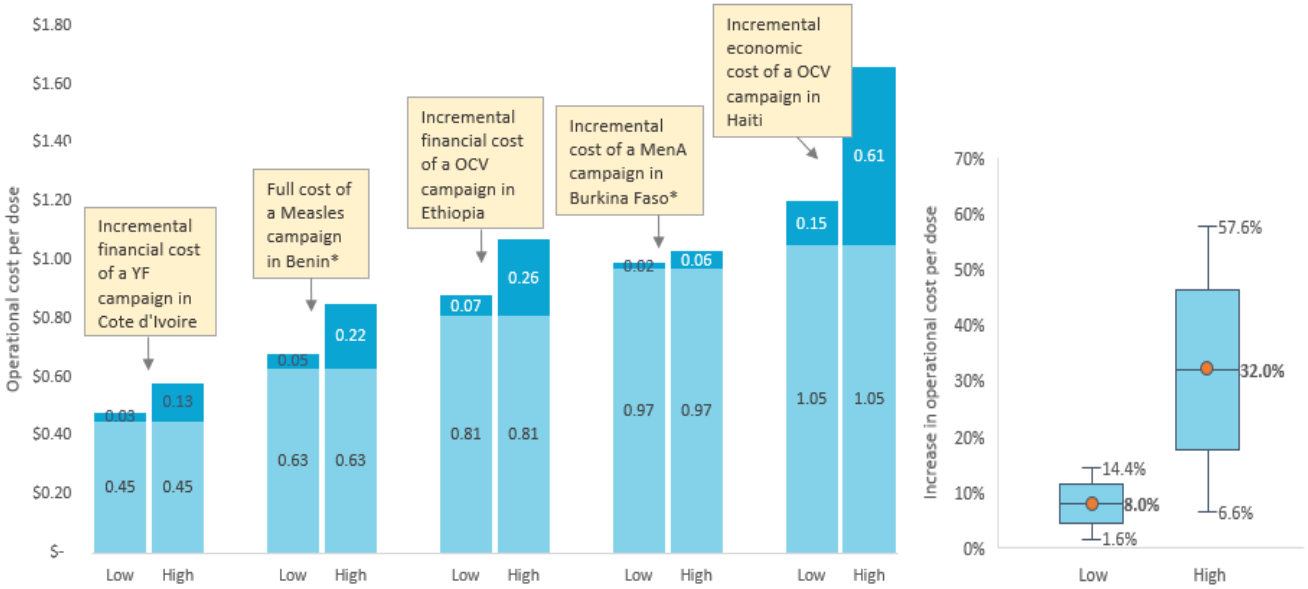


* It is unclear whether the costs reported in this study represented the financial or economic costs.

3. Additional per diem costs as a result of an extension of the campaign duration

If campaigns would take twice as long to complete, the additional expenses on health worker per diems alone could already increase the operational cost of the campaign by 32%. Figure 3 summarizes the results for this scenario. If health workers would have lower daily targets due to physical distancing measures or a change in delivery strategy (from school-based to fixed sites, or increasing the number of sites to decrease the number of beneficiaries per site, for example), the impact on their required per diems could be significant. If the campaigns in this analysis would have been able to reach only 80% of their achieved targets each day (low scenario), and therefore spent more days on completing the campaign, the added per diem expenses would have been around US$ 0.02-0.15 per dose or an increase of 1.6-14.4% (median 8%). The scenario looked only at health worker per diems, and so does not assume any implications on health workers' regular salaries or any recurrent hazard pay that they may receive during COVID-19 times. However, note that these scenarios do not consider a potential reduction in target to focus only on those most at risk.

Figure 3 – Scenario 3: Additional per diem costs as a result of an extension of the campaign duration



* It is unclear whether the costs reported in this study represented the financial or economic costs.

4. An increase of certain operational cost of the campaign

If expenses on social mobilization activities, training, transport and microplanning were to increase by 25% (low scenario), the cost of the campaign would increase by 10% or approximately 40% if they were to double. The scenario does not include increases in per diems (as per scenario 3) and does not assume any vaccine-related expenses would increase. The range of the increase is mainly determined by whether the studies were reporting incremental or full costs, and as OCV campaign usually have a smaller target population size, the increases were generally greater.

