# The cost of delivering yellow fever and meningitis A vaccines through campaigns in Nigeria

**FINAL REPORT – March 2022**

BREAKING NEW GROUND

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## EXECUTIVE SUMMARY

### Background

In 2017, Nigeria launched a 10-year yellow fever elimination plan aiming to vaccinate at least 80% of the target population (9 months to 44 years of age) in all states by 2026, through a series of phased immunization campaigns. Despite their resource-intensive nature, little evidence exists on the cost of campaigns globally nor in Nigeria. A detailed understanding of delivery costs is essential to ensuring effective and efficient financial planning for high-quality campaigns. With support from the Bill & Melinda Gates Foundation (BMGF), ThinkWell and the Health Policy Research Group (HPRG) at the University of Nigeria have conducted a study to estimate the operational cost of delivering yellow fever (YF) and co-delivery of YF with meningitis A (MenA) vaccines through immunization campaigns in Nigeria.

Together with the government, three states were purposively selected to cover the north, middle and south of the country. YF campaigns were conducted in Katsina (September 2019), Rivers (February 2020), and Anambra (October 2020) states. In Anambra, the campaign was implemented alongside a Meningococcal A catch-up campaign targeting 1- to 6-year-olds. The campaigns were coordinated at federal level by the Department of Disease Control and Immunization of the National Primary Health Care Development Agency (NPHCDA), and supported by Gavi, the Vaccine Alliance. In each state, local government areas (LGAs) took 10 days to complete the campaign and most health facilities conducted a 1- or 2-day mop-up. According to post-campaign coverage surveys, the campaigns achieved 83% coverage in Katsina, 82% in Rivers, and 76% (YF) and 96% (MenA) in Anambra.

### Methodology

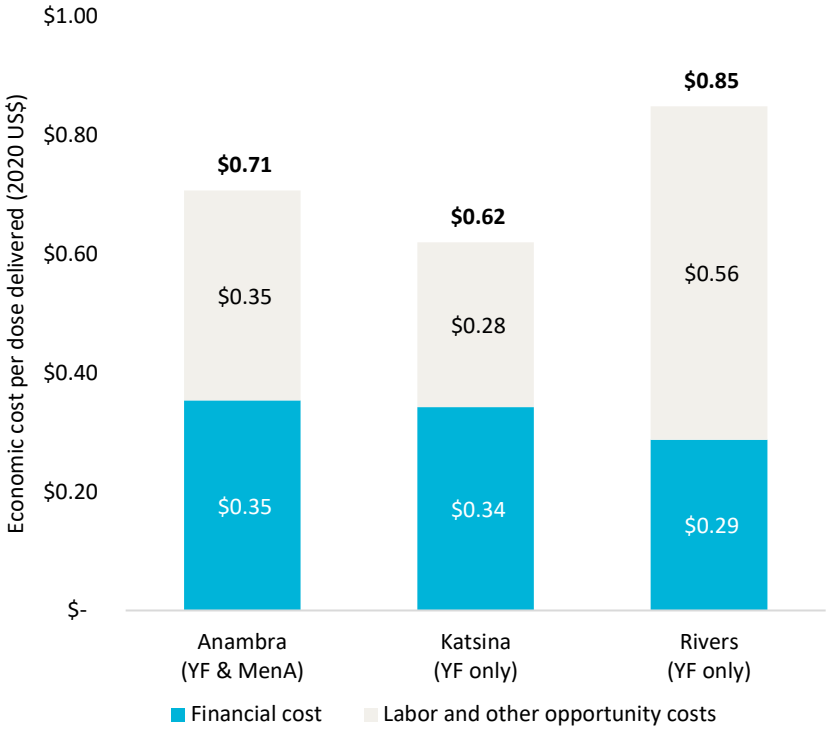
Costs were estimated from the payer perspective, including costs incurred by health service providers, the NPHCDA, and development partners, through ingredients-based costing and review of financial reports. The study estimated the full financial and economic costs of the campaigns, including campaign-specific costs as well as costs shared with the wider health system. The sample included total of 28 wards within 10 LGAs and covered a total of 78 health facilities involved in the campaigns. Data was collected retrospectively between October 2020 and May 2021 at health facilities, wards, LGAs, as well as state-level and federal-level government offices and development partners. Costs were categorized by campaign activity (e.g., training, service delivery, social mobilization, etc.) and resource type (e.g., per diems, transport costs and volunteer labor, etc.). Costs were aggregated to estimate the volume and sampling probability weighted average cost per dose delivered, as well as the total cost of the campaign.

### Key findings

The financial delivery cost of the campaign—excluding vaccines costs—was US$ 2,290,290 (₦ 769,780,004) in Katsina, US$ 1,804,205 (₦ 647,368,269) in Rivers, and US$ 2,578,029 (₦ 925,024,731) in Anambra, where YF and MenA vaccines were co-delivered. Service delivery covered the largest proportion of costs across all three states—accounting for 38-45% of financial costs and 30-35% of economic costs—followed by social mobilization and record keeping. The financial cost of the campaign was mostly driven by per diem and allowances, vaccine injection supplies, and transport and fuel costs, while paid and volunteer labor were the key cost drivers among economic cost. Per dose delivered, the financial delivery cost was US$0.34 in Katsina, US$0.29 in Rivers, and US$0.35 in Anambra. The cost per dose of labor and other opportunity costs was estimated at US$0.28 in Katsina, US$0.56 in Rivers, and US$0.35 in Anambra. The majority of the delivery costs were incurred at facility level, even if they may have been paid for at other levels.

Financial cost drivers showed similar patterns across the three states, and no clear difference between the integrated and non-integrated states could be identified. While the financial cost per dose delivered was higher in Anambra—where YF delivery was integrated with MenA—than in Katsina and Rivers—where only YF was administered—the difference in financial cost per dose between Anambra and the state with the second highest financial cost per dose, Katsina, is very small and insignificant. The difference between the two states that only delivered yellow fever is larger. The median number of doses delivered per ward was lowest in Anambra compared to the other states, suggesting that the difference in cost per dose could be driven more by volume delivered rather than the number of different vaccines. Other differences between the states and how the campaign was implemented may also have played a larger role in driving cost differences than the co-delivery component.

*The economic delivery costs per dose administered in Anambra (YF & MenA), Katsina and Rivers (YF only), in 2020 US$*



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## ACRONYMS

| | | | |
|---|---|---|---|
| **AFENET** | African Field Epidemiology Network | **MR** | Measles-rubella |
| **BMGF** | Bill and Melinda Gates Foundation | **NCDC** | Nigeria Centre for Disease Control |
| **CHAI** | Clinton Health Access Initiative | **NGN** | Nigerian Naira |
| **EYE** | Eliminate Yellow Fever Epidemics | **NPHCDA** | National Primary Health Care Development Agency |
| **FCT** | Federal Capital Territory | **PPE** | Personal Protective Equipment |
| **HPRG** | Health Policy Research Group | **SIA** | Supplemental immunization activities |
| **ICAN** | Immunization Costing Action Network | **SMOH** | State Ministry of Health |
| **IDCC** | Immunization Delivery Cost Catalogue | **SPHCDA** | State Primary Healthcare Development Agencies |
| **IEC** | Information Education and Communication | **UNICEF** | United Nations Children's Fund |
| **IPC** | Infection prevention and control | **UN** | United Nations |
| **LGA** | Local Government Area | **USD** | United States Dollar |
| **MenA** | Meningococcal A | **WHO** | World Health Organization |
| **MOH** | Ministry of Health | **YF** | Yellow Fever |

# 1. INTRODUCTION

**With support from the Bill & Melinda Gates Foundation (BMGF), ThinkWell and the Health Policy Research Group (HPRG) at the University of Nigeria have conducted a study to estimate the operational cost of delivering yellow fever (YF) and meningitis A vaccines through immunization campaigns in Nigeria.** After the re-emergence of yellow fever in 2017, Nigeria launched a 10-year yellow fever elimination plan as part of the World Health Organization's (WHO's) Eliminate Yellow Fever Epidemics (EYE) strategy**.** Under this strategy, Nigeria has committed to vaccinate at least 80% of the target population (9 months to 44 years of age) in all states by 2026 through a series of phased immunization campaigns. Despite their resource-intensive nature, little evidence exists on the cost of campaigns. In Nigeria, only one previous study has estimated the cost of campaign-based delivery, and none have assessed the cost of integrated delivery.[1] A detailed understanding of delivery costs is essential to ensuring effective and efficient financial planning for high-quality campaigns. This study estimates the operational cost of yellow fever immunization campaigns in the Nigerian states of Katsina and Rivers, and of an integrated yellow fever and meningitis A campaign in Anambra state.

# 2. BACKGROUND

## 2.1 YELLOW FEVER CAMPAIGNS IN NIGERIA

**Since its introduction into the routine childhood immunization schedule in 2004, routine coverage of the yellow fever vaccine has been low and in 2017 was only 39% nationally.** Following a yellow fever outbreak in Nigeria in September 2017, and in pursuit of WHO's EYE strategy, the country launched a 10-year strategic elimination plan. The EYE strategy is a long-term policy for 2017-2026, centered around three objectives: (1) to protect at-risk populations, (2) prevent international spread and (3) contain outbreaks rapidly. As part of this yellow fever elimination plan, Nigeria has already completed a range of yellow fever campaigns, some preventive and others in response to outbreaks.

**Following the introduction of the elimination plan, Nigerian states are implementing yellow fever campaigns in a phased manner, in line with a prioritization based on risk levels.** Phases 1 and 2 of the 10-year plan were completed by the end of 2018. The campaigns have reached varying levels of coverage, ranging from 62% in Sokoto state to 96% in Federal Capital Territory (FCT) Abuja, as illustrated in Table 1.[2] The post-coverage survey for phase 2B indicated a lack of awareness that the campaign was taking place as the main reason for individuals not having been vaccinated, followed by fear of injection and the timing of the vaccination being unsuitable.[3] Recommendations for improvements coming out of each campaign phase for yellow fever, as well as from measles and polio campaigns, are constantly implemented in consecutive phases of the campaign.

*Table 1: Results of previous yellow fever campaigns by state*[4]

| Previous campaigns (Nov-Dec 2013) | | YF elimination plan phase 1 (Jan-Feb 2018) | | YF elimination plan phase 2 (Nov-Dec 2018) | |
|---|---|---|---|---|---|
| **States** | **Coverage** | **States** | **Coverage** | **States** | **Coverage** |
| Akwa Ibom | 59% | Kwara | 91% | FCT Abuja | 96% |
| Cross River | 84% | Kogi | 95% | Niger | 78% |
| Nasarawa | 91% | Zamfara | 86% | Plateau | 94% |
| | | Borno (partial) | 96% | Kebbi | 69% |
| | | | | Sokoto | 62% |
| | | | | Borno (partial) | n.a.* |

** Post campaign coverage survey following the yellow fever campaigns conducted in late 2018 did not include Borno state.*

**Between September 2019 and December 2020, Nigeria implemented phase 3 of the yellow fever 10-year elimination strategy, and campaigns were conducted in Katsina, Anambra, Ekiti and River states.** The target population for the campaigns was the entire population in each state aged 9 months to 44 years.[5] Microplans were developed at the ward level, and the campaign utilized fixed posts (health facilities) and temporary vaccination posts at schools, homes of traditional or religious leaders, mosques, churches, bus stops and terminals, major streets, motor parks, hard-to-reach areas, borders, and markets. Each local government area (LGA) took 10 days to complete the campaign. In most states, all LGAs conduct the campaign at the same time, though some states employed a phased approach with LGAs conducting the campaign in sequence to better leverage existing resources such as cold chain equipment and human resources. In wards and settlements that achieved less than 90% coverage or where rapid convenience monitoring showed that more than 5% of children have been missed, a one or two day-mop up was conducted. In Anambra, the yellow fever vaccine was delivered alongside meningococcal A (MenA) targeting 1–6-year-olds.[6] Campaign start dates, target populations as well as doses delivered for both vaccines, are illustrated in Table 2.

*Table 2: Phase 3 yellow fever campaigns*

| | **Yellow Fever** (Target group: 9 months - 44 years) | **Meningococcal A** (Target group: 1 - 6 years) |
|---|---|---|
| | **Target population** | **Target population** |
| **Katsina** (Sept 2019) | 8,716,415 | n.a. |
| **Ekiti** (Jan 2019) | 1,126,705 | n.a. |
| **Rivers** (Feb 2019) | 8,581,155 | n.a. |
| **Anambra** (Oct 2020) | 6,043,277 | 1,137,549 |

**The yellow fever campaigns are coordinated at federal level by the Department of Disease Control and Immunization of the National Primary Health Care Development Agency (NPHCDA), and largely funded by Gavi, the Vaccine Alliance, through a direct disbursement mechanism implemented by WHO.**

Implementation of the yellow fever campaigns is coordinated by the federal NPHCDA with support from WHO, United Children's Fund (UNICEF), Nigeria Centre for Disease Control (NCDC), African Field Epidemiology Network (AFENET), Clinton Health Access Initiative (CHAI), and other partners. A steering committee chaired by the Executive Director of the NPHCDA provides technical guidance in planning, implementation, monitoring and evaluation of all campaign activities. The committee includes a resource mobilization group, logistics working group, advocacy, communication and social mobilization working group, training working group, monitoring and evaluation working group. At the state level, campaign oversight follows the same structure. In terms of financing, while states are expected to provide counterpart financing, most of the funding is provided by Gavi, with a total of US$123 million committed for the 2019-2021 period to support vaccines procurement and operational cost of yellow fever campaigns.[7] Donor contributions for the campaign as well funds from the federal government were disbursed through a direct disbursement mechanism established by WHO in 2014 to ensure timely payments and to circumvent issues with funds not making their way down from federal level to facilities and health workers. In parallel, UNICEF channelled funding for logistics and social mobilization directly to the states.

