THINK WELL

THE COST OF DELIVERING COVID-19 VACCINES IN MOZAMBIQUE

STUDY REPORT | OCTOBER 2023

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RESEARCH TEAM

This study was implemented by ThinkWell and the Centro de Estudos de Economia e Gestão (CEEG) at the Universidade Eduardo Mondlane (UEM) in coordination with the Ministry of Health (MOH).

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ACRONYMS

AEFI	Adverse Effects Following Immunization
AGL	Africa Global Logistics
C19	COVID-19
CEEG	Centro de Estudos de Economia e Gestão of the Universidade Eduardo Mondlane
CNC	National Coordination Committee
CoPI	Immunization Expert Committee
COVAX	COVID-19 Vaccines Global Access
DPS	Provincial Health Directorate
EPI	Expanded Program on Immunization
ICC	Interagency Coordination Committee
ICS	Institute of Social Communication
MCH	Maternal and child health
MOH	Ministry of Health
MT	Mozambican Meticais
OCV	Oral cholera vaccine
PIRCOM	Plataforma Inter-Religiosa de Comunicação para a Saúde
SNS	National Health System
SPS	Provincial Health Services
UEM	Universidade Eduardo Mondlane
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USD	United States dollars
USG	United States government
WHO	World Health Organization

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EXECUTIVE SUMMARY

RATIONALE

The delivery of COVID-19 (C19) vaccines posed unprecedented challenges in terms of delivery volume and reaching new target populations. Meanwhile, what it costs to deliver these vaccines remains highly uncertain. To support the government in planning and budgeting for the COVID-19 vaccination program, ThinkWell in collaboration with the Centro de Estudos de Economia e Gestão (CEEG) at Universidade Eduardo Mondlane (UEM), conducted a study to estimate the cost of delivering C19 vaccines in Mozambique.

METHODOLOGY

This was a retrospective, bottom-up costing study that estimated the financial and economic costs of delivering C19 vaccines from March 2021 to February 2022. Costs were estimated for the initial low-volume period from March to April 2021 (Phase I) as well as for the high-volume period of December 2021 to February 2022. The study was conducted from a payer perspective, including costs incurred by health service providers, the Ministry of Health (MOH) and development partners at all levels of the health system. Data was collected retrospectively at health facilities in May-August 2022 from a purposively selected sample of 27 vaccination sites within six districts and two provinces (Maputo Province and Nampula), as well as from district and provincial health offices, the Expanded Program on Immunization (EPI) at the MOH, and from development partners. Costs were disaggregated across program activities and resource types to analyze cost drivers. Volume-weighted average unit costs were estimated for each administrative level and then aggregated to obtain the overall volume-weighted cost per dose. A qualitative assessment was also conducted to identify operational challenges and enabling factors in the implementation of the vaccination effort, as well as to better understand financial support provided by partners and donors and help contextualize cost findings.

IMPLEMENTATION OF THE C19 VACCINATION PROGRAM IN MOZAMBIQUE

On March 8th, 2021, Mozambique launched its national C19 vaccination program, delivering C19 vaccine doses to priority populations, including frontline workers and vulnerable individuals. The program was implemented in a phased manner, progressively expanding the target population. Mass vaccination began in the second half of 2021 and by November 2021 eligibility was expanded to anyone who was not yet vaccinated. In the second half of 2022, as vaccine recommendations changed and C19 vaccines were approved for adolescents, Mozambique kicked off a vaccination drive targeting 12-to-17-year-olds. By the end of 2022 the country had delivered more than 29 million doses and by June 2023 almost 35 million doses had been administered.

Mozambique offered C19 vaccines at health facilities (fixed sites) as well as at high-traffic areas, including markets, neighborhood centers, schools, and sporting centers (temporary sites staffed by mobile teams) and through outreach. The delivery strategy mix evolved over time. Initially, vaccines were only delivered at fixed sites. When eligibility was expanded, most vaccines were delivered at temporary posts, and mobile teams also conducted outreach to offices, nursing homes, and remote communities. To implement the C19 vaccination program, Mozambique exclusively relied on its existing health workforce and volunteers. The C19 vaccination program was financed through domestic resource mobilization and external donations, mostly channeled through existing structures within the health system, though some development partners channeled their support to the provinces, to their implementation partners, or directly funded some activities. Overall, additional funding for the C19 vaccination program was limited and delays in disbursement and release of donated funds caused disruptions to the implementation of the program.

ENABLING FACTORS IN THE IMPLEMENTATION OF THE C19 VACCINATION PROGRAM

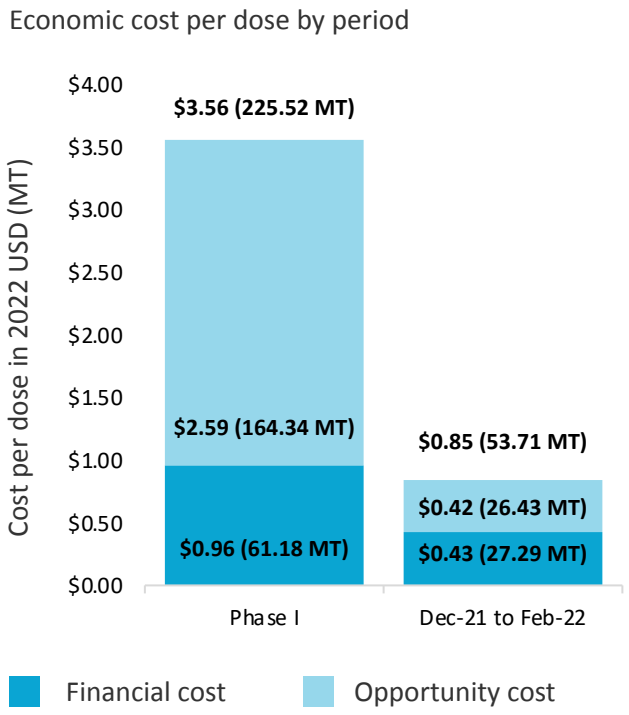
- Political prioritization at the highest levels of government enabled a successful program implementation by aligning priorities at all levels of the health system.
- Support from development partners on critical implementation areas was essential for the success of the program.
- Large scale deployment of temporary sites at strategic high-traffic areas in the community facilitated achievement of high vaccination coverage.
- Virtual technologies were leveraged to train vaccination team members quickly while reducing training costs.
- The use of health staffs' private vehicles filled critical gaps in transportation needs.