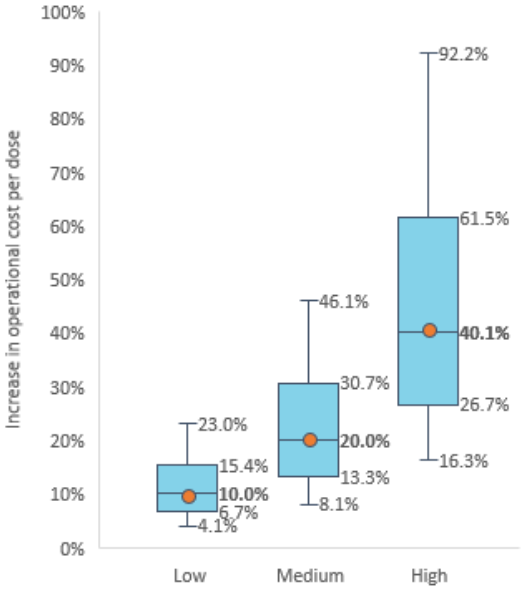
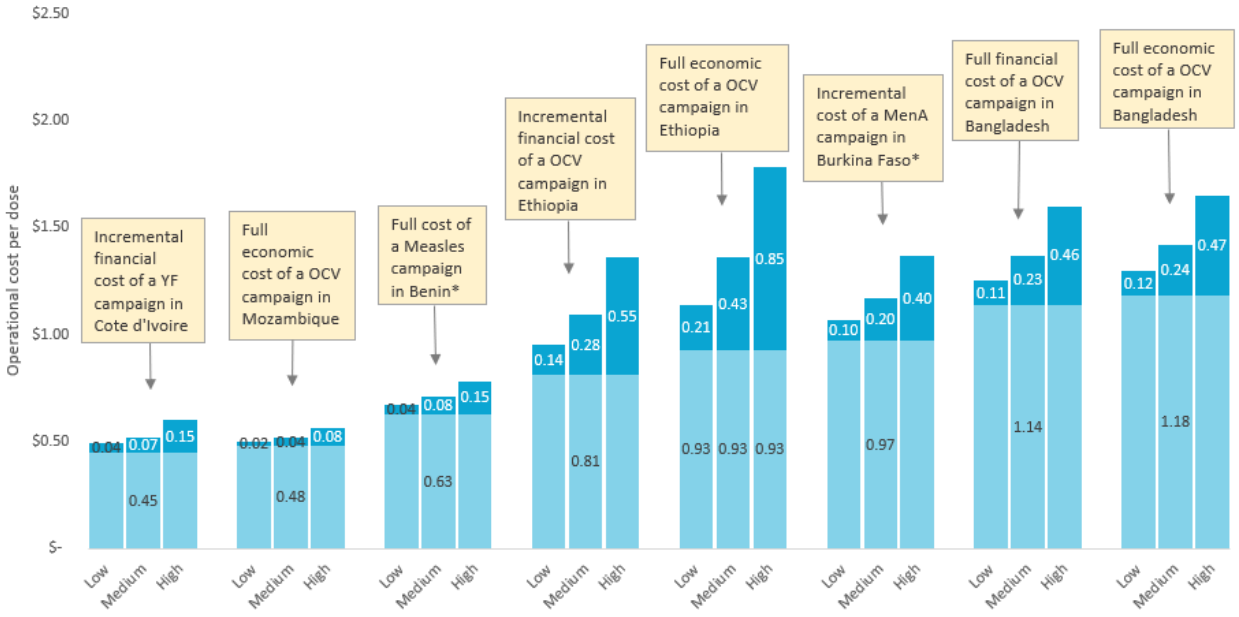