### 2.2 MENINGITIS A CAMPAIGNS IN NIGERIA

**The MenA campaign in Anambra was part of a subnational catch-up campaign effort following the introduction of the MenAfriVac vaccine into the routine schedule in 2019.** Nigeria is a part of the so-called meningitis belt, a region extending from Ethiopia to Senegal characterized by recurring bacterial meningitis epidemics. After the development of the novel meningococcal serogroup A conjugate vaccine (MenAfriVac) in 2010, Nigeria was identified by the WHO among the region's highest priority countries for vaccine introduction, due to its high epidemic risk and high burden of disease. Following WHO recommendation, Nigeria conducted a series of MenA mass immunization campaigns, implemented in four phases between 2011 and 2014, targeting high risk areas (17 northern states) and reaching a coverage level of 69.9%.[8] In 2019, as MenAfriVac was approved for routine use and introduced into the childhood immunization schedule, a series of catch-up campaigns were planned over three implementation phases to cover the children missed in between the initial preventive campaigns and the routine introduction. The campaigns targeted all 1- to 7-year-old children in high-risk northern states, and 1- to 6-year-olds in high and medium risk states—including Anambra state.

## 3. RATIONALE AND OBJECTIVE

**Evidence on what it costs to conduct a campaign and primary data on the costs of vaccine delivery is limited in Nigeria.** For the development of the Immunization Delivery Cost Catalogue (IDCC)—last updated in 2019—the Immunization Costing Action Network (ICAN) reviewed over 17,000 peer-reviewed articles, reports and grey literature; none of them contained primary costing data from Nigeria.[9] Furthermore, out of the over 660 cost records in the IDCC, only 33 were for campaigns and outbreak responses. In recent years, Nigeria has undertaken numerous supplemental immunization activities, from outbreak response campaigns to preventative campaigns (polio, measles and yellow fever) and mass vaccination campaigns for the introduction of a new vaccine (meningitis A). Nevertheless, as of July 2021 only one publication is currently available on the cost of vaccine delivery in Nigeria, a study aimed at assessing the cost-effectiveness of routine and supplemental immunization activity (SIA) delivery of measles vaccines in Anambra state in 2016.[10]

**The purpose of this study is to estimate the cost of delivering yellow fever and meningitis A vaccines through campaigns in Nigeria.** The specific objectives of the study are:

- To estimate the campaign-specific or shared costs of yellow fever campaigns in Nigeria

- To identify the main cost drivers of the campaigns
- To determine how costs and cost drivers vary by delivery strategy and administrative area
- To estimate the cost of integrating the delivery of yellow fever and the meningitis A through campaign delivery in Nigeria

The findings from this study can be used to improve budgeting and planning for future immunization campaigns, to provide evidence for resource mobilization and advocacy, and to inform the level of Gavi support for campaigns.

## 4. STUDY DESIGN, SCOPE AND METHODS

### 4.1 STUDY DESIGN

**This was a retrospective study that captured the full financial and economic costs of the campaign**. The study estimated both the delivery cost of the campaign as well as the cost of the commodities. Delivery costs are defined as the costs associated with delivering immunizations to target populations, exclusive of vaccine costs, but including supplies. The costs included in the study captured both the additional resources used to implement the campaign (such as per diems and supplies), as well as an estimation of the use of existing resources (such as capital costs and a share of routine government health worker salaries). Costs were collected from all administrative levels in Nigeria that participated in the implementation of the campaign (federal, state, LGA, ward and facility level) and all costs incurred from the moment the planning activities for the campaign first started until the final reports were submitted (generally from about six months before and up to one month after the campaign).

**This study estimated campaign-specific costs, as well as shared costs of the campaign.** The campaign-specific costs consist of all additional financial and non-financial resources used solely for the purpose of the campaign. This includes the funding in the campaign's budget but also any additional funding used to complete the campaign, such as resources pulled from other health budgets. The value of staff overtime and volunteer labor were also included in the campaign-specific cost. The shared costs of the campaign would include existing resources that were deployed for the campaign, such as the cost of the use of existing equipment and a share of the cost of routine government health sector workers. By including both campaign-specific and shared cost, this study also estimates the burden that the campaigns placed on the routine system.

**The study was conducted from the payer perspective, thereby including costs incurred by health service providers, the National Primary Healthcare Development Agency (NPHCDA), and development partners**. The study captured the costs of all health sector stakeholders that supported the implementation of the campaign, including the NPHCDA, the federal Ministry of Health, the relevant State Primary Healthcare Development Agencies (SPHCDA), the relevant State ministries of Health (SMOHs), technical partners supporting the campaign at federal level (i.e., WHO, UNICEF, CHAI), as well as partners that provided support at state level (i.e. Nigerian Red Cross Societies, the CORE Group Polio Project). As per ICAN's methodological guidance on how to cost an immunization campaign, this is defined as the payer perspective.[11] A full list of partners included in the study can be found in Annex I: Names of partners included in study. Costs incurred by other sectors and government entities, and the beneficiaries were not included. These could have included costs for other ministries to promote the campaign, as well as the costs to households of traveling to immunization sites. The study received ethical approval from the Health Research Ethics Committee from the University of Nigeria Teaching Hospital and steps were taken to ensure that the names of the participating health facilities remained confidential.

## 4.2 SAMPLING STRATEGY

**Working with the government, three states were purposively selected, while data collection sites for lower administrative levels were randomly sampled.** Phase 3 of Nigeria's yellow fever campaigns included a total of four states, of which three were purposively selected for this study to represent different coverage level achievements in past campaigns (see Table 3)[12], as yellow fever campaign coverage was not yet available for all states at the time of sampling. To facilitate the selection of the samples in each state, the research team used the Sample Design Optimizer developed by the Harvard T.H. Chan School of Public Health.[13] This tool utilizes auxiliary data that is expected to be correlated with the cost per dose of vaccine administration at the chosen sampling unit to produce the most optimal sample for the study, within a given data collection budget. The ward was selected as sampling unit, and all teams and vaccination sites covered by each sampled ward—both fixed posts and temporary posts—were included in the data collection. Equal probability simple random selection was used to draw the sample, selecting 1 to 4 LGAs in each state and 1 to 4 wards in each LGA. Sampling was done separately for each of the states, right before the start of data collection in a given state.

*Table 3. Previous campaign coverage achievement in the sampled states*

| State | Measles 2018 campaign survey coverage[1] |
|---|---|
| Katsina | 91.9% |
| Rivers | 80.4% |
| Anambra | 95.7% |

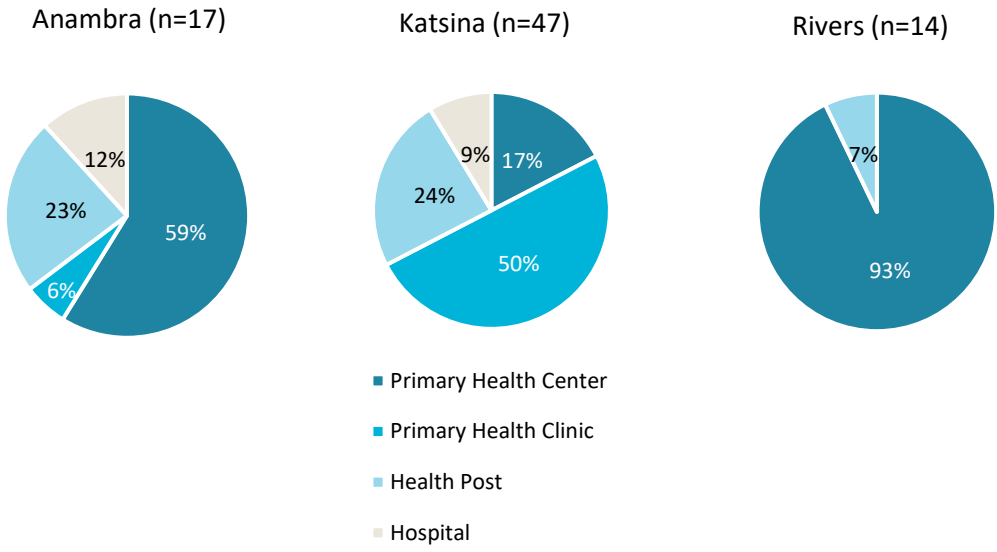
*Figure 1: Sampling strategy and final sample size*


**In the three states, a total of 28 wards within 10 LGAs were sampled for data collection, covering a total of 78 health facilities involved in the campaigns**. At the time that the sample for Katsina, was drawn, the feasibility of collecting data in a third state (Rivers) was highly uncertain due to the COVID-19 pandemic. Therefore, a decision was taken to increase the sample size in Katsina to ensure a large overall sample size for the study, even in case no further data could be collected. Due to security issues, 2 LGAs in Rivers and 1 in Katsina that were originally sampled could not be visited and were replaced with LGAs of similar size. One health facility in Katsina could not be visited due to the security issues and was not replaced. The final sample included 4 LGAs, 8 wards and 17 health facilities in Anambra, 2 LGAs, 7 wards and 47 health facilities in Katsina, and 4 LGAs, 13 wards and 14 health facilities in Rivers (Figure 1).

**Although our sampling strategy allowed for the inclusion of private facilities, 97% of the sampled health facilities were government owned.** The majority of all facilities in the sample were primary health centers (40%)—the largest type of primary care facilities in Nigeria, typically covering a catchment population of 10,000 to 20,000 people. These were followed by primary health clinics (31%)—the second largest type of primary facilities, serving about 2,000 to 5,000 people—and health posts (21%), which usually cater to about 500 people. The sample also included some secondary level facilities—6 hospitals—which

represented 8% of the total sample. While primary health clinics are a significant share of the overall sample, they were only 6% of the sample in Anambra, and no primary health clinic was sampled in Rivers (Figure ). Although our sampling strategy allowed for the inclusion of private facilities—which represent almost 20% of all facilities in the three states—only 3% of all facilities in the samples were private (two hospitals).

*Figure 2: Breakdown of sampled health facility types by state*




## 4.3 METHODOLOGY

**The costing study used a mixed methods approach, combining review of expenditures reports and bottom-up micro-costing (or ingredients-based).** Campaign-related activities (defined in Annex II) at each administrative level were costed by measuring the quantity of the inputs (resource types defined in Annex III) used to achieve these activities, which were then multiplied by a price for each of these inputs (unit cost) to calculate the cost of each resource type under each activity. Most data used in this study were collected through in-person or virtual interviews at federal and state level, LGAs, and health facilities; when needed, additional requests for information were made via email. Campaign-related records were also reviewed, including micro-plans, tally sheets, and additional monitoring tools. We focused on costs incurred and staff time during the campaign and the time from the first planning meeting to the completion of final reporting, covering costs incurred in the period from August 2019 to October 2019 for Katsina state, December 2019 to March 2020 in Rivers state, and September 2019 to December 2020 in Anambra state.

**Price information was obtained from various national and international sources.** To cost health worker time, we used salary scale information for federal employees and for each of the three states. The unit costs for electricity and fuel, as well as replacement prices and useful life measurements for vehicles and equipment used during the campaign were also obtained from data collection sites. Lastly, vaccine unit prices were sourced from Gavi's Detailed Product Profiles.[14] As international shipment costs could not be obtained, global level assumptions were used. It was assumed that the additional international transportation costs for the vaccines amounted to 5% of vaccine price, and freight charges for injection devices were 30% of unit prices given as per the UNICEF's guidance on the Costs of Vaccinating a Child.[15] For costs incurred during 2019, including the campaign conducted in Katsina at the NPHCDA National Strategic Cold Store, costs were first inflated from 2019 to 2020 NGN using the IMF consumer price index[16]—except for the vaccine costs, which

were first deflated to 2020 USD and then converted to 2020 NGN. The World Bank Official exchange rate (local currency unit per US$, period average)[17] was used to convert 2020 NGN into USD (358.81 NGN to 1 USD).

**Capital costs were annualized and discounted, and allocated to the campaign using the number of vaccination days as a share of the useful life of the equipment.** A straight-line depreciation of capital items was included using the number of campaign days as a share of the estimated useful life of the vehicle or equipment item. When calculating the economic costs, capital costs were discounted at the global standard rate of 3%. The economic costs also include volunteer time, which was valued at an equivalent of the salary grade.