CHALLENGES FACTORS IN THE IMPLEMENTATION OF THE C19 VACCINATION PROGRAM

- Delays in funding availability and insufficient funds slowed program implementation and caused amendments of vaccination plans.
- The lack of financial incentives for health workers reportedly led to a reduction in the number of vaccination team and of the vaccination team size, particularly from the end of December 2021.
- The lack of transportation constrained vaccination activities in some sampled sites.
- Insufficient training on the newly deployed C19 module of Mozambique's DHIS2 (SIS-MA) resulted in a lack of granular data about doses delivered.

COST OF DELIVERING C19 VACCINES

The cost per dose was high in March-April 2021 (Phase I), and decreased considerably when delivery volume increased in the period between December 2021 and February 2022. Phase I was characterized by a much smaller target population and vaccine supply constraints, which led to a much lower volume delivered per day compared to December 2021 to February 2022 (64 vs. 225 dose/vaccination day).



The cost of delivering vaccines in Mozambique found in our study is lower than available estimates for C19 vaccines in other countries when looking at comparable delivery periods. The financial costs per dose found by our study are also lower than delivery costs estimated by COVAX's model to reach 70% of the target population ($1.08 to $2.56). Our results show far lower costs for the December 2021 to February 2022 period—which is most comparable to COVAX estimates as it targeted the general population—but also slightly lower cost for Phase I, during which a very small share of the population was vaccinated.

Paid labor was the key cost driver during both periods, consisting exclusively of salaries for existing health staff, as no additional staff were hired for the C19 vaccination program. Paid labor represented a much larger share of the cost during Phase I (64% vs. 37%) as similarly sized vaccination teams were deployed, but the volume delivered was significantly lower. Conversely, transportation and fuel represent a much higher share of the cost during the December 2021 to February 2022 period (19% vs. 3%), as during Phase I vaccines were only delivered at fixed sites. Although usually a large cost driver of delivery costs for vaccination campaigns, per diems and allowances amounted to only a small part of the cost per dose (3% in Phase I and 4% in December 2021 to February 2022) as very few facilities reported receiving per diem for vaccination team members. During Phase I, most costs went towards social mobilization (23%), while during December 2021 to February 2022 most costs went towards vaccine administration (32%). While training costs often represent a larger share of the cost per dose for the delivery of newly introduced vaccines, Mozambique leveraged virtual technologies to conduct trainings down to the district level, and virtually no financial expenses were incurred for trainings at health facilities.

Our cost analysis also found that delivering vaccines in rural areas was more expensive than in urban areas ($1.62 in rural areas vs. $0.67 in urban areas during December 2021 to February 2022), due the much lower volume delivered—an average of 89 doses per vaccination day in rural areas compared to 350 doses in urban areas. A similar pattern was observed when comparing rural and urban facilities during Phase I. These results are in line with the immunization delivery cost literature, which often finds an inverse relationship between the volume delivered and the cost per dose, due to economies of scale.

KEY TAKEAWAYS

- Although donors and partners supported key areas of the vaccination effort, funding still fell short.
- Even where funding was available, delays in disbursements and release of funds disrupted program implementation.
- The low financial cost per dose found in the study reflects the inadequacy of available resources, rather than low financial requirements to support C19 vaccination.
- Since no additional health workers were hired to carry out C19 vaccination, the pressure to achieve high vaccination coverage within a short period of time might have impacted the provision of other health services.
- Our study found relatively high cost levels during Phase I, when a small priority group was targeted, suggesting a need to rethink delivery strategies to ensure cost-efficiency in future implementation phases.
- Despite the significant resource constraints, Mozambique achieved high vaccination coverage thanks to political prioritization and the dedication of health workers.

I INTRODUCTION

To support the government in the planning and budgeting of the Expanded Program on Immunization (EPI), ThinkWell, in partnership with the Centro de Estudos de Economia e Gestão (CEEG) at Universidade Eduardo Mondlane (UEM), and in coordination with the Ministry of Health (MOH), conducted a study to estimate the cost of delivering COVID-19 (C19) vaccines in Mozambique.

The delivery of C19 vaccines presented unprecedented challenges in terms of delivery volume and reaching new target populations. Meanwhile, the cost of delivering these vaccines remained uncertain. To address this knowledge gap and support planning and budgeting in Mozambique for future vaccine introductions, vaccine program implementation and vaccination campaign activities, ThinkWell and CEEG, in coordination with the Ministry of Health (MOH), conducted a study to estimate the cost of administering C19 vaccines in Mozambique. This study estimates the cost per dose of delivering C19 vaccines, broken down by resource type, program activity, in different geographic areas—urban and rural—and during different implementation periods. It also illustrates the vaccine administration process, maps the funding flows for the C19 vaccination effort, and explores the challenges and lessons learned in program implementation.

ESTIMATING THE COST OF DELIVERING COVID-19 VACCINES IN LOW- AND MIDDLE-INCOME COUNTRIES

This study is part of a multi-country project that utilizes standardized methods to generate cost evidence on the delivery of C19 vaccines in low- and middle-income countries. The project is led by ThinkWell, and supported by the Bill & Melinda Gates Foundation, and covers studies in Côte d'Ivoire, the Democratic Republic of Congo, Mozambique, Uganda, Vietnam, Bangladesh, and the Philippines.