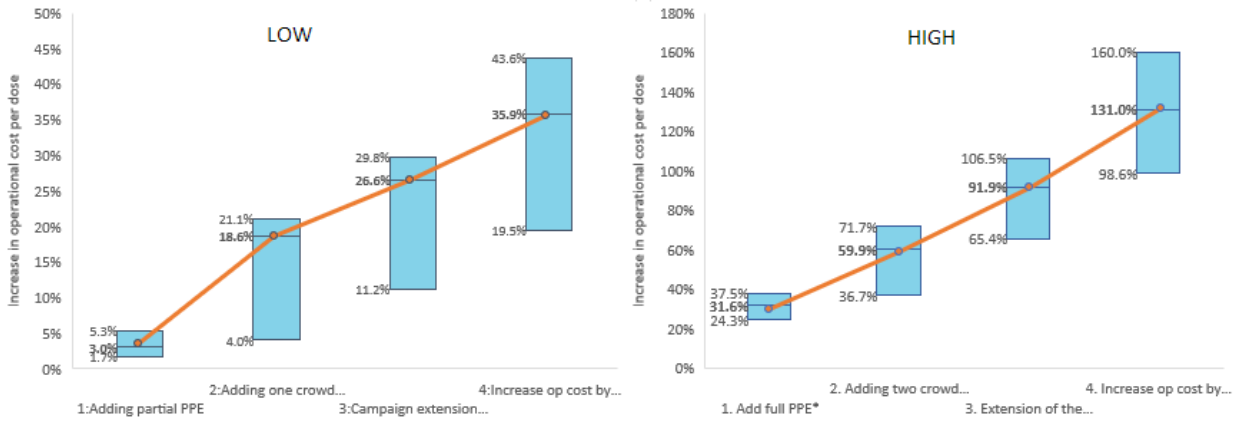
Figure 4 – Scenario 4: an increase of certain operational costs