**In order to allocate costs that were shared between the campaign and the routine system, or between activities, resource types, and interventions, allocation rules were established.** Most of the resources were allocated based on time spent (labor, equipment, utilities, and vehicles). Cold chain costs were allocated based on the share of the campaign's commodity volume, while incinerator costs were allocated based on incinerator usage. Due to the integrated nature of the campaign in Anambra, many costs could not be traced back to a single intervention (yellow fever, meningococcal A vaccines). Therefore, the proportion of the doses delivered was used to allocate shared costs to the two interventions.

## 4.4 DATA COLLECTION

**Data was collected between October 2020 and May 2021 by a team of 24 data collectors and one supervisor from the University of Nigeria, Nsukka using questionnaires designed in Microsoft Excel.** Tailored questionnaires for data collection at federal, state, LGA and facility level use were designed in Excel. The questionnaires contained built-in validation checks to aid data collectors identify and correct inconsistencies. The data collection team underwent four days of training and participated in two days of pilot testing of the study materials at four health facilities in Benue state. Questionnaires were subsequently revised to reflect learnings and feedback. The 24 data collectors worked in teams of two to administer the questionnaires.

**Box 1: Data collection during COVID-19**

- Increasing COVID-19 case numbers in Nigeria and ensuing lockdowns caused the campaign in Anambra—initially scheduled for Q1 of 2020—to be postponed to October 2020, and delayed the beginning of the data collection by 7 months.
- Due to travel restrictions, the initial data collection training was held virtually rather than in person as originally planned. Moreover, as 7 months had passed between the initial training and the start of data collection, half-day refresher trainings were held virtually before the beginning of data collection at federal level and state level.
- Due to COVID-19 travel restrictions, part of the data collection at federal level was also conducted through virtual interviews.

**The number of sites visited by data collectors depended on how the campaign was organized in a given ward.** Depending on the state and the specific LGA and ward strategy, the campaign's implementation was managed either at ward level, by a ward focal point health facility or by each individual health facility. Therefore, in Anambra and Rivers, all data could be collected at the ward focal point facility. On the other hand, in Katsina, about half of the facilities managed the campaign individually, such that each had to be visited, while the other half managed the campaign's implementation in pairs, such that only one facility per pair had to be visited.

**Where data was missing or unavailable, alternative sources were used, or assumptions were made to impute the data**. Completed facility, LGA, state and federal questionnaires were sent to the study team for

review and went through several rounds of revision. If after several rounds of review and follow up some data could not be retrieved, alternative sources were employed, or assumptions were made to impute the missing data. Data most commonly missing included the breakdown of vehicle fuel use across campaign activities, and the breakdown of travel allowances and per diem across activities. At federal level, data collection took place before the start of the campaign in Anambra. For this reason, cost captured at federal level for the periods during and after the campaigns usually referred to the campaigns in Katsina and Rivers only—with the sole exception of costs incurred by the NPHCDA National Strategic Cold Store as there all activities relating to the three campaigns took place before data collection, in August 2019. Where costs were only captured for two states, costs were imputed for the third state with the assumption that costs the contributions by federal-level entities would be similar for all three campaigns. When salary information for partner staff were missing, this was imputed from salaries at similar partners.

### 4.5 DATA ANALYSIS

**To calculate the average unit costs at facility and LGA level, we used a volume weighted average, also accounting for sampling probability.**[18] Data analysis was carried out by researchers from the University of Nigeria and ThinkWell. After data cleaning and a review of outlier data points, costs were calculated in Microsoft Excel for each cost type (financial/economic cost and campaign-specific/shared cost), intervention (YF, MenA), delivery strategy (facility-based, temporary sites, mop up), cost activity (Annex II) and resource type (Annex III). For Anambra state, the cost per dose was calculated for two denominators: the total number of doses delivered across both YF and MenA and the total number of YF doses delivered. The data collected at the state and federal level represents the enumeration of the population at that level (rather than a sample), and therefore a simple average across the total number of doses delivered was taken. A description of all formulas used can be found in Annex IV.

**To obtain a total unit cost per dose for each of the three states, the unit costs for the facility, LGA, state and federal level were aggregated**. All findings are shown for each of the three states individually. Unlike a campaign that is administered nationwide at the same time, Nigeria's yellow fever elimination plan covers a 10-year period with campaigns taking place at various points in time with varying strategies. Therefore, it would not be appropriate to extrapolate state level findings to develop a unit cost estimate representing the cost of implementing yellow fever campaigns in the country as whole.

**Variance in the unit costs is shown through the use of 95% confidence intervals.** Estimating the aggregated level of uncertainty present at facility and LGA levels has been calculated using the svyratio function in the survey package in R, which uses the ratio estimation as described in Levy and Lemeshow.[19] Significance testing has also been carried out to test the differences in results between subgroups (e.g. integrated vs. non-integrated states).

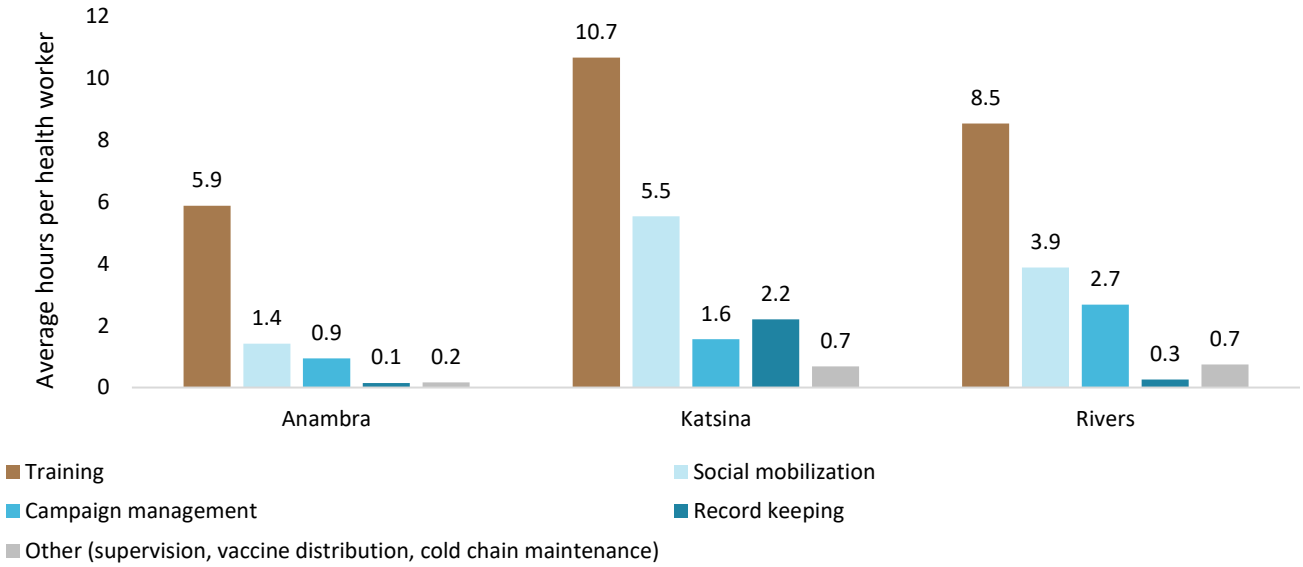
## 5. CAMPAIGN PREPARATIONS AND IMPLEMENTATION

### 5.1 PREPARATORY ACTIVITIES

**In the month leading up the campaign, health workers in Katsina spent a median of 17 hours on preparatory activities, compared with 8 hours in Rivers, and only 4 hours per health worker in Anambra.** In all three states, planning at facility and LGA level often only started in the month before the campaign started. In about half of the facilities in Anambra and Katsina (51%-53%, respectively), the first planning meeting took place earlier than that, while in Rivers this was the case for 23% of the facilities. During the entire preparatory period, facilities organized several preparatory meetings and events, such as trainings, social mobilization

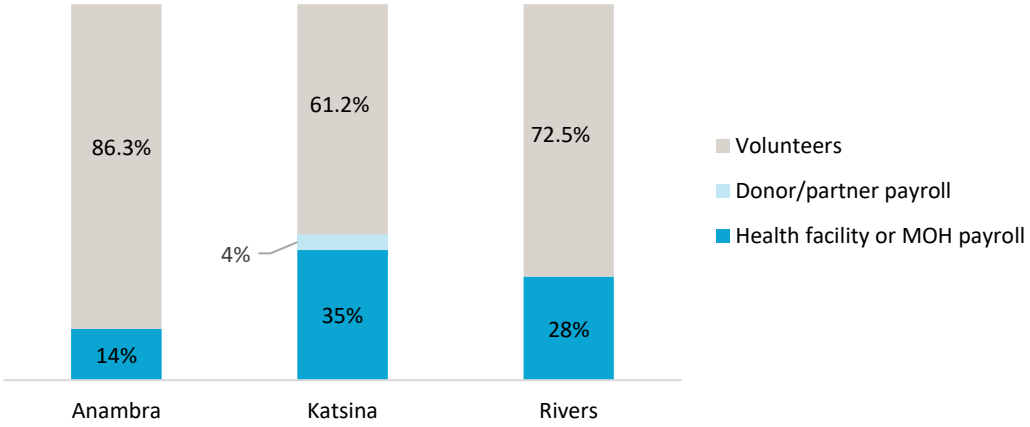
events and campaign planning meetings. Facilities in Katsina organized about 5.5 such events (median), followed by a 4 in Rivers, and a median of 3 events in Anambra. During the final month leading up to the campaign, health workers mostly spent time on training activities, followed by social mobilization, and then campaign management as seen in Figure 3.

*Figure 3: Average number of hours spent per health worker on pre-campaign activities in the month before the campaign*




**Of the health workers involved in campaign activities at the facilities, the majority were volunteers mobilized specifically for the campaign (61-86%, Figure 4).** In Anambra, only 14% of the health workers that participated in the campaign were regular facility staff, while 86% were volunteers. In Rivers, this share was slightly higher, with 28% being regular staff, and 72% volunteers that were mobilized specifically for the campaign. In Katsina, 35% were regular staff, 4% were staff funded by a donor or partner, and the remaining 61% were volunteers. Regular health workers mainly included vaccinators, supervisors, and the ward focal persons while volunteers filled positions such as house-to-house mobilizer, crowd controller, and record keeper.

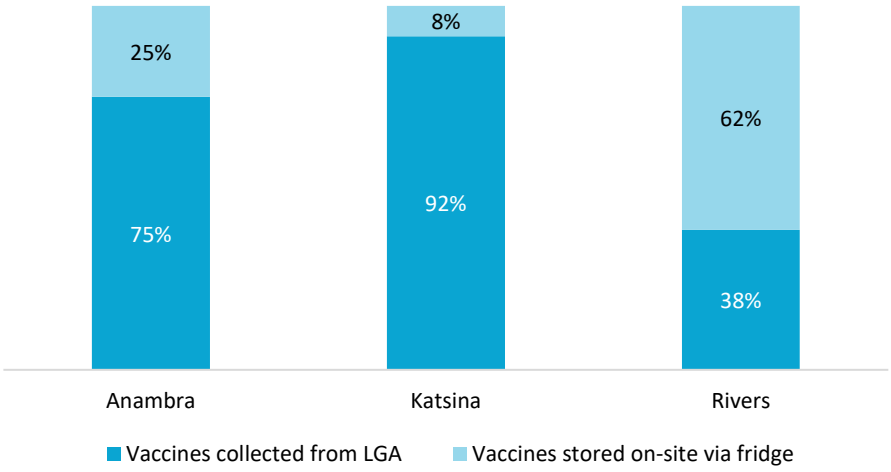
*Figure 4: Proportion of campaign staff by payroll status*



## 5.2 IMPLEMENTATION

**In Anambra and Katsina, vaccines were generally stored at LGA level and collected daily for use at vaccination sites while most wards in Rivers stored campaign vaccines at the facilities (Figure 5).** Three quarters of sampled wards in Anambra and 92% of facilities visited in Katsina collected vaccines directly from the LGA level, while most facilities in Rivers had their vaccines stored within the health facilities themselves with 62% of ward focal point facilities using an on-site fridge. Rivers also had better access to electricity than the other states, with 4 out 13 ward focal point facilities indicating that they had used grid electricity during the campaign. In Katsina, only 2 out of the 36 visited facilities reported using grid electricity during the campaign, while in Anambra none of the facilities did. There, the facilities that stored vaccines on-site mainly used solar fridges. At the end of the campaign, most of the waste was collected by LGA staff to be disposed of via incinerators at the state level, except for two wards in Anambra that used burn pits for waste disposal.