For more information, please see: https://immunizationeconomics.org/covid19-vaccine-delivery-costing

II OBJECTIVES AND STUDY METHODS

RATIONALE AND OBJECTIVES

The C19 pandemic emphasized the need for cost evidence on C19 vaccine delivery to inform efficient allocation of available resources. In a context of pre-existing resource scarcity, the negative impact of the C19 pandemic on the Mozambican economy reduced available resources while placing a huge burden on the health system. For this reason, evidence-based decision-making became even more important to ensure rational use of existing resources in the health sector. However, the actual cost of delivering C19 vaccines in Mozambique was unknown. Hence, this study sought to provide cost evidence to enable policymakers to make crucial resource allocation decisions in an informed manner.

The main objective of this study was to estimate the cost of administering C19 vaccines in Mozambique.

Specifically, the objectives of the study were to:

- Estimate the average cost per C19 dose delivered for each period included in the study, by resource type, by program activity, by geographic area, by implementation period, and by type of cost;
- Map the main sources of financing for the different activities of the C19 vaccination program;
- Describe how the vaccination effort was implemented, identify operational challenges and enabling factors

STUDY DESIGN

This was a retrospective, bottom-up costing study that estimated the financial and economic costs of delivering C19 vaccines from March 2021 to February 2022. This study estimated the costs of delivering C19 vaccines, defined as the costs associated with immunizing the target population, excluding the cost of acquiring the vaccines themselves. We collected costs related to the C19 vaccination program incurred between March 2021 and February 2022, using a bottom-up costing approach (or ingredient-based costing), supplemented by a review of financial expense reports and budgets to fill data gaps. Activities related to the vaccination program (defined in Table 7 of **Annex 1**) at each administrative level were costed by measuring the quantity of inputs (or resource types, defined in Table 7 of **Annex 1**) used to implement these activities, which were then multiplied by the unit price of each input. We captured both the additional resources used to implement the C19 vaccination program—for example, new investments such as cold chain equipment, per diem and allowances, vaccination materials, and fuel—as well as an estimate of the use of existing resources. The study estimates financial costs, which are financial expenses, with linear depreciation of capital items, as well as opportunity costs, which represent the value of using existing resources for activities related to the C19 vaccination program, and economic costs, which are the sum of financial and opportunity costs. For an explanation of why our study includes opportunity costs, refer to **Box 1**. The study protocol was approved by UEM's Faculty of Medicine and Maputo Central Hospital join ethical review board on February 15th, 2022, with the approval registration number CISB FM&HCM/105/2021**.**

The study analyzed startup costs as well as costs incurred during two periods, the low-volume period at the start of the roll-out (March to April 2021), and a later high-volume period (December 2021 to February 2022). The first vaccination period included in the study was Phase I of the national vaccination plan, the start of the roll-out which targeted priority populations and took place from March to April 2021. This period was characterized by limited vaccine supply and a small target population, and vaccines were delivered only through fixed vaccination sites. The second vaccination period analyzed in our study is the three-month period of December 2021 to February 2022. During this high-volume period, vaccination was open to the general population, and vaccines were delivered both at fixed sites and through temporary vaccination posts. We also included startup costs, defined as those costs incurred 30 days before the start of vaccination activities until the end of the study period (February 2022), which are related to inputs and activities specifically associated with the introduction of the new C19 vaccination program.

The study was conducted from a payer perspective, including costs incurred by health service providers, the MOH and development partners at all levels of the health system. The study aimed to capture the costs incurred by all key stakeholders at all levels of the health system. At the national level, it included costs incurred by the MOH, the national vaccine cold store, as well as partner organizations, including the United Nations Children's Fund (UNICEF), the World Health Organization (WHO), and USAID's implementation partners (PIRCOM, Jon Snow Inc, John Hopkins University)[i]. At lower administrative levels, the study included costs incurred at provincial health offices, district health offices, and at health facilities.

BOX 1
Why include opportunity costs?

Opportunity costs represent the monetary value associated with the use of existing resources—such as existing cold chain equipment or existing health staff—to provide C19 vaccines. Utilizing these resources for C19 vaccination does not require additional expenditure. However, when existing resources are used for a new purpose, other health services may be negatively affected. For instance, when a maternal and child health (MCH) nurse, previously dedicated to well-child checkups, spends the entire day administering C19 vaccines outside the health facility, the health facility may have to offer fewer well-child checkups per day. Therefore, this study included opportunity costs, alongside financial costs, to illustrate the total cost to the health system of administering C19 vaccines.

The costing analysis was complemented by a qualitative assessment of enabling factors and operational challenges from the implementation of the C19 vaccination effort, as well as a mapping of funding flows. Through interviews with key informants at all levels, we assessed how the C19 vaccination program was implemented, and identified challenges and enabling factors in the implementation of the C19 vaccination effort. We also identified funding sources, mapped out funding flows at all administrative levels, and where possible, identified how specific program activities were financed.

STUDY SAMPLE

The study sample was purposively selected in three stages. First, in collaboration with MOH we purposively selected two provinces, out of 11 in the country: one from the southern region (Maputo Province) and one from the northern region (Nampula), the latter also being the most populous province in Mozambique. Both provinces encompass extensive urban areas as well as a large number of rural health facilities. Next, in collaboration with each province's provincial health office, a total of six districts were selected across the two provinces, including two urban districts and four with mixed characteristics (rural and urban). Subsequently, between four to five health facilities were selected within each sampled district, including both rural and urban sites, for a total of 27 health facilities (of which 14 are urban and 13 are rural).

BOX 2
Sampling criteria

The sample was purposively selected, based on the following criteria to include:

- A province from the northern region and one from the southern region;
- Urban districts and districts with mixed (rural and urban) characteristics;
- Health facilities in rural and urban settings;
- Health facilities that participated in the C19 vaccination effort during the study period.
- Health facilities that employed the two main delivery strategies (fixed sites and temporary sites)

The sampling criteria used to select the study sites can be found in **Box 2**. Interviews for the qualitative assessment were conducted at all national and provincial sites and at a subset of district-level and implementation sites. At lower administrative levels, we aimed to conduct at least two qualitative interviews at two rural and at two urban districts and at a minimum of one health facility in each sampled district. In total, we conducted 24 qualitative interviews across all levels. Table 1 shows the full sample for both the costing and qualitative assessments.