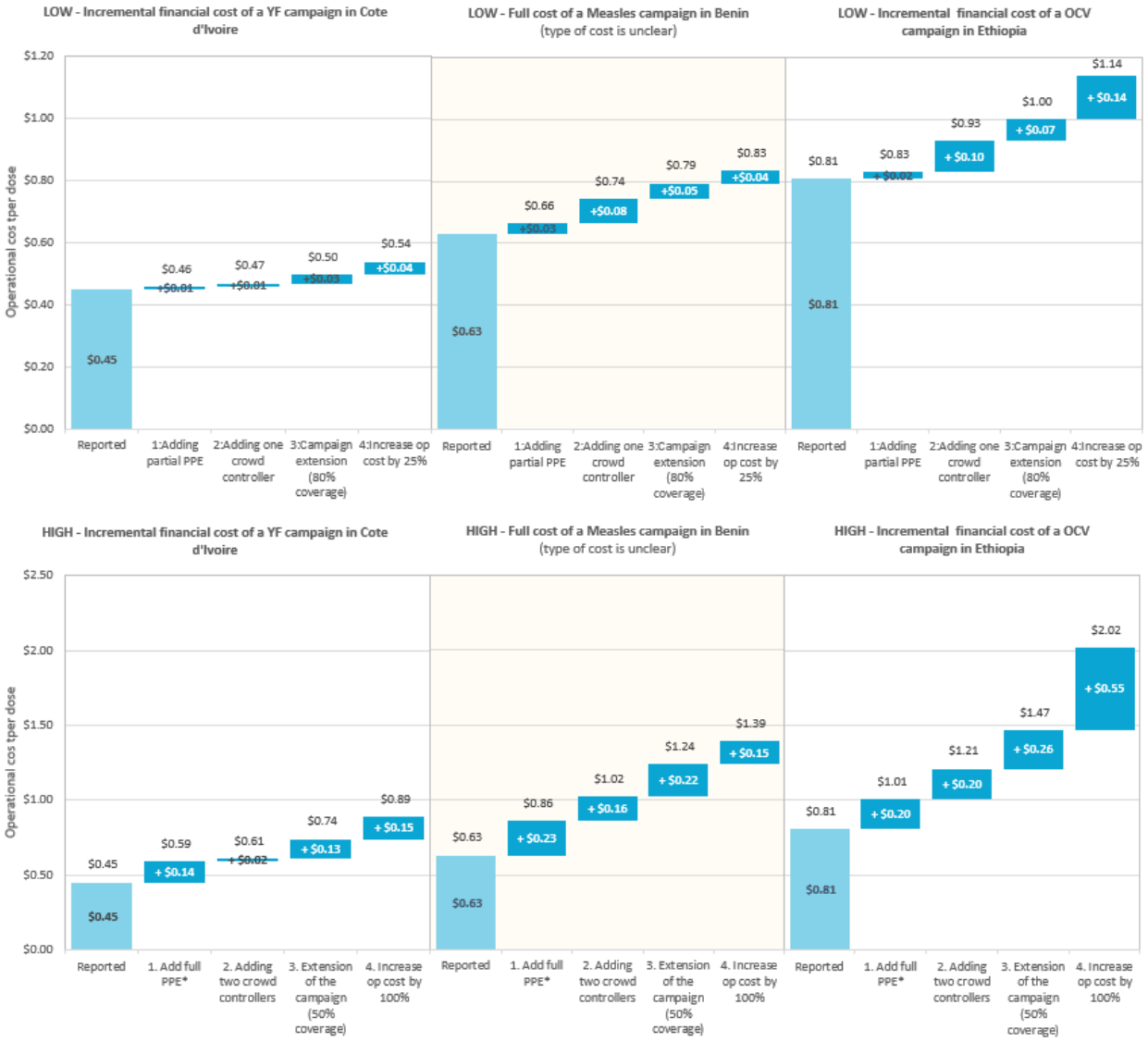


5. Combined effect

If the minimum amount of PPE equipment is provided to health workers, basic handwashing stations are put in place at vaccination sites, daily coverage targets are reduced to 80% and certain operational costs were to increase by 25%, this could increase the operational cost per dose by 36%. To estimate the effect of all four interventions side-by-side the same set of studies must be used, and only three studies offered enough data to be used in all scenarios. Under the high scenario, with more elaborate PPE for vaccinators, two additional crowd controllers to support vaccination teams, if teams could only reach half the children they normally reach each campaign day, and a doubling of operational cost such as social mobilization, training and transport, the operational cost could jump to 131% of the original cost per dose. The comparison in Figure 5 shows that adding staff to vaccination teams has the greatest impact in the low scenario, while because hand washing stands are already fairly costly, that increase is smaller in the high scenario, where overall operational cost increases have the greatest impact.

Figure 5 – Scenario 5: adding PPE & IPC, crowd controllers, extra per diems and added operational cost





LIMITATIONS

The results of this analysis are meant to offer general guidance but should be interpreted with great caution, as several important limitations apply. First, the scenarios costed in this analysis are not based on actual protocols, and the exact policies and practices in countries will vary from this. Second, the analysis relied on the data as reported by the authors, and several assumptions had to be made in the classification of certain costs, in the estimations of per diems, etc. Third, the analysis did not consider changes in the size of the target population, while in reality it is likely that outbreak response campaigns that would continue during the COVID-19 pandemic would focus only on those populations most at risk. Moreover, other kinds of changes in how campaigns were operated have not been explored, including a reduction or increase in the number of campaign sites or a change from school-based delivery to fixed sites or to self-administration for oral vaccines. Fourth, the price assumptions in the UNICEF Supply Catalogue for COVID-19 response materials are changing rapidly, which would change the second scenario where infrared thermometers have been included. Last, one could consider that if a campaign were to be conducted, that it would be co-delivered with other antigens or health interventions, COVID-19 screening and testing, mask distributions for those with symptoms or any counseling, resulting in shared costs and efficiencies that have not been taken into account. A forthcoming study from ICAN on the Sierra Leone campaign during which MR, polio, Vitamin A supplements and deworming tablets were

administered, will offer lessons on potential efficiencies associated with co-delivery. Overall, caution should be taken before translating the results to other country contexts.

CONCLUSION

This rapid analysis is meant to illustrate a range of potential cost implications to provide general guidance for the direction of policies and potential cost expectations that would require the mobilization of additional resources. The results indicate that adding basic PPE and handwashing stations on their own will likely not drive up the costs significantly, but that having to add staff, pay staff additional per diems to implement the work over a longer period of time or additional cost from e.g. intensified social mobilization efforts could potentially have a large impact on the operational cost of a campaign. Comprehensive cost-benefit analyses will be required based on detailed budgets for each specific setting to evaluate the trade-off between the risks of postponing immunization campaigns and the risks involved in accelerating the spread of COVID-19 during immunization campaigns. Follow-up analyses conducted by ThinkWell and the Harvard T.H. Chan School of Public Health will assess the cost implications for routine and routine outreach immunization service delivery.