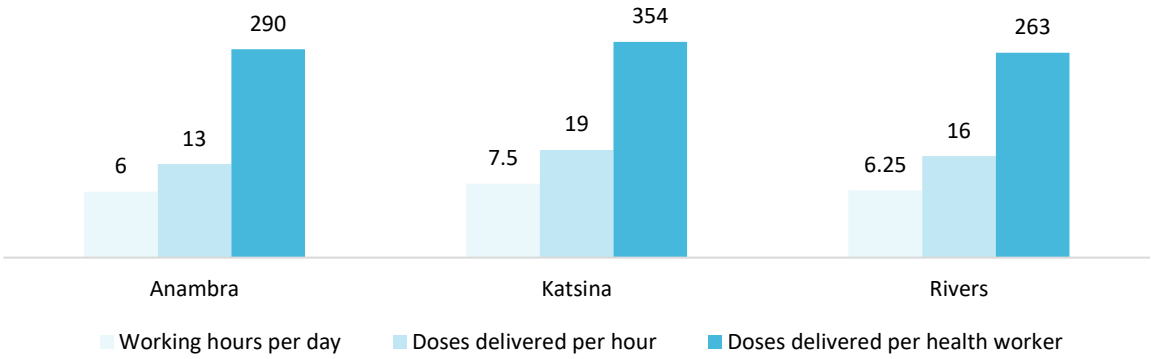
*Figure 5: Proportion of facilities that collected vaccines from the LGA or stored vaccines on-site*




**The median number of daily working hours per health worker during the campaign was highest in Katsina, followed by Rivers, and then Anambra**. In Katsina, all health workers that participated in the campaign (whether they were part of the vaccination teams or supported the campaign in other ways) at the facilities worked a median of 7.5 hours per day during the campaign, followed by 6.3 hours per day in Rivers, and 6.0 hours per day in Anambra as seen in

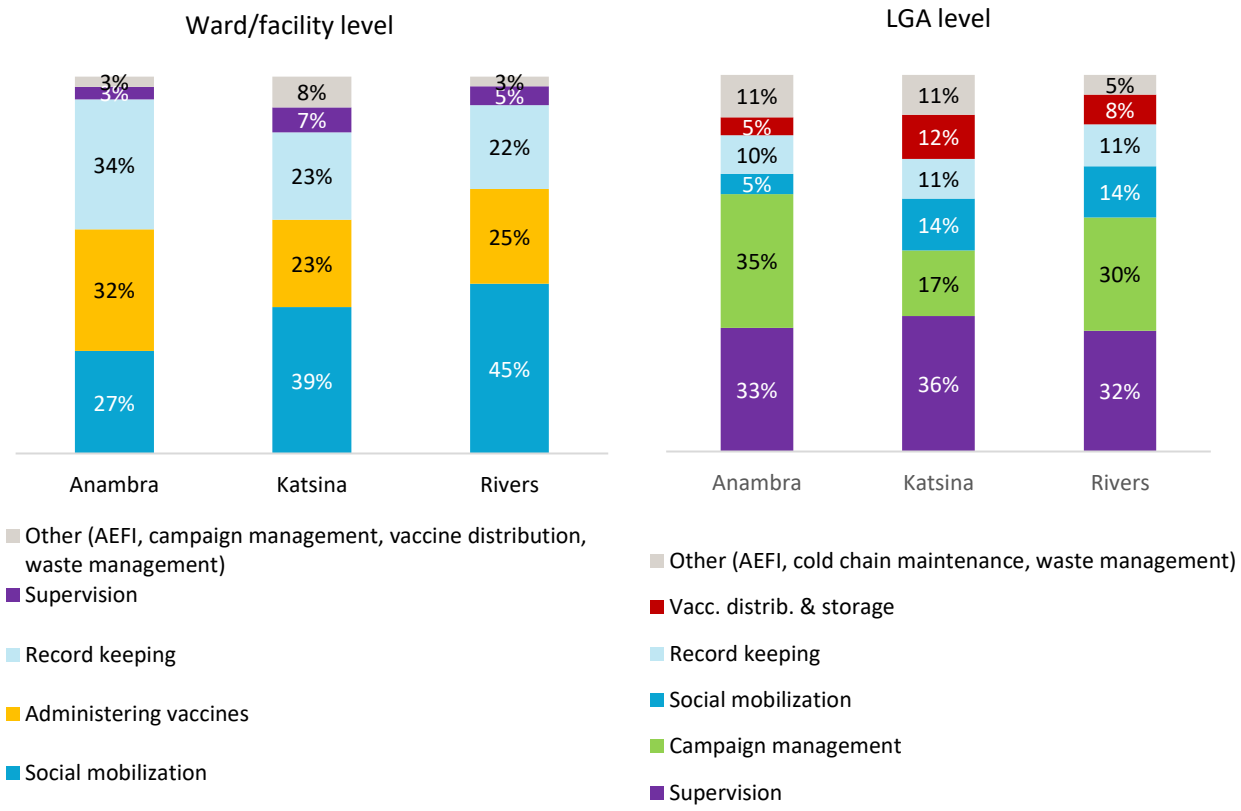
Figure 6. Similarly, the median number of doses delivered per hour of administering vaccines was also highest in Katsina (19/hr), followed by Rivers (16/hr), and then Anambra (13/hr). Lastly, the median number of doses delivered per health worker was highest in Katsina (354 doses/worker followed by Anambra (290 doses/worker), and then Rivers (263 doses/worker).

*Figure 6: Median number of working hours per day, doses delivered per hour, and doses delivered per health worker at the facility level*



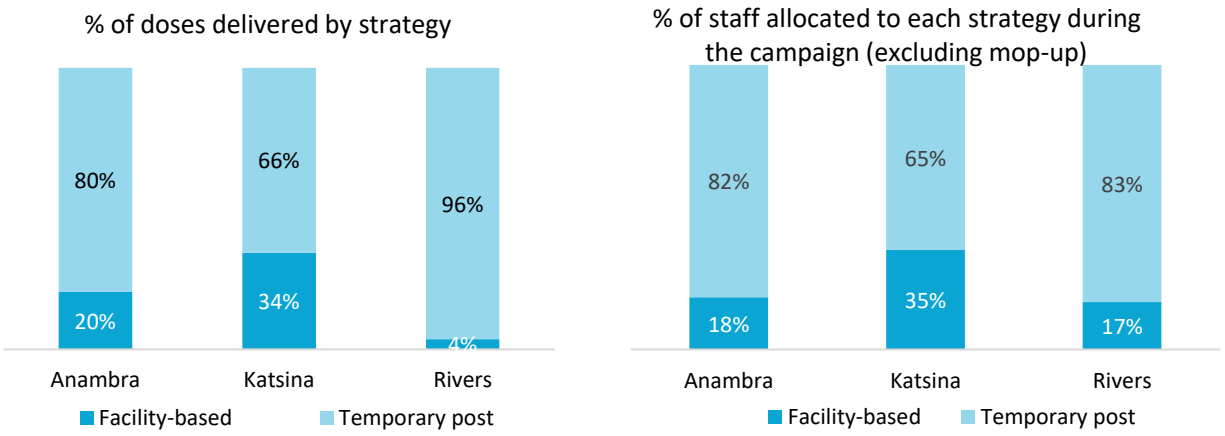

**The main activities undertaken from the facility level during the campaign were social mobilization, administering vaccines, and record-keeping, while at LGA level most time was spent on management and supervision activities (Figure 7)**. In Rivers and Katsina, social mobilization took up the largest share of health workers' time during the campaign, while in Anambra, most time was spent on record keeping. Time spent on administering vaccines differed from 23% in Katsina to 32% in Anambra. At the LGA level, in Anambra most of the staff time was dedicated to campaign management activities, and in Katsina and Rivers the largest share of staff time was dedicated to supervision.

*Figure 7: Median proportion of staff time spent by activity during the campaign*



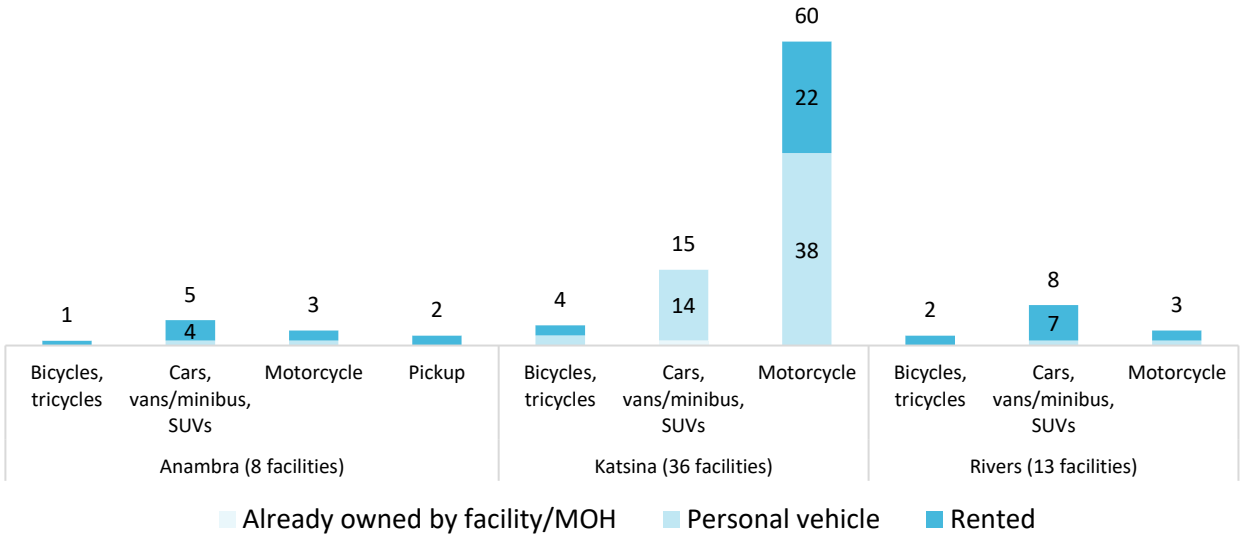
**During the campaign, in all three states, most health workers were allocated to temporary posts (65%-83%); this is also where the majority of the vaccines were administered (66-96%), with the remainder delivered at facilities (Figure 8).** In Katsina, 66% of all doses were delivered at temporary fixed posts, where 65% of the teams were allocated. In the other two states, this share was even higher. In Anambra, 80% of all doses were administered at temporary posts, where 82% of the health workers were assigned, while 96% of all doses delivered and 83% of the health workers were located at such posts in Rivers. The remainder was administered through facility-based delivery.

*Figure 8: Median proportion of doses delivered, and proportion of staff time by strategy*




**Most facilities used vehicles during the campaign, with the majority in Anambra and Rivers being larger rental vehicles, and most in Katsina being rented motorcycles or staff's own motorcycles**. In each state, 75% to 92% of facilities used at least one vehicle during the campaign. Among facilities that used vehicles in Anambra and Rivers, 82%-86% of the vehicles were rented, mostly consisting of cars, pickups and vans/minibuses as seen in Figure 9. In Katsina however, around 68% of the vehicles used for the campaign were personal vehicles owned by facility staff with the majority of these being motorcycles. Motorcycles also accounted for almost all of the rented vehicles in Katsina (92%).

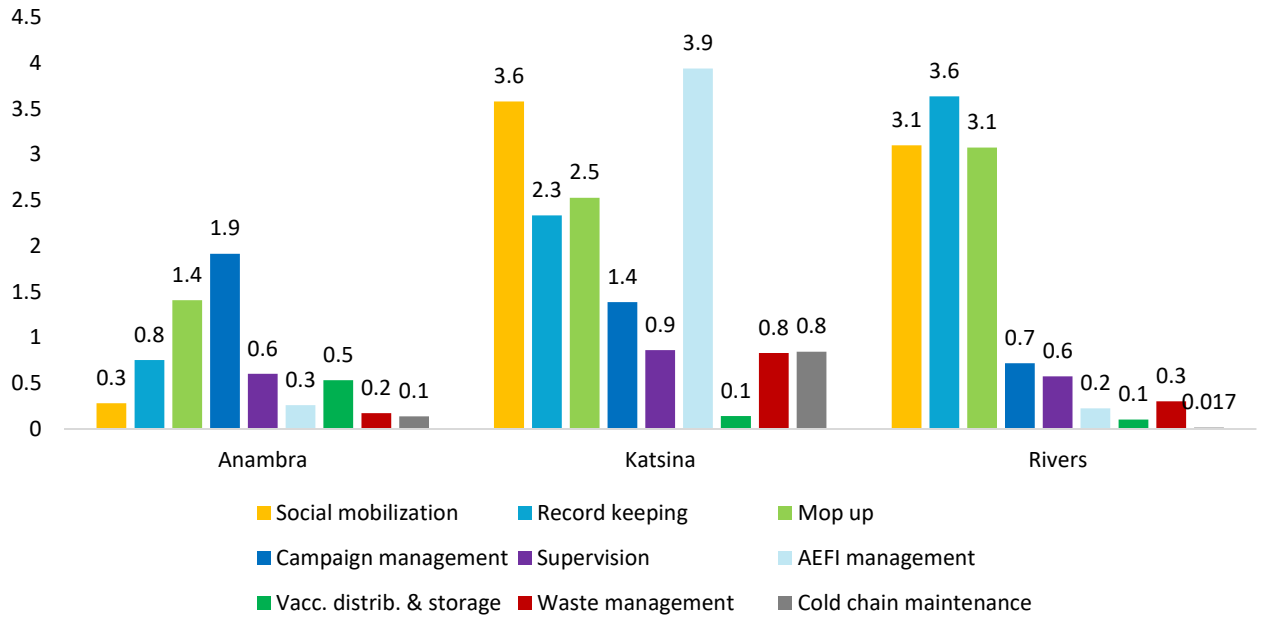
*Figure 9: Number of vehicles used at facility level by vehicle type and vehicle ownership*



## 5.3 POST-CAMPAIGN ACTIVITIES

**After the main campaign ended, most facilities conducted mop-up activities to reach children missed during the campaign.** In the month following the completion of the campaign, health facility workers spent a median of 8.3 hours on post campaign activities (varying from 4 hours in Anambra to 12 hours in Rivers). Most health worker time was spent on social mobilization and vaccine administration as part of the mop-up (Figure 10). In Rivers, almost all facilities (92%) conducted mop-up activities after the campaign, followed by 86% in Katsina and 63% in Anambra. Mop-up activities usually took up about one or two days. Most facilities also spent quite some time on record keeping, and some facilities in Katsina also reported to have spent a considerable amount of time on AEFI management. At the LGA level, health workers spent a median of 8.5 hours on post-campaign activities in the month following the campaign, mostly focused on record-keeping and waste management.