Table 1. Study sample

Level		Sampled sites		Sampled sites - cost data	Sampled sites - qualitative data
Administrative levels	National[ii]	6		6	6
	Provincial	2		2	2
	District	6		6	4
Subtotal				**15**	**7**
Implementation level	Health Facilities	Urban (n = 14)	Rural (n = 13)	27	17
Subtotal				**27**	**17**
Grand total				**42**	**24**

[i] The study team also interviewed a representative for Africa Global Logistics which manages the USAID-funded "projecto Chegar". However, this organization did not support C19 vaccination during our study periods and was therefore excluded from the analysis.
[ii] MOH, UNICEF, WHO, PIRCOM, JSI, JHU and Africa Global Logistics.

DATA COLLECTION

Key informant interviews were the primary source of data collection for the cost analysis and the qualitative assessment. Data collection took place between May 2022 and August 2022 at health facilities, districts and provinces, and between May 2022 and June 2023 at national level. Following a 5-day training for data collectors—of which two days of theoretical learning, two days of pilot testing at health facilities, and 1 day of review—a team of eight data collectors were deployed to conduct interviews with key informants at all sampled sites. For both the cost data collection and the qualitative interviews, the research team first interviewed the focal point for C19 vaccination—who was usually also the EPI focal point—or someone designated by management to be the most knowledgeable about the C19 vaccination effort. For the cost data collection, additional information was gathered through interviews with the transportation and logistics officer, the statistics officer, and the officer in charge of administration and finance. Cost data were collected using data collection instruments developed by the research team in Microsoft Excel. The data collection instruments were developed for use across the ThinkWell-led C19 vaccination costing study countries and were tailored to Mozambique's country context. During data collection visits, the research team also administered a semi-structured questionnaire to collect qualitative data at a subset of locations. Detailed notes were taken during the qualitative interview, which were reviewed and synthesized by the research team.

Cost data were also gathered from written records, interviews with key informants, and publicly available sources. Information on resource use was gathered from health facility registers, financial reports, and other written records as well as interviews with key informants. To estimate labor cost for health staff, we used the publicly available salary scale for civil servants which was in effect during the study period. [iii] We collected the make and model of vehicles and cold chain equipment during the data collection visits, and recorded usage as reported by staff. Replacement prices for cold chain equipment were obtained from the UNICEF supply catalogue. Prices for vaccination supplies were taken from a MOH database were possible, or from publicly available local pharmacy catalogues. Financial reports were used to collect costs related to fuel and transport, printing, and per diem. When written reports were not available, we estimated fuel costs by asking health staff to estimate distances travelled in kilometers or hours and converted that to fuel usage based on the assumptions described in **Annex 2**.

Data collection was followed by a comprehensive data validation and cleaning process. After data collection, two researchers reviewed all data sheets to ensure they were complete and to identify any potential data entry errors. If any issues were identified, the data collector who completed the sheet was requested to review the data, and if necessary, further verification was conducted directly with key informants at the relevant sampled site. If, after following up with the interviewee, it was still not possible to obtain certain data, assumptions were made to impute the data, as detailed in **Annex 2**.

DATA ANALYSIS

We estimated financial and opportunity costs, disaggregated by resource types, program activities, province, geographic area, and implementation period (see Box 3). For resources that were shared across the health system, the share of the resource used for the C19 vaccination program was estimated to allocate a portion of the cost. For costs that could not be directly attributed to the two delivery periods analyzed in this study (Phase I and December 2021 to February 2022), costs were allocated proportionally based on the number of days in each period (for one-off start up activities like trainings) or based on the number of doses administered in each period (for activities such as cold chain maintenance and printing of registers and vaccination cards). More details on all allocation assumptions can be found in **Annex 3**. All costs are presented in 2022 US dollars (USD, $) and in Mozambican meticais (MT). Costs incurred in 2021 were inflated to 2022 using the Consumer Price Index published by the International Monetary Fund (IMF). Costs were then converted from meticais to US dollars using a conversion rate of 1 USD = 63.43 MT. Depreciation of capital items was calculated based on the year of acquisition, acquisition cost, and useful life assumptions defined by existing guidance on immunization costing, using a discount rate of 3%.

[iii] As approved by the decree n. 69/2021 of September 21st, 2021.

The volume-weighted cost per dose for study sites at each level (implementation, district, province, national) was estimated by dividing the total cost incurred at sites at that level by the total number of vaccine doses administered at site at the same level, according to the following formula:

$$unit\_cost\_level\_A_{vw} = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} Q_i}$$

where Ci represents the total cost of vaccine delivery at location i, Qi is the total quantity of doses delivered at location i, and n is the sample size for that level. Then, the overall delivery cost per dose was obtained by summing the volume-weighted average costs obtained for each administrative level. That is, the volume-weighted average cost per dose for the health facility level was added to the volume-weighted average cost per dose at district, province, and national level (which also included costs incurred by partner organizations).

LIMITATIONS

Cost estimates in this study were derived from a small, purposely sampled selection of vaccination sites, which limits the generalizability of the results. The study included a total of 27 health facilities, located in six districts from two provinces, out of the country's 11 provinces. The study team selected sites located in urban and rural districts to capture expected variability in different geographic areas. Moreover, the sites were selected in collaboration with EPI officials at all levels of the health system, with the objective of selecting districts and health facilities that could be representative of the variation which can be found across the country. However, the overall sample size remains relatively small, which limits the generalizability of the results. Additionally, the site selection for the study was not random.

The evidence from our study reflects how the C19 vaccination program operated during the initial phase of March to April 2021 and during the December 2021 to February 2022 period, and may not be generalizable to the current context of the program. Our study time frame captures all one-off investments related to the C19 vaccination activities that took place from February 2021 to February 2022. We also capture in-depth cost data for the low-volume period of March to April 2021 (Phase I of the National C19 Vaccination Plan) as well as for the higher-volume period of December 2021 to February 2022.