ANNEX A – IDCC STUDIES

Campaign description	Type of campaign	Study type	Reference
Cholera vaccination campaign in Mozambique	Planned (for feasibility study)	Full economic costs	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.
Meningococcal conjugate vaccine campaign in Burkina Faso[8]	Reactive	Incremental costs (type not reported)	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
Cholera vaccination campaign in India	Planned pilot	Full financial costs	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).
Measles campaign in Benin	Planned follow-up SIA	Full SIA delivery costs at vaccination posts only (type not reported)	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
Cholera vaccination campaign in Bangladesh	Planned (for feasibility study)	Full financial costs	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.
Cholera vaccination campaign in Haiti	Reactive	Incremental economic costs	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. The American Society of Tropical Medicine and Hygiene, 97(4), 37-42
Cholera vaccination campaign in Bangladesh	Planned (for feasibility study)	Full economic costs	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

[8] The cost per dose exclusive of the vaccine for this study was calculated using the average price of the 10 dose and 50 dose presentations

			cholera vaccine in Bangladesh. Vaccine, 33(38), 4916–4921.
Cholera vaccination campaign in Tanzania	Planned (to estimate cost-effectiveness in an endemic region)	Full economic costs	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. PLoS Neglected Tropical Diseases, 6(10).
Cholera vaccination campaign in Ethiopia	Planned (for feasibility study)	Full economic and incremental financial costs	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.
Yellow fever campaign in Cote d'Ivoire.[9]	Outbreak response	Incremental financial costs	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.

[9] Due to insufficient information relating to campaign logistics, supplementary information on the campaign from the International Federation of Red Cross and Red Crescent Societies final report accessible from **https://www.ifrc.org/docs/appeals/01/3001F.pdf** and Fitzner, J., Coulibaly, D., Kouadio, D. E., Yavo, J. C., Loukou, Y. G., Koudou, P. O., & Coulombier, D. (2004). Safety of the yellow fever vaccine during the September 2001 mass vaccination campaign in Abidjan, Ivory Coast. Vaccine, 23(2), 156-162.

ANNEX B – PPE COST COMPARISON

Cost of health worker PPE scenarios per day (USD 2020)			
Combination	WHO forecasting supplies tool (used in this analysis)**Error! Bookmark not defined.**	UNICEF Supply Catalogue[28]	PPE for Ebola in West Africa[29]
Goggles, gown, two masks and one pair of gloves per beneficiary*	17.91	15.80	-
Goggles, gown, two masks and two pairs of gloves per day	5.24	3.23	1.97**
Mask and two sets of gloves	0.94	0.56	0.43

* Vaccinators are allocated one set of gloves per beneficiary, the estimate here is based on the median use across the studies

** This study reported the use of a face shield instead of goggles

Unit costs of PPE (USD 2020)			
Item	WHO forecasting supplies tool (used for this analysis)[21]	UNICEF catalogue**Error! Bookmark not defined.**	PPE for Ebola in West Africa**Error! Bookmark not defined.**
Face shield	-	-	0.63
Protective goggles	2.80	6.51	-
Gloves (pair)	0.12	0.17	0.18
Gown	0.80	0.998	0.82
Mask	0.70	0.22	0.08
Biohazard bag	0.15	0.72	-

Hand washing station components (USD 2020) Error! Bookmark not defined.	
60-liter bucket	6.20
Hand washing stand	31.20
Basin	2.30
Soap	0.9[21]

Thermometer (USD 2020)	
	UNICEF catalogue[30]