*Figure 10: Average hours spent on post-campaign activities per health worker*




## 5.4 CAMPAIGN RESULTS

**The post-campaign coverage survey identified yellow fever coverage ranging from 76-83% across the states.** The yellow fever administrative coverage achieved across the three sampled states varied from 73% in Rivers to 79% in Katsina, and 101% in Anambra, as the number of doses delivered there exceeded the reported target. In Anambra, both yellow fever and MenA coverage were above reported at above 100% (101% and 102% respectively), due to issues with the target population data, while the post-campaign coverage survey found 76% coverage for yellow fever and 96% coverage for MenA. At LGA level, reported coverage exceeded 100% even more frequently, with one LGA in Anambra reporting 126% coverage for MenA. In contrast, in Katsina and Rivers, post-campaign survey coverage was higher than administrative coverage, at 83% and 82%, respectively, compared to administrative coverage of 79% and 73%. Reported coverage at LGA level was 85-88% in Katsina and varied between 52% and 107% across the sampled LGAs in Rivers, as shown in Figure 11. Table 4 shows the total number of doses delivered in each state as per administrative data, with the highest number of YF doses being delivered in Katsina but the highest in total in Anambra where over 1.1 million

doses of MenA vaccine were delivered in addition to YF vaccines. Data on the number of persons reached with either YF, MenA or both in Anambra was unavailable.

*Figure 11: Administrative coverage reported in sampled LGAs and states (%)*

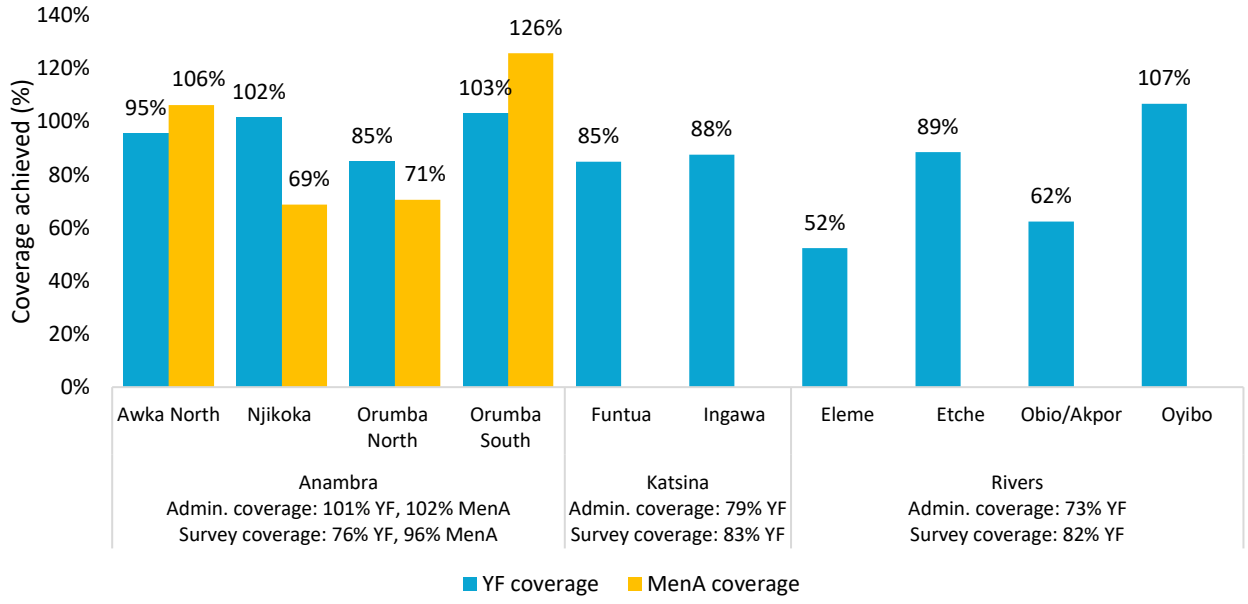



*Table 4: Target population size and total number of doses delivered in the three sampled states*

| States | Yellow fever target population size (1-44 year old) | Meningitis A target population size (1-6 year old) | Total number of yellow fever doses delivered | Total number of meningitis A doses delivered |
|---|---|---|---|---|
| Anambra | 6,043,277 | 1,137,549 | 6,130,080 | 1,163,588 |
| Katsina | 8,716,415 | N/A | 6,695,692 | N/A |
| Rivers | 8,581,155 | N/A | 6,279,531 | N/A |

## 6. COST OF THE CAMPAIGN

### 6.1 TOTAL COST OF THE CAMPAIGNS

**The financial delivery cost of the campaign ranged from $1,804,205 to $2,578,029 across the sampled states while the economic cost was between $4,148,610 and $5,328,639.** Table 5 shows the total cost of the campaign across the three states. The estimates include costs incurred at facility, LGA, and state level, as well as an allocation of cost incurred at the national level and by partners. Syringes and other consumables are included in the financial delivery cost, and the cost of vaccines includes an estimate of international

transportation. The total financial cost including vaccine and delivery costs ranged from $10,394,504 in Rivers to $11,220,436 in Anambra, and $11,839,056 in Katsina. When including labor and other opportunity costs (such as capital costs for vehicles and cold chain equipment), the estimated total economic cost of the campaign ranged from $13,697,376 in Katsina, to $13,800,035 in Anambra, and $13,918,668 in Rivers).

*Table 5: Total cost of the campaign by state, including costs incurred at all levels (2020 US$ and 2020 NGN)*

| | **Anambra (YF + MenA, 7,293,668 doses delivered)** | **Katsina (YF only, 6,695,692 doses delivered)** | **Rivers (YF only, 6,279,531 doses delivered)** |
|---|---|---|---|
| Financial delivery cost | $ 2,578,029 (₦ 925,024,731) | $ 2,290,290 (₦ 769,780,004) | $ 1,804,205 (₦ 647,368,269) |
| Labor and other opportunity costs | $ 2,579,599 (₦ 925,587,847) | $ 1,858,321 (₦ 624,592,628) | $ 3,524,163 (₦ 1,264,507,902) |
| **Economic delivery cost** | **$ 5,157,628 (₦ 1,850,612,578)** | **$ 4,148,610 (₦ 1,394,372,634)** | **$ 5,328,639 (₦ 1,911,876,172)** |
| Vaccine cost (including international shipment) | $ 8,642,407 (₦ 3,100,988,826) | $9,548,766 (₦ 3,209,397,279) | $8,590,299 (₦ 3,082,292,126) |
| **Total financial cost (including vaccines)** | **$ 11,220,436 (₦ 4,026,013,557)** | **$11,839,056 (₦ 3,979,177,283)** | **$10,394,504 (₦ 3,729,660,395)** |
| **Total economic cost (including vaccines)** | **$ 13,800,035 (₦ 4,951,601,404)** | **$13,697,376 (₦ 4,603,769,913)** | **$13,918,668 (₦ 4,994,168,298)** |

## 6.2 COST PER DOSE

### Vaccine and delivery cost per dose

***The financial delivery cost per dose delivered was highest in Anambra ($0.35), followed by Katsina ($0.34) and Rivers ($0.29). The economic delivery cost was highest in Rivers ($0.85), followed by Anambra ($0.71) and Katsina ($0.62).*** *Table 6 and*

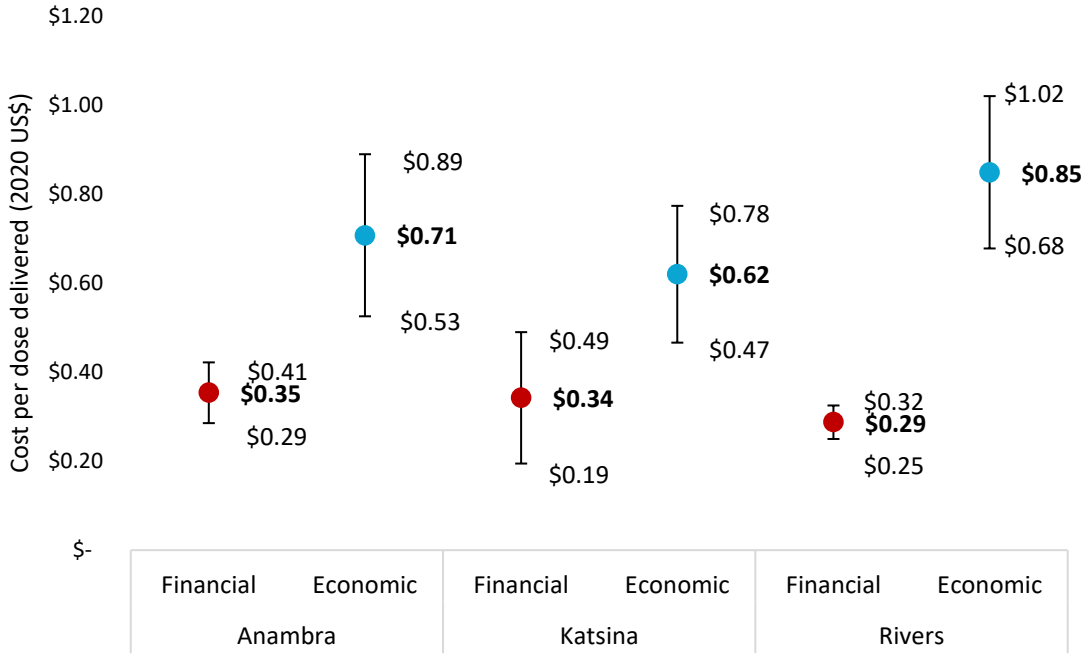
Figure 12 shows the various unit cost components per dose delivered for each state, including costs incurred at all levels. The difference in financial cost per dose delivered between Anambra—where YF delivery was integrated with MenA— and the state with the second highest financial cost per dose, Katsina, is small (3.2%), and the difference between the two states that only delivered yellow fever is larger. As international shipment costs are included as a fixed percentage, the higher vaccine cost in Katsina reflects a higher number of vaccines doses used proportional to doses delivered, and therefore reflects a higher wastage rate in this state. State level administrative data showed a slightly higher wastage rate in Katsina (9%) than Rivers (8%).