BOX 3
Cost categorization

We disaggregated financial and economic delivery cost per dose by:

- **Resource type:** the inputs necessary to implement the C19 vaccination program;
- **Program activities:** the activities necessary for the implementation of the C19 vaccination program, carried out using the allocated resource;
- **Implementation period:** Phase I of the C19 vaccination program and the period from December 2021 to February 2022;
- By **province**, and by **rural and urban** geographic area.

However, since the end of the study period in February 2022, the C19 vaccination program in Mozambique underwent important changes, including an expansion of the target population to everyone over 12 years old. Therefore, while our results can provide insights into delivery costs at lower and higher delivery volume until the end of the study period (February 2022), the results of our study might not be an adequate reflection of the current cost structure of the program.

Cold chain energy costs, which in immunization delivery costing study represent a very small share of the cost per dose, are underestimated due to missing data. The great majority of sampled sites could not report cold chain energy costs. While 22 of 27 sampled health facilities used grid electricity, only one reported any energy costs. Energy costs were missing also at higher levels, with two districts (out of six) and one province reporting any energy costs, and no costs reported at the national level.

Costs could not be disaggregated by delivery strategy, due to a lack of records on doses delivered at sampled sites. Originally, the study also aimed to estimate the vaccination costs by delivery strategy. However, due to a lack of records regarding the doses administered thought each strategy, it was not possible to estimate strategy-specific delivery costs.

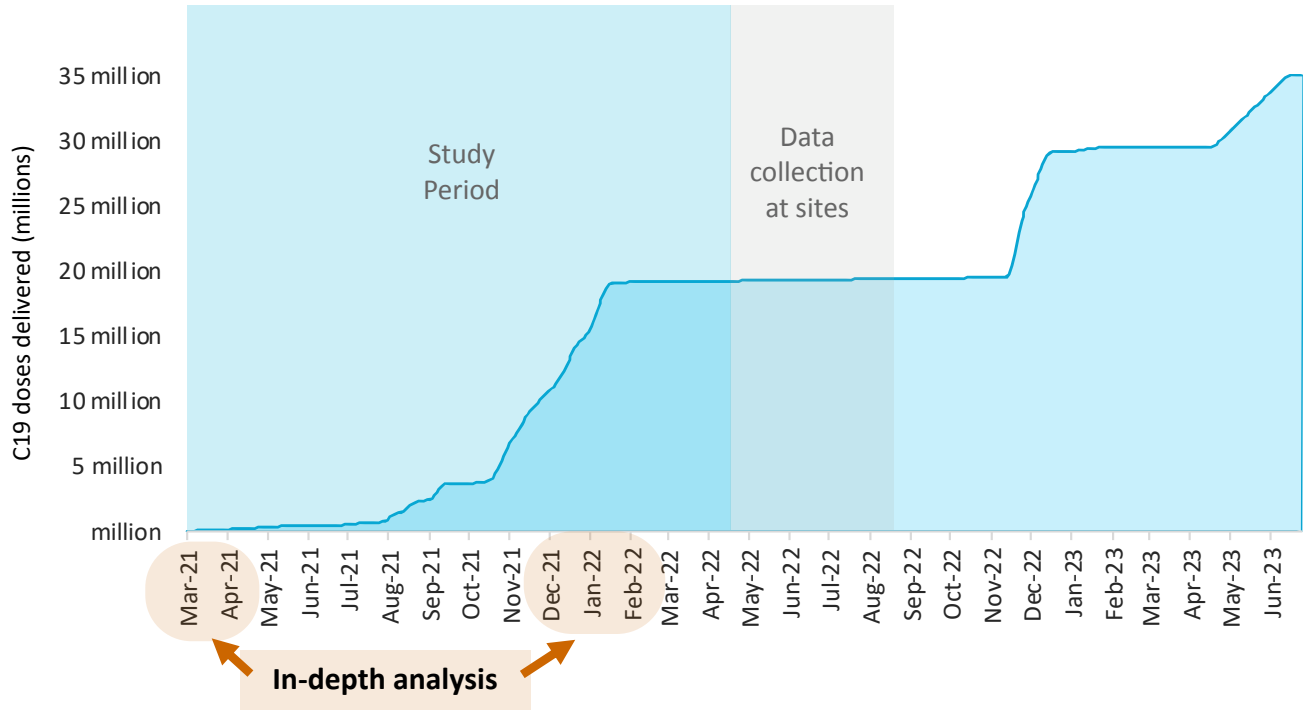
III

THE C19 VACCINATION PROGRAM IN MOZAMBIQUE

OVERVIEW OF THE C19 VACCINATION PROGRAM

By the end of our study period (February 2022), Mozambique had administered 19,137,848 doses[4]. Following the approval of the national C19 vaccination plan in Mozambique, the MOH launched the C19 vaccination program on March 8th, 2021. The plan aimed to vaccinate 16,825,333 people over the age of 15, representing 54.6% of the total Mozambican population[5]. By February 2022, over 19 million doses had been administered, with more than 50% of these doses administered during the study period of December 2021 to February 2022. By the end of 2022 the country had delivered more than 29 million doses and by June 2023 almost 35 million doses had been administered.