Infrared thermometer	27.89

ANNEX C – RESULTS TABLES

1. Infection prevention and control: PPE for health workers & handwashing stations						
Study description	**Type of cost reported**		**Original cost per dose without vaccine (2020 USD)**	**Additional cost per dose in each scenario (2020 USD)**		
	Economic/ financial	**Full/ incremental**		**Low**	**Medium**	**High**
Outbreak campaign for YF in Cote d'Ivoire	Financial	Incremental	$ 0.45[10]	$ 0.01 (+1.7%)	$ 0.13 (+28.5%)	$ 0.14 (+31.6%)
Mass vaccination campaign for OCV in Mozambique	Economic	Full	$ 0.48 ($ 1.06 per person in the target population)	$ 0.03 (+6.1%)	$ 0.16 (+32.6%)	$ 0.19 (+41.0%)
Mass vaccination campaign for OCV in India	Financial	Full	$ 0.57	$ 0.08 (+13.6%)	$ 0.21 (+36.7%)	$ 0.29 (+50.3%)
SIA for Measles in Benin	Unclear	Full	$ 0.63[10]	$ 0.03 (+5.3%)	$ 0.15 (+24.7%)	$ 0.23 (+37.5%)
SIA delivery of OCV vaccine in Ethiopia in a rural setting	Financial	Incremental	$ 0.81	$ 0.02 (+3.0%)	$ 0.15 (+18.0%)	$ 0.20 (+24.3%)
SIA delivery of OCV vaccine in Ethiopia in a rural setting	Economic	Full	$ 0.93[10]	$ 0.02 (+2.6%)	$ 0.15 (+15.8%)	$ 0.20 (+21.3%)
SIA delivery of OCV vaccine in Haiti in urban and rural settings	Economic	Incremental	$ 1.05	$ 0.02 (+2.3%)	$ 0.15 (+14.1%)	$ 0.18 (+17.5%)
Mass vaccination campaign for OCV in Bangladesh	Financial	Full	$ 1.14	$ 0.04 (+3.4%)	$ 0.17 (+14.5%)	$ 0.21 (+18.3%)
Mass vaccination campaign for OCV in Bangladesh	Economic	Full	$ 1.18 ($ 2.52 per fully immunized person)	$ 0.04 (+3.2%)	$ 0.17 (+14.0%)	$ 0.21 (+17.7%)
Mass vaccination campaign for OCV in Tanzania.	Economic	Full	$ 5.76 ($ 11.9 per person in the target population)	$ 0.05 (+0.9%)	$ 0.17 (+3.0%)	$ 0.28 (+4.8%)
Median				**3.1%**	**16.9%**	**22.8%**

[10] For these studies, no unit cost was given, number of persons vaccinated was used as proxy for doses delivered

2. Additional crowd controllers at vaccination sites					
Study description	**Type of cost reported**		**Original cost per dose without vaccine (2020 USD)**	**Additional cost per dose in each scenario (2020 USD)**	
	Economic/ financial	**Full/ incremental**		**Low**	**High**
Outbreak campaign for YF in Cote d'Ivoire	Financial	Incremental	$ 0.45[11]	$ 0.01 (+2.0%)[12]	$ 0.02 (+3.8%)
SIA for Measles in Benin	Unclear	Full	$ 0.63	$ 0.08 (+13.4%)[11]	$ 0.16 (+25.0%)
SIA delivery of OCV vaccine in Ethiopia in a rural setting	Financial	Incremental	$ 0.81	$ 0.10 (+12.9%)	$ 0.20 (+25.0%)
SIA delivery of OCV vaccine in Haiti in urban and rural settings	Economic	Incremental	$ 1.05	$ 0.24 (+22.5%)	$ 0.47 (+44.2%)
Median				**+13.2%**	**+25.0%**

3. Extended duration of the campaign & additional health worker per diems					
Study description	**Type of cost reported**		**Original cost per dose without vaccine (2020 USD)**	**Additional cost per dose in each scenario (2020 USD)**	
	Economic/ financial	**Full/ incremental**		**Low**	**High**
Outbreak campaign for YF in Cote d'Ivoire	Financial	Incremental	$ 0.45	$ 0.03 (+7.2%)	$ 0.13 (+28.7%)
SIA for Measles in Benin	Unclear	Full	$ 0.63[11]	$ 0.05 (+8.7%)[13]	$ 0.22 (+34.8%)
SIA delivery of OCV vaccine in Ethiopia in a rural setting	Financial	Incremental	$ 0.81	$ 0.07 (+8.0%)	$ 0.26 (+32.0%)
Outbreak campaign for Meningitis in Burkina Faso	Not reported	Incremental	$ 0.97**Error! Bookmark not defined.**	$ 0.02 (+1.6%)	$ 0.06 (+6.6%)