*Table 6: Cost per dose administered in the sampled states with 95% confidence intervals including costs incurred at all levels (2020 US$ and 2020 NGN)*

| | Anambra (YF + MenA) | Katsina (YF only) | Rivers (YF only) |
|---|---|---|---|
| Financial cost | $ 0.35 ($0.29–$0.42) (₦ 127) | $ 0.34 ($0.19–$0.49) (₦ 115) | $ 0.29 ($0.25–$0.32) (₦ 103) |
| Labor and other opportunity costs | $ 0.35 ($0.22–$0.49) (₦ 127) | $ 0.28 ($0.24–$0.32) (₦ 93) | $ 0.56 ($0.42–$0.71) (₦ 201) |
| **Economic cost (delivery costs only, excluding vaccines)** | **$ 0.71 ($0.53–$0.89) (₦ 254)** | **$ 0.62 ($0.47–$0.78) (₦ 208)** | **$ 0.85 ($0.68–$1.02) (₦ 304)** |
| Vaccine cost (including international shipping and wastage) | $ 1.18* ($1.13–$1.24) (₦ 425) | $ 1.43 ($1.19–$1.66) (₦ 512) | $ 1.37 ($1.25–$1.48) (₦ 491) |
| **Economic cost (including vaccines)** | **$ 1.89 ($1.65–$2.13) (₦ 679)** | **$ 2.05 ($1.66–$2.44) (₦ 720)** | **$ 2.22 ($1.93–$2.50) (₦ 795)** |

* Includes the weighted average cost of yellow fever ($ 1.25) and meningitis A ($0.86) vaccine prices

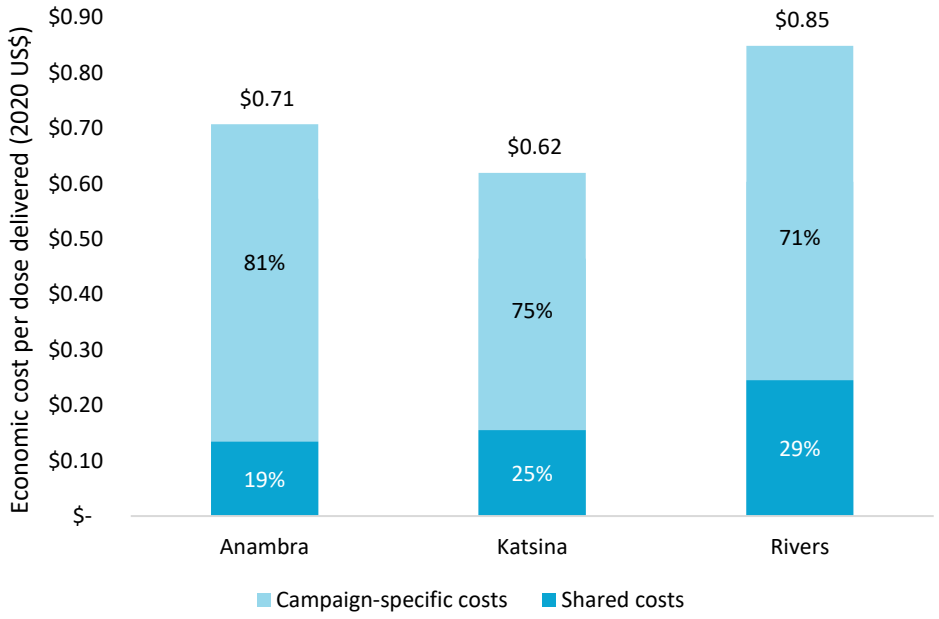
*Figure 12: Financial and economic cost per dose delivered with 95% confidence intervals (2020 US$)*



### Shared and campaign-specific delivery costs

**Between 71% and 81% of economic costs were campaign-specific costs while the rest were shared costs**. Campaign-specific costs include all costs incurred for the specific purpose of the campaign, consisting of financial costs plus volunteer labor costs and overtime spent on the campaign. Shared costs consist of an allocation of the use of existing resources, such as regular labor expenses and capital costs. A higher proportion of campaign-specific costs was found in Anambra as seen in Figure 13, and was driven by the high cost of volunteer labor per dose.

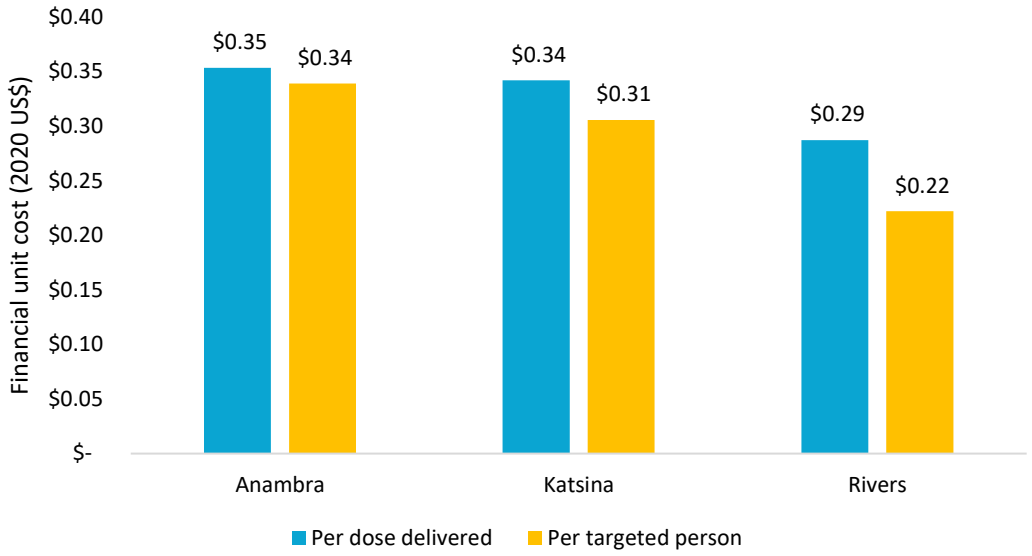
*Figure 13: Breakdown of the economic cost per dose delivered by shared and campaign-specific costs (2020 US$)*




### Financial delivery cost per targeted person

**The financial delivery cost per person targeted for the campaign ranged from $0.22 to $0.34 (Figure 14)**. As none of the states achieved 100% coverage, the financial delivery cost per person in the target population was lower than the cost per dose delivered. Although Anambra's overall administrative coverage level for the state, and that of some individual LGAs in the sample was reported to be above 100% (see Figure 11), the wards included in the study sample reached a median overall coverage of 98%. In addition, for the facilities and wards where target population issues had been reported during data collection, the target population figures given were replaced with the number of doses received minus an assumed wastage of 5%, as the calculation used in the microplan for the number of doses needed was the target population plus 5%.

*Figure 14: The financial cost per targeted person and dose delivered (2020 US$)*



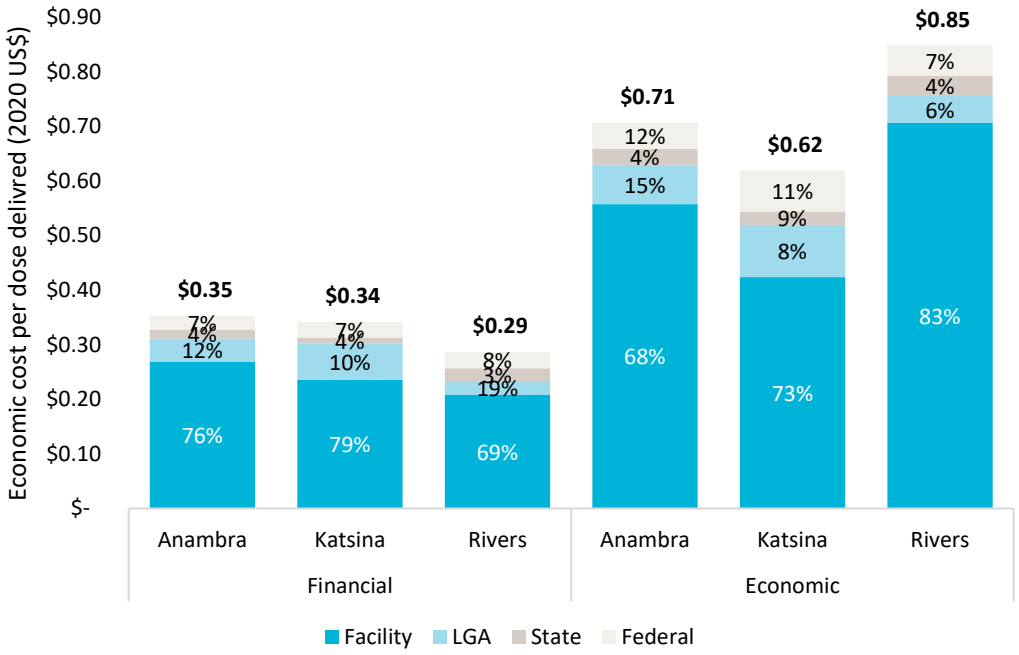

## 6.3 COST DIFFERENCES ACROSS ADMINISTRATIVE LEVELS

### Costs by level at which they were incurred

**The majority of costs were incurred at the facility level, including 68-83% of the economic costs across the three states (**

**Figure** *15***)**. Although many resources will have been paid for at higher levels, most financial costs were incurred at facility level (68-78%). Most of the financial costs incurred at the state level in Anambra were due to workshops and meetings costs from WHO, transport and fuel costs from UNICEF in Katsina, and then information, education, and communication (IEC) and other printing costs in Rivers. At the federal level, the majority of financial costs were due to both IEC and other printing costs (63% from NPHCDA and 37% from WHO) and transport and fuel (50% from the NPHCDA National Strategic Cold Store and 46% from WHO). Most of the economic costs were also incurred at facility level, mainly driven by labor costs.

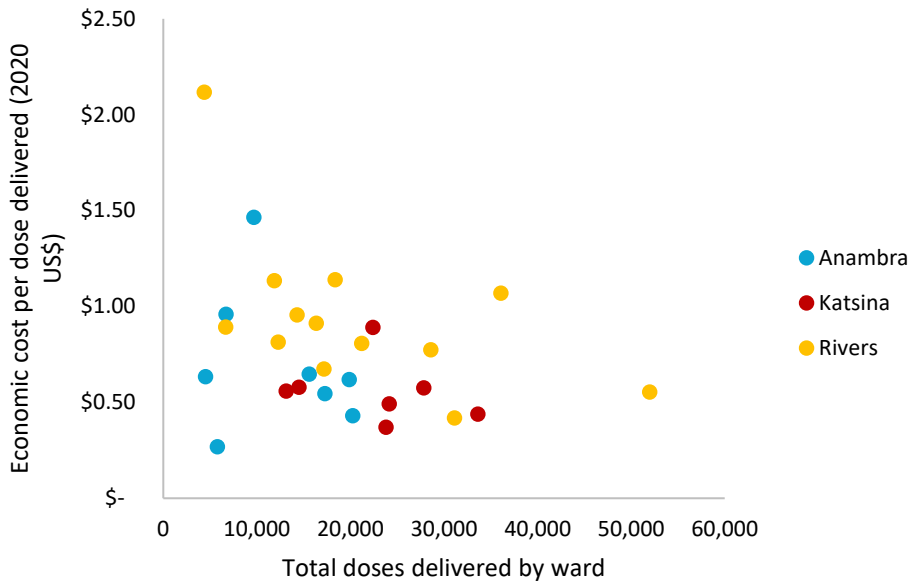
*Figure 15: Cost per dose delivered and the proportion incurred at different health system levels (2020 US$)*




## Cost per dose versus delivery volume

**As commonly found in immunization delivery costing studies, the cost per dose delivered was lower in wards that delivered a greater number of doses during the campaign.** Figure 16 shows the economic delivery cost per dose in each of the wards in the sample, as well as the number of yellow fever and meningitis A doses delivered from that ward during the campaign. The relationship is shown at ward level rather than facility level as data in Anambra and Rivers were collected from the ward focal point facility, and a breakdown by individual facility was not available there. Aggregating the costs incurred at all levels (facility, LGA, state and federal), a negative relationship can be observed between the volume delivered at a given ward and the delivery cost per dose incurred at that ward. The same pattern was observed for both the financial and the economic cost per dose.

*Figure 16: Total doses delivered in each ward, and the economic delivery cost per dose incurred at all levels (2020 US$)*




**Overall, Anambra state delivered fewer doses per ward than the other states, and had the highest financial cost per dose**. Although Anambra delivered the highest number of doses overall, as shown in Table 7, the median number of doses delivered per ward was lower than in the other states, which may explain the higher financial unit cost. While Katsina delivered the highest number of doses per ward, as these were delivered at multiple facilities within each ward, they may have experienced fewer economies of scale. In Anambra and Rivers, the wards pooled their resources and implemented the campaign through one health facility per ward.

*Table 7: The financial cost per dose and doses delivered across the three states*

| State | Financial cost per dose delivered (2020 US$) | Total number of doses delivered | Median number of doses delivered per ward | Number of facility delivery points |
|---|---|---|---|---|
| Anambra | $ 0.35 | 7,293,668 | 12,650 | 8 |
| Katsina | $ 0.34 | 6,695,692 | 23,822 | 37 |
| Rivers | $ 0.29 | 6,279,531 | 17,186 | 13 |

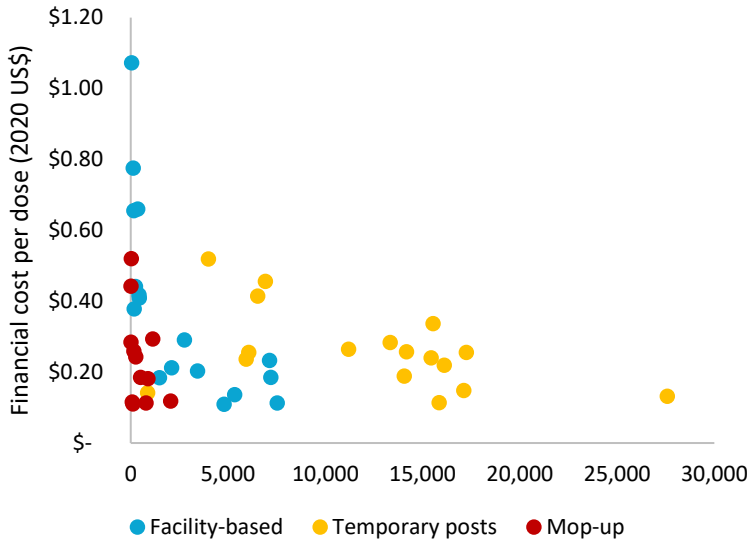
## 6.4 COST DRIVER ANALYSIS

### Delivery strategy

**Generally, facilities delivered fewer doses through facility-based delivery and mop-up activities, resulting in a higher cost per dose delivered (Figure 17).** The cost of delivery at temporary posts was mainly driven by transport costs. Therefore, despite higher delivery volumes, the delivery cost was often similar that of lower delivery volume strategies. Facility-based delivery had a higher cost per dose than delivery at temporary posts at all facilities in Rivers and one of the seven facilities with this breakdown available in Anambra. The number of staff allocated to facility-based delivery in Rivers was generally higher per dose than for the temporary

posts. The cost per delivery strategy was calculated for only a subset of wards and facilities which provided this breakdown and does not include costs incurred at any other level.