Figure 1. C19 vaccine doses delivered in Vietnam in 2021



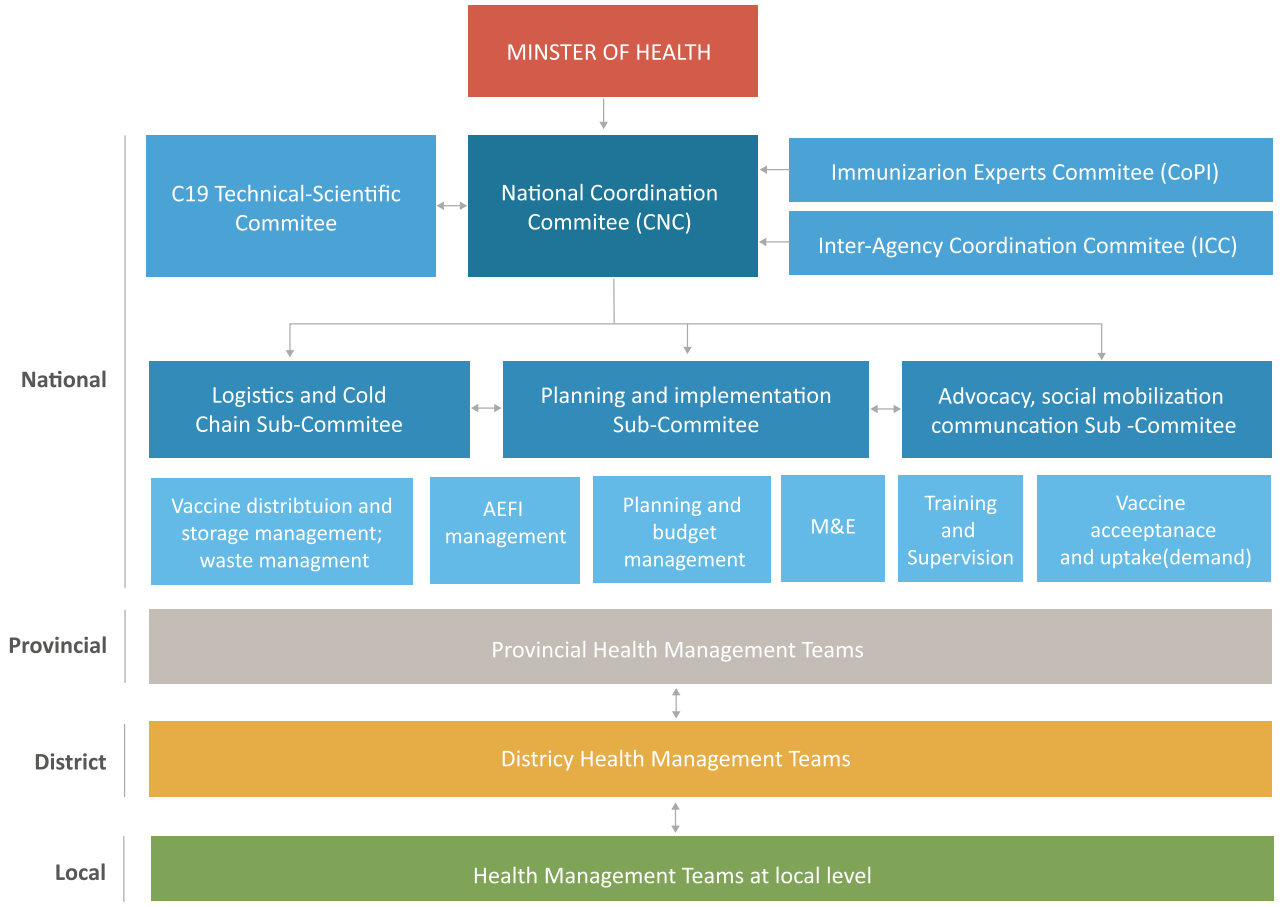
MANAGEMENT OF THE C19 VACCINATION PROGRAM

Mozambique's C19 vaccination program, locally referred to as the '*Campanha de vacinação contra a COVID-19*', was implemented based on its C19 National Vaccination Plan. The plan provided guidelines for prioritizing the implementation of C19 vaccination in the country: it described the implementation process, defined the target groups and delivery strategies to be used for vaccination, and detailed implementation phases. Following the plan, a National Coordination Committee (CNC) was established under the leadership of the Minister of Health to facilitate the introduction of the vaccine into the national health system.

The plan also established several sub-committees tasked with managing different aspects of the C19 vaccine introduction, as illustrated in Figure 2. The terms of reference for each sub-committee can be found in **Annex 4**. The committees and subcommittees at the national level coordinated resource mobilization, the definition of target groups, and were in charge of determining and communicating the implementation phases.

At lower administrative levels, the C19 vaccination program leveraged existing structures, such as health management teams at provincial, district, and health facility level. Provincial health management teams supported districts in planning and organizing the necessary logistics for the vaccination sites. Finally, districts and local health management teams carried out vaccination activities, and provided input to inform decision-making at higher levels.

Figure 2. C19 vaccination program planning and coordination structure



Source: Mozambique's C19 National Vaccination Plan [6]

All administrative levels held regular meetings to review the progress of the vaccination program. These meetings were conducted in a hybrid format (in-person and virtual) and covered the review of data on C19 cases and vaccination in the country, logistics, and next steps in program implementation. The frequency of these meetings varied at each level and over time.

In the early stages of the vaccination effort, national level meetings were held daily, while during Phase III, which began in August 2021, they were held weekly. The frequency of these meetings at provincial level varied, with Nampula reporting daily meetings and Maputo province reporting biweekly meetings.

C19 VACCINE STORAGE AND DISTRIBUTION

Distribution and storage of C19 vaccines leveraged existing infrastructure and processes, and partners provided additional capacity at national and provincial level during higher volume periods. Following the same processes used for routine EPI vaccines, C19 vaccines entered the country through the Maputo International Airport. Vaccines were then stored at the Zimpeto Central Depot in Maputo Province before being distributed to provincial depots across the country, which in turn distributed the vaccines to districts, and from districts to health facilities. During initial, lower volume months of the vaccination program, vaccines were transported exclusively by the EPI leveraging the childhood routine vaccines infrastructure. However, when mass vaccination began, UNICEF supported the expansion of vaccine transportation and storage capacity, by directly arranging additional transportation from the national to the provincial level, and by expanding storage capacity at provincial level through the rental of cold rooms.

IMPLEMENTATION OF THE C19 VACCINATION PROGRAM

The C19 vaccination program in Mozambique was implemented in a phased manner, and additional target populations were added as vaccine supply increased and recommendations changed. Mozambique's C19 National Vaccination Plan defined four implementation phases. Phase I aimed to vaccinate priority populations with a high risk of exposure or that were particularly vulnerable to the virus. Phase II was divided into three rounds, and targeted more categories of individuals with comorbidities and other priority populations. Phase III marked the beginning of mass vaccination due to the expanded target population. As vaccine supply increased, Phase IV was kicked off while Phase III was still ongoing, expanding eligibility to anyone who was not yet vaccinated. In September 2022, as vaccine recommendations changed and C19 vaccines were approved for adolescents, Mozambique kicked off a vaccination drive targeting 12-to-17-year-olds.