[11] For these studies, no unit cost was given, number of persons vaccinated was used as proxy for doses delivered

[12] These two studies gave the per diem costs for each cadre of which the rate for the lowest cadre was used to calculate the additional costs of crowd controllers, the others assumed an equal per diem rate which may have led to an overestimation

[13] Results for this study show the increase in cost in personnel costs for the vaccination team members only while others show the increase in cost for all personnel

SIA delivery of OCV vaccine in Haiti in urban and rural settings	Economic	Incremental	$ 1.05	$ 0.15 (+14.4%)	$ 0.61 (+57.6%)
Median				**+8.0%**	**+32.0%**

4. An increase of certain components of the operational cost of the campaign						
Study description	**Type of cost reported**		**Cost per dose without vaccine (2020 USD)**	**Additional cost per dose in each scenario (2020 USD)**		
	Economic/ financial	**Full/ incremental**		**Low**	**Medium**	**High**
Outbreak campaign for YF in Cote d'Ivoire	Financial	Incremental	$ 0.45**Error! Bookmark not defined.**	$ 0.04 (+8.3%)	$ 0.07 (+16.6%)	$ 0.15 (+33.2%)
Mass vaccination campaign for OCV in Mozambique	Economic	Full	$ 0.48 ($ 1.06 per person in the target population)	$ 0.02 (+4.1%)	$ 0.04 (+8.1%)	$ 0.08 (+16.3%)
SIA for Measles in Benin	Unclear	Full	$ 0.63**Error! Bookmark not defined.**	$ 0.04 (+6.1%)	$ 0.08 (+12.3%)	$ 0.15 (+24.5%)
SIA delivery of OCV vaccine in Ethiopia in a rural setting	Financial	Incremental	$ 0.81	$ 0.14 (+17.0%)	$ 0.28 (+34.1%)	$ 0.55 (+68.1%)
SIA delivery of OCV vaccine in Ethiopia in a rural setting	Economic	Full	$ 0.93 [14]	$ 0.21 (+23.0%)	$ 0.43 (+46.1%)	$ 0.85 (+92.2%)
Outbreak campaign for Meningitis in Burkina Faso	Not reported	Incremental	$ 0.97**Error! Bookmark not defined.**	$ 0.10 (+10.4%)	$ 0.20 (+20.8%)	$ 0.40 (+41.5%)
Mass vaccination campaign for OCV in Bangladesh	Financial	Full	$ 1.14	$ 0.11 (+10.1%)	$ 0.23 (+20.1%)	$ 0.46 (+40.2%)
Mass vaccination campaign for OCV in Bangladesh	Economic	Full	$ 1.18 ($2.52 per fully immunized person)	$ 0.12 (+10.0%)	$ 0.24 (+20.0%)	$ 0.47 (+39.9%)
Median				**+10.0%**	**+20.0%**	**+40.1%**

[14] For this study, no unit cost was given, number of doses delivered used

5. Combination of PPE for health workers & handwashing stations, additional crowd controllers at vaccination sites, additional per diems due to a campaign extension, and an increase of certain components of the operational cost of the campaign						
Study description	**Type of cost reported**		**Cost per dose without vaccine (2020 USD)**	**Additional cost per dose in each scenario (2020 USD)**		
	Economic/ financial	**Full/ incremental**		**Low**	**Medium**	**High**
Outbreak campaign for YF in Cote d'Ivoire	Financial	Incremental	$ 0.45**Error! Bookmark not defined.**	$ 0.09 (+19.5%)	$ 0.36 (+78.9%)	$ 0.45 (+98.6%)
SIA for Measles with different strategies in Benin	Unclear	Full	$ 0.63**Error! Bookmark not defined.**	$ 0.22 (+35.9%)	$ 0.66 (+105.9%)	$ 0.82 (+131.0%)
SIA delivery of OCV vaccine in Ethiopia in a rural setting	Financial	Incremental	$ 0.81	$ 0.35 (+43.6%)	$ 0.97 (+119.7%)	$ 1.30 (+160.0%)
Median				**+35.9%**	**+105.9%**	**+131.0%**

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