*Figure 17: The financial cost per dose and volume delivered per delivery strategy (2020 US$)*




### Resource type

**The financial cost of the campaign was mostly driven by per diem and allowances, vaccine injection supplies, and transport and fuel costs, while paid and volunteer labor were the key cost drivers among economic cost.** Per diem and travel allowances, vaccine supplies and transport and fuel cost account for 78-82% of the financial cost per dose in the three states. Transport and fuel were the single largest financial costs in Katsina ($0.10), while in Anambra this was vaccine injection and safety supplies as this also contained PPE ($0.10). The largest financial cost in Rivers was per diem and allowances ($0.10), which was also a key cost driver in Anambra ($0.09). The vaccine injection and safety supplies cost per dose was also high in Katsina ($0.10) and Rivers ($0.09). When looking at economic costs, paid and volunteer labor accounted for over two thirds of the economic cost per dose in Rivers (66%), while they accounted for around half of the economic cost per dose in Anambra (49%) and slightly less in Katsina (43%). Although Rivers only administered yellow fever during the campaign, it incurred the highest economic delivery costs, driven by higher labor costs. The cost per dose for each state for all other resource types can be found in Figure 18, which shows the cost per dose by resource type, by decreasing economic unit cost.

**The cost of personal protective equipment (PPE) and infection prevention and control (IPC) materials was higher in Anambra which implemented the campaign at the end of 2020 compared to Katsina where the campaign was held prior to the COVID-19 pandemic.** In Anambra, where the campaign was conducted over six months after the onset of the pandemic, the PPE and IPC cost per dose was $0.02 (5% of the overall financial delivery unit cost). This includes hand sanitizer, masks, gloves, soap and buckets for hand washing. In Rivers state, where the campaign was held at the start of the pandemic in February/March, 46% of the wards reported not using any of these supplies and the PPE and IPC cost amounted to $0.003 per dose delivered (1% of the financial cost per dose) in those which did. The campaign in Katsina was conducted prior to the COVID-19 pandemic in 2019, and 31% of the facilities visited did not report having used any PPE or IPC. Among the 25 which did, only $0.01 of the facility level cost per dose was spent on PPE and IPC materials such as gloves and hand sanitizer (2% of the financial cost per dose).

*Figure 18: Breakdown of the economic cost per dose by resource type (2020 US$)*

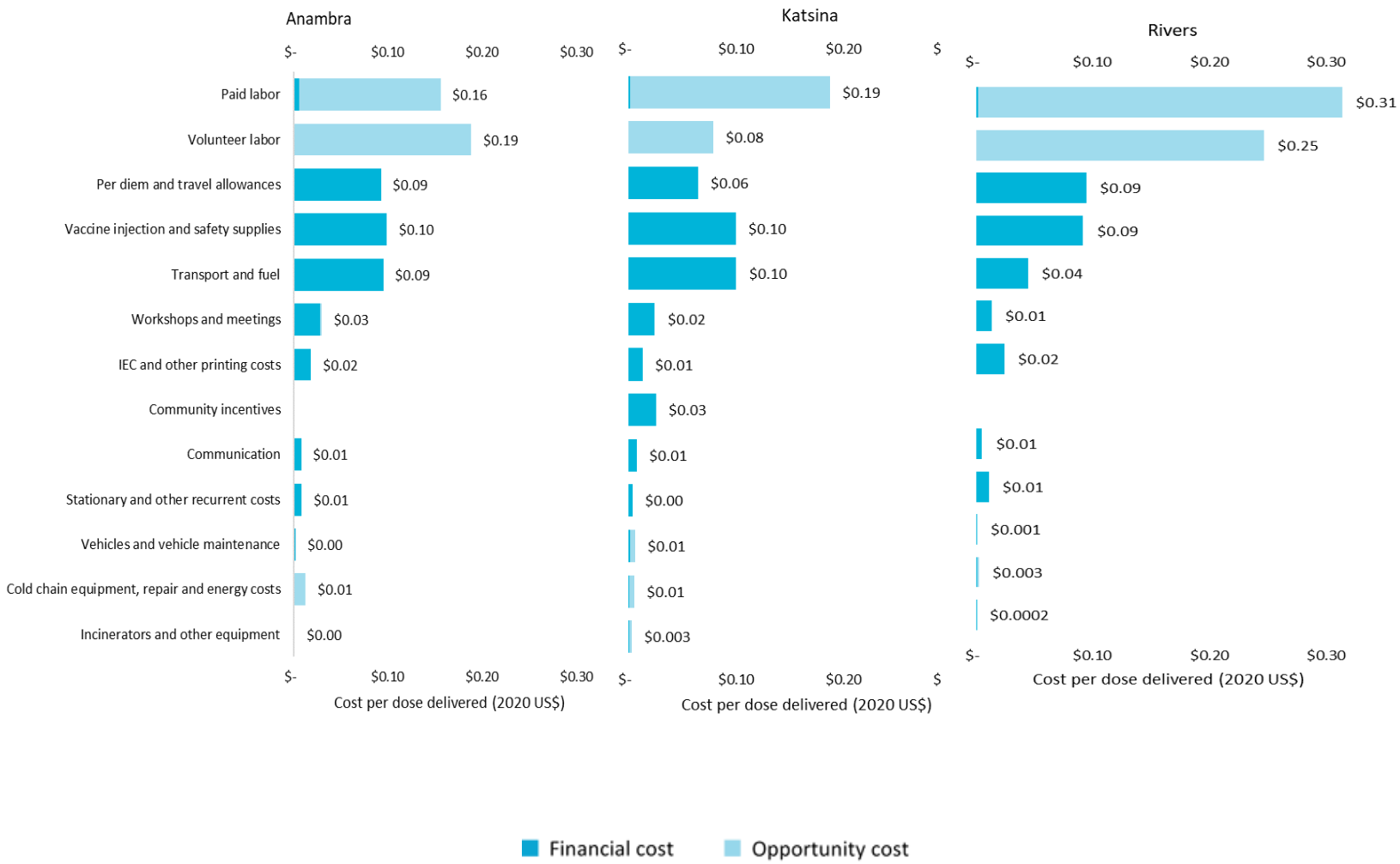


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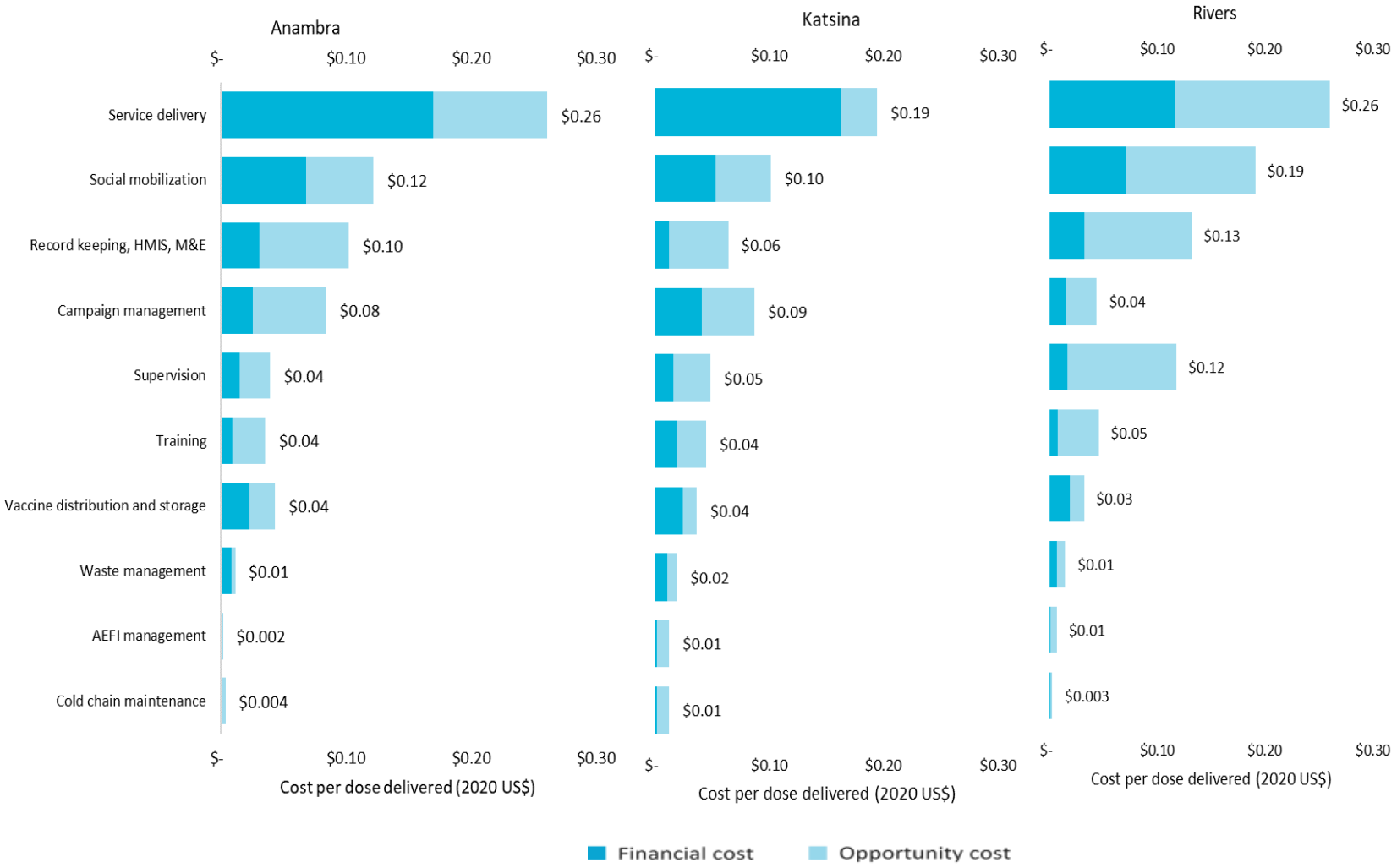
*Table 8: Campaign dates and PPE/IPC use and cost across the sampled states*

| | Katsina | Rivers | Anambra |
|---|---|---|---|
| Campaign dates | September 2019 | February 2020 | October 2020 |
| Proportion of facilities which reported use of PPE/IPC | 69% | 54% | 100% |
| PPE/IPC cost per dose cost among facilities which reported use of materials (2020 US$) | $ 0.01 | $ 0.003 | $ 0.02 |

### Campaign activity

**Service delivery covered the largest proportion of costs across all three states—accounting for 41-48% of financial costs and 31-37% of economic costs—followed by social mobilization and record keeping.** Service delivery financial unit costs ranged from $0.12 in Rivers to $0.17 in Anambra, while economic costs ranged from $0.19 in Katsina to $0.25 in Anambra and Rivers. Economic costs per dose were highest in Rivers also for social mobilization and record keeping activities, largely driven by higher opportunity costs of volunteer and paid labor. Cost per dose for each state for all other campaign activities can be found in Figure 19, which shows the cost per dose by activity, by decreasing economic unit cost.

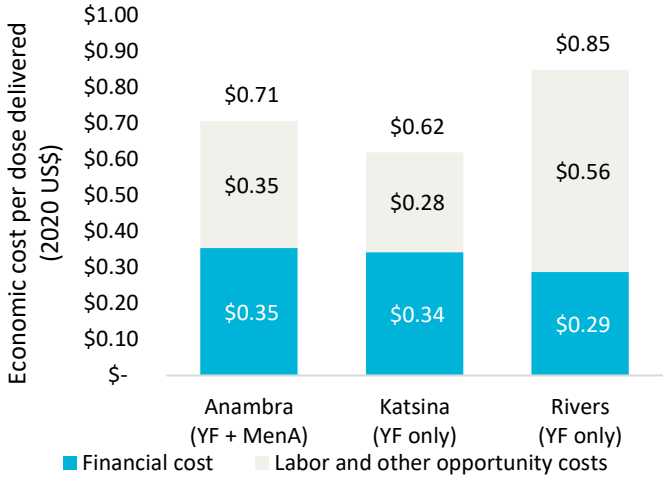
*Figure 19: Breakdown of economic cost per dose delivered by campaign activity (2020 US$)*



### Integrated delivery vs. yellow fever only states

**Delivery costs were driven more by the delivery volume in each ward, than the number of different vaccines delivered**. As per **Error! Reference source not found.**, the financial cost per dose delivered was higher in the co-delivery state Anambra ($0.35) compared with Katsina ($0.34) and Rivers ($0.29), indicating no financial cost efficiencies from co-delivery. The opportunity unit cost was 21.5% higher in Anambra than Katsina, mainly driven by labor costs for service delivery, record keeping, campaign management and vaccine distribution and storage. None of the cost differences (financial or economic) between the states were significant, using either two-sample t tests or bootstrap regression. Despite the co-delivery of two vaccines, the median number of doses delivered per ward was lower in Anambra than in the other states (see Table 7), indicating that delivery volume likely had a greater effect on the financial delivery unit cost than the co-delivery of two different vaccines.