Table 2. Target population by implementation phase, as per the national vaccination plan

Phase	Implementation period	Target population
I	From March 2021	Active health workers (including from the private sector and the military), community health workers, retired health workers, elderly residents of nursing homes, nursing homes staff, individuals with diabetes mellitus, and members of the Defense and Security Forces.
II	From April 2021	Final-year students enrolled in health training courses; diabetic patients not reached in the first phase; patients on immunosuppressive therapy; patients with chronic kidney disease on hemodialysis or on the waiting list; patients with chronic respiratory failure; patients with chronic heart failure; population residing in accommodation centers; inmates and prison staff; police officers over 50 years old; and primary school teachers over 50 years old.
III	From August 2021	All individuals aged 50 and above, and individuals of all ages in the following professions: transport operators, motorcycle taxi riders, and bicycle taxi drivers, teachers, and other high-risk groups for C19.
IV	From November 2021	Adult population not immunized in previous phases.

Temporary sites and fixed vaccination sites were the two main delivery strategies employed by the C19 vaccination program, while outreach was only conducted during certain phases of the campaign or in remote areas. Mozambique offered C19 vaccines at health facilities (fixed sites) as well as through temporary sites at high-traffic areas (markets, neighborhood centers, schools, sporting centers) strategically selected to reach specific target populations. Temporary sites offered C19 vaccines on a daily basis and were active for several months. These sites were staffed by mobile brigades, which in some rural areas also conducted outreach trips to remote communities, and that in during Phase II of the program, which is not covered by our study, also delivered vaccines at offices and nursing homes. The strategy mix implemented by each health facility depended largely on the population density of the catchment area as well as target group for the phase being implemented, and was determined in coordination with the district and province. Once the strategy mix had been defined, health facilities worked with community leaders to identify the specific location for temporary sites in the community. For each health facility, the strategy mix usually included both temporary sites and fixed sites, with the exception of Phase I during which only fixed sites were employed. While strategy-specific doses delivered data were not recorded, qualitative reporting from sampled sites indicates that that during the study period most of the doses were delivered at temporary sites.

STAFFING FOR C19 VACCINATIONS

The MOH defined a standard vaccination team as consisting of six team members, although due to shortages in human resources, teams were often smaller. Almost all categories of health workers were involved in implementing the vaccination program, including nurses, MCH nurses, clinical officers, doctors, administrators, assistants, and community health workers. The MOH's standard vaccination team included: 1 vaccinator, 1 data entry clerk, 1 recorder, 1 mobilizer, 1 queue organizer, and 1 person responsible for adverse event monitoring. However, the actual team composition varied significantly, with some health facilities in our sample reporting one-person teams, while others reported having two or three vaccination team members.

No additional hiring was reported at implementation level, and gaps were exclusively filled with volunteers. Existing health staff were tasked with activities such as vaccine administration, adverse event management, and record-keeping. Volunteers were leveraged mostly for social mobilization activities and crowd controll. They were mobilized among retired health professionals, and members of health committees (Comités de saúde) and co-management committees (Comités de co-gestão). These committees consist of volunteers from the community who receive training on community health and are tasked with health promotion in remote areas, increasing accountability on service quality and providing oversight over the supply chain of medications. In some cases, final-year students and trainees in medicine, preventive medicine, and MCH were also recruited as volunteers and deployed in the vaccination teams to meet the demand for human resources.

C19 VACCINATION TRAINING

Training sessions were conducted for staff involved in the vaccination program and were repeated whenever a new vaccine product was added to the program. Training modules were designed by the national-level EPI team in partnership with the WHO. Training sessions were aimed at preventive medicine officers and other health professionals such as nurses, MCH nurses, general medicine officers, and doctors. Implementation followed a training of trainers model, where the central level EPI officers trained provincial-level staff, who, in turn, trained district-level trainers, and then district officials trained trainers at health facilities, who subsequently replicated the training for the vaccination team members. Trainings were carried out every time a new vaccine product was introduced.

Most trainings were conducted virtually, and no significant costs were reported for conducting trainings related to C19 vaccination program. Unlike in other vaccination campaigns and new vaccine introductions, key informants indicated that there were no significant financial costs for training related to the C19 vaccination programs. This is largely because training sessions from the central level down to the district level were conducted virtually without requiring any additional expenses. While the training sessions held at health facilities were conducted in person, they lasted no more than four hours and no venue rental, refreshment or per diem costs were reported.

SOCIAL MOBILIZATION FOR C19 VACCINATION

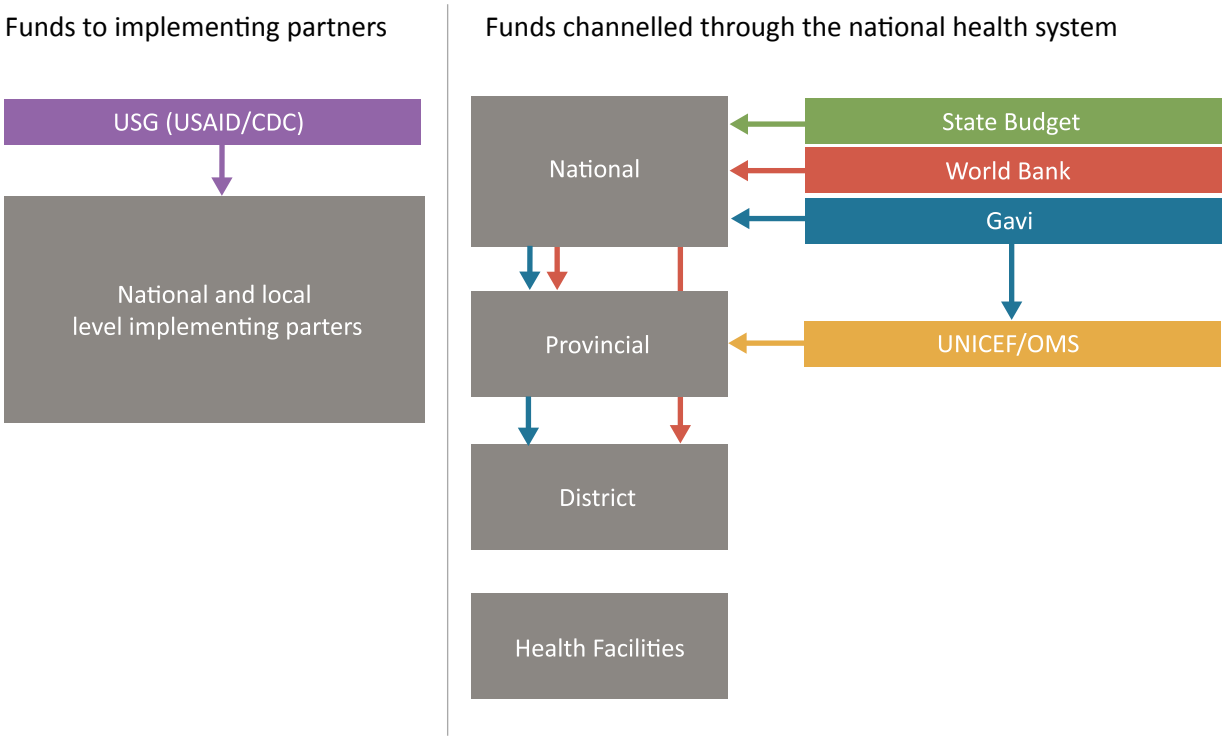
The program's social mobilization strategy leveraged the involvement of government officials and other prominent figures at all levels of the health system. At the national level, the government leveraged traditional media outlets as well as social media to showcase testimonials from influential figures—ranging from famous singers and other celebrities to religious leaders and the country's First Lady—about getting vaccinated and to provide key information about the vaccination effort. The MOH also established a toll-free hotline to educate the population about the vaccine and its side effects, and a dedicated website to provide information on vaccination phases, eligibility and where to get the vaccine. At the district and health facility levels, community leaders, religious leaders, and traditional medicine practitioners were mobilized to communicate to the local population about the importance of getting vaccinated and how to get the vaccine. Additionally, government officials such as provincial governors, provincial state secretaries, and district administrators were also involved social mobilization, participating in social mobilization events as vaccination phases were kicked off in their provinces or districts. At health facilities, health workers included C19 vaccination as a topic in their daily morning lectures to health facility clients.

FINANCING OF THE C19 VACCINATION PROGRAM

The C19 vaccination program was financed through domestic resource mobilization and external donations, mostly channeled through existing structures within the health system. To finance the C19 vaccination program, the MOH mobilized funds through the state budget as well as from Gavi and the World Bank, which channeled their support through the MOH's public financial management system. Through the MOH, funds were then passed down to lower administrative levels, to finance the implementation of program activities at each level. Health facilities did not manage any funds and were dependent on higher levels (such as district and provincial health offices) for financing of implementation activities.

Some partners channeled their support directly to the provinces, their implementation partners, or funded specific program activities. UNICEF and WHO channeled some financial resources directly to provincial health directorates, and also directly funded some national and provincial activities. The United States Government (USG) through USAID and CDC supported the vaccination effort by channeling funds directly to its national and local implementing partners. Private corporations as well as individuals also provided financial and in-kind donations on a one-off basis, both at central level at health facilities.

Figure 3. Funding flow for the C19 vaccination program



Donor funding for vaccine delivery amounted to approximately 22 million USD during the study period (until February 2022), but there were disparities in funding across program activities. Key informants reported that activities like social mobilization and vaccine distribution were more adequately funded compared to financial incentives or per diems for health workers involved in the vaccination effort. UNICEF funded per diem for the vaccination team for a portion of the vaccination days in Phase II and III. They also funded trainings, vaccine vial collection and incineration, vaccine transportation from the central to provincial level, rental of cold storage facilities, and communication and social mobilization activities. WHO supported transportation of vaccines as well as training vaccination team members and the design of vaccination guidelines. While some of UNICEF's funding went towards financing per diem for vaccination team members, the budget allocated to per diem for health workers was considered insufficient by respondents interviewed at implementation level, as it only covered per diem for a very small share of the vaccination days worked. Insufficient per diem were found to be a critical pain point for health workers in our analysis as well as in other reports[7].

IV

QUALITATIVE RESULTS

FACTORS THAT ENABLED THE SUCCESSS OF THE C19 VACCINATION PROGRAM

- **Political prioritization of the C19 vaccination effort at the highest levels of government enabled a successful implementation by aligning priorities at all levels of the health system.** Key informants reported that direct involvement of the highest level of government, including the President of the Republic, in the management and oversight of the vaccination effort set clear priorities at all levels of the health system and facilitated the mobilization of political leaders and other influential figures. This increased visibility of the C19 vaccination effort among the population, and contributed to generating demand for the vaccine. It also ensured political prioritization at all administrative levels. At the MOH, the Minister of Health was personally involved in management meetings and implementation reviews, and appointed a newly created figure of Director of the C19 Vaccination Program to ensure coordination between the National Directorate of Public Health, the EPI and all other actors involved in the vaccination effort. This political prioritization reverberated at lower administrative levels as well as at health facilities, where it strengthened vaccination team members' commitment to reach vaccination targets.

- **Support from development partners and other donors in critical implementation areas facilitated the success of the program**. Development partners provided financial and in-kind support to the MOH in essential areas of implementation, supporting vaccine transportation and distribution from the central level to provinces, increasing vaccine storage capacity through the rental of cold storage facilities, funding social mobilization activities, funding per diems for health workers, and providing technical assistance on planning and on the development of vaccination protocols.

- **Large scale and long-term deployment of temporary sites at strategic high