*Figure 20: Comparing financial and economic costs between integrated and YF-only states*




## 7. DISCUSSION

**The delivery costs found in this study were generally lower than that found in other campaign costing studies, although the main cost drivers were similar**. There is limited campaign costing evidence available in the global literature, but we have compared our results to the four most comparable studies: measles SIAs in Nigeria, a yellow fever campaign in Cote d'Ivoire, a measles-rubella (MR)/oral polio vaccine (OPV) campaign in Sierra Leone and an MR campaign in India. First, a Nigerian study which analyzed the cost of SIAs to deliver measles in Anambra state found a higher economic delivery cost per child vaccinated ($0.81 compared to our $0.71 estimate for Anambra), even though the study excluded costs incurred above LGA level, vaccine supplies and waste management costs.[10] Our financial cost per dose estimates ($0.29-0.35) are also lower than what was found for a nationwide YF campaign in Côte d'Ivoire ($0.43 in 2020 US$), and an MR/OPV campaign in Sierra Leone ($0.39 in 2019 USD).[20-21] Compared with the financial costs of an MR campaign in India, our results were similar ($0.16-0.34 in 2019 USD across four Indian states).[22] However, the largest cost drivers identified (labor, per diems and travel allowances) and the share they made up in the total costs were similar. Finally, the inverse relationship between delivery volume and delivery unit cost found in our study is in line with the global immunization delivery costing literature. The share of financial cost out of the total economic cost found in this study (34-55%) were also similar to what other campaign costing studies have found.

**The financial delivery cost per person in the target population ($0.21-$0.32) was also much lower than Gavi's operational cost support for campaigns ($0.45-0.65 per targeted child)**. Depending on a country's transition phase, Gavi's operational support for campaigns is US$0.45-0.65 per targeted child, which it estimates covers up to 80% of an average campaign's operational cost, and countries are expected to fund the remainder. Gavi's estimate is an average based on a wide range of data for many LMICs and different types of campaigns, using decades-old Comprehensive Multi-Year Plan (cMYP) estimates.[23] The results of this study would indicate that the operational cost of a campaign may only be about half of this. However, an important caveat is that Gavi's operational cost grants may cover large investments in infrastructure (such as

cold chain equipment and vehicles) as well, while our financial delivery cost estimates include only annualized allocations of such costs. In addition, because the target population figures were largely based on outdated census data, the true financial delivery cost per targeted person may be even lower than what we have estimated.

**Although outreach-style service delivery is generally assumed to be more costly, our study found that facility-based delivery resulted in similar or sometimes higher delivery costs per dose.** Most of the delivery volume in the three states was administered at temporary posts. Therefore, although no transport costs were incurred for facility-based delivery, for many wards and facilities the delivery cost per dose (both in financial and economic terms) was often similar or higher than delivery at temporary posts due to a higher number of staff per dose delivered. For mop-up activities, delivery volume was low and transport costs were incurred, though oftentimes no per diems were paid, such that the delivery costs were similar to facility-based delivery. These results therefore differ from what was observed during an MR/OPV campaign in Sierra Leone, where temporary fixed site and mobile delivery had a higher financial cost per dose than facility-based delivery.

**The COVID-19 pandemic likely increased the cost of the campaign in Anambra state due to the additional cost of PPE and IPC materials, but the impact is smaller than modelled in a previous study.** The yellow fever/MenA campaign in Anambra took place from October to November 2020, thus in midst of the COVID-19 pandemic. PPE and IPC materials that were used included hand sanitizer, masks, gloves, soap and buckets for hand washing. The cost per dose of PPE and IPC materials in Anambra was over three times higher than in Katsina which was held pre-pandemic in 2019. Nevertheless, the PPE and IPC cost in Anambra of $0.02 (5% of the financial delivery cost per dose) per dose was less than a modeled estimate of the incremental cost of providing PPE and IPC materials during campaigns of $0.13 per dose for similar measures.[24]

**This study did not find significant differences between the cost of delivering an integrated campaign compared with a single antigen campaign.** Differences in cost and cost drivers were greater between the two states that delivered only yellow fever vaccines (Katsina and Rivers) than between these two states and the co-delivery state (Anambra). Cost differences across states are therefore more likely to be driven by the volume delivered during the campaign and other state characteristics, such as capacity differences, and security and geographic challenges. Without a sample size larger than three states of which only one delivered integrated services, and lacking the ability to account for many other state level characteristics and operational differences, it will remain challenging to determine the precise effect of integrated delivery on the cost of conducting campaigns. Nevertheless, compared with two standalone single antigen campaigns, it is likely that Anambra state still incurred financial and economic efficiencies from co-delivery.

## 8. LIMITATIONS

**The cost evidence presented in this study suffers from a few limitations, mainly due to record-keeping limitations and potential recall bias.** While data collection was initially scheduled to begin only 6 months after the campaign in Katsina, and one month after the campaign in Rivers, lockdown restrictions related to the COVID-19 pandemic caused significant delays. This likely contributed to recall bias which may have impacted the quality of the data collected, particularly in Katsina and Rivers—for which data collection took place respectively 19 and 15 months after the beginning of the campaign—and for the NPHCDA National Strategic Cold Store, where data were collected 14 months after its contribution to the campaigns. The COVID-19 pandemic also impacted our ability to collect more detailed data from the federal government and development partners, as these agencies were focused on responding to the pandemic and the opportunities for in-person interviews were limited. Additionally, limited record-keeping, respondents' refusal to provide some information, and the timing of the data collection meant that some data had to be imputed. Therefore,

there is additional uncertainty around our estimates that the confidence intervals do not capture. We also did not include costs incurred by beneficiaries, such as travel costs to reach immunization sites and time taken off work. Finally, catchment population size, target population size, and coverage data were often missing at facility level, limiting our ability to analyze cost estimates against output indicators.

## 9. CONCLUSION

**The cost evidence generated from this study can be used for future planning and budgeting of campaigns in Nigeria and similar settings.** This is the second campaign costing study conducted in Nigeria, and the first to examine an integrated campaign. As Nigeria is expected to require many more immunization campaigns over the coming years, cost evidence is greatly needed. This study provides cost evidence on the delivery campaigns in three Nigerian states, which can be used for planning and budgeting of future campaigns in Nigeria as well as other countries. It also offers initial insights on the effect of integration on cost, though more research is needed to study the cost implications of co-delivery campaigns.

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## ANNEX I: NAMES OF PARTNERS INCLUDED IN STUDY

| Partner name | Level of health system |
|---|---|
| World Health Organization | Federal and state level (Anambra, Katsina, Rivers) |
| United Nations Children's Emergency Fund | Federal and state level (Katsina, Rivers) |
| Clinton Health Access Initiative | Federal level |
| IVAC | Federal level |
| Solina Group | Federal level |
| Bill and Melinda Gates Foundation | Federal level |
| SYDANI | Federal level |
| Nigerian Red Cross Societies | Federal level |
| Nigeria CDC/AFENET | State level (Katsina) |
| CORE Group | State level (Katsina) |

## ANNEX II: DEFINITION OF CAMPAIGN ACTIVITIES

| Campaign activity | Definition |
|---|---|
| **Campaign management** | Time and resources spent on planning, budgeting, managing the immunization program at various levels, including attendance at immunization-related meetings. General management of the health system has not been allocated here. |
| **Vaccine distribution and storage** | Time and resources spent collecting vaccines and other campaign commodities at the airport or other distribution points, storing vaccines in national or subnational cold stores, distributing vaccines down to the facilities, and to the temporary campaign sites. |
| **Cold chain maintenance** | Time and resources spent on cold chain maintenance at all levels. |
| **Training** | Time and resources spent attending and/or providing campaign-related training. All trainings held in the lead up to the campaign have been considered fully campaign-specific. Training costs include the cost of venue, per diem for participants, cost of trainers, and reproduction of training materials. |
| **Social mobilization and advocacy** | Time and resources spent on mobilizing the community and households, and advocating for vaccination. This includes the costs of holding community meetings, printing flyers and educational materials, conducting events, and the cost of television and radio time etc. |
| **Supervision** | Time and resources spent on supervising subordinate or peer health or community workers, including staff time and transport costs etc. |
| **Service delivery: facility-based** | Time and resources spent on the act of administering the vaccines to the target groups within the facility/compound. |
| **Service delivery: temporary posts** | Time and resources spent on traveling to and from temporary posts and the act of administering the vaccines to the target groups at these sites. Temporary posts could include schools, market places, and churches. |
| **Service delivery: sweeping/mop-up** | Time and resources spent on traveling to and from sites and the act of administering the vaccines to the target population not reached during the campaign. |
| **Waste management** | Time and resources spent on disposing sharps and infectious non-sharp waste. |
| **AEFI management** | Time and resources spent following-up on adverse events following immunization (AEFI). |
| **Record-keeping, HMIS, monitoring and evaluation** | Time and resources spent on health management information systems (HMIS), data entry and analysis, including maintaining stock registers and records of children vaccinated, completing reports and analysing, monitoring, and evaluating campaign data. |

## ANNEX III: DEFINITION OF RESOURCE TYPES

| Resource type | Description |
|---|---|
| **Operating costs** | |
| **Paid labor** | Allocation of salaried labor to campaign-related activities. Salaries are fully loaded thus including any regular fringe benefits. Includes regular monthly stipends paid to volunteer workers. |
| **Volunteer labor** | Estimation of the market value of volunteer labor used for campaign-related activities. For unpaid health workers, an equivalent salary grade was collected. |
| **Workshops and meetings** | Costs related to workshops, trainings and meetings, including the venue and refreshments provided on the day, but not including transport or per diem costs. |
| **Per diem and travel allowances** | Any allowances paid to campaign staff and health workers for campaign-related activities. |
| **Transport and fuel** | Cost of bus fares, boat travel/hire, vehicle hire, and the cost of fuel for campaign-related transport. |
| **Vaccines** | Cost of vaccines including wastage and, freight and insurance fees. |
| **Vaccine injection and safety supplies** | Cost of auto-disabled syringes, reconstituting syringes, safety boxes, personal protective equipment and other supplies used for the administration of vaccines during the campaign. |
| **Stationery and other supplies** | Cost of stationery and other supplies used for the campaign. |
| **IEC and other printing costs** | The cost of printing immunization cards, training materials, radio jingles, tv ads and other information, education, and communication (IEC) materials that are campaign-related. |
| **Communication** | Costs related to purchasing airtime and mobile data for the purpose of the campaign, as well as a portion of regular phone and internet connection charges. |
| **Other recurrent** | Any other recurrent costs incurred during the campaign, this includes the cost of running incinerators used for the campaign and equipment rental costs. |
| **Vehicle maintenance** | Cost of maintaining vehicles (of all types) used for campaign-related activities. |
| **Cold chain repairs and energy costs** | The cost of repairing existing cold chain equipment and running the cold chain (electricity etc.). |

| **Capital costs** | |
|---|---|
| **Cold chain equipment** | Value of all cold chain equipment used to store and transport vaccines. |
| **Vehicles** | Value of all vehicles and modes of transport used for the campaign. |
| **Incinerators** | Equipment used for incinerating waste at all levels. |
| **Other equipment** | Value of other equipment, such as generators, computers, printers, peripherals, phones, other medical equipment used for campaign-related activities. |

## ANNEX IV: UNIT AND TOTAL COST CALCULATIONS

Formula (*a*) denotes the calculation for unit costs, where *n* is the number of facilities/LGAs in the sample, *Ci* represents the total service delivery cost at facility/LGA *i*, Qi represents the total service delivery volume at facility/LGA *i*, and *wi* is the inverse probability of sampling for facility/LGA *i*.

$$a)\ unitcost_{svw} = \frac{\sum_{i=1}^{n} C_i * w_i}{\sum_{i=1}^{n} Q_i * w_i}$$

Formula (*b*) shows the simple average taken to obtain a state and federal level unit cost, with C representing the total costs incurred for a particular state, and Q the number of doses delivered in the state.

$$b)\ unitcost_{state/federal} = \frac{C}{Q}$$

Formula (*c*) shows that to calculate total costs, the sampling and volume-weighted mean unit cost per dose was multiplied by the total delivery volume for the campaign represented by Q.

$$c)\ totalcost_{svw} = unitcost_{svw} * \sum_{i=1}^{N} Q_i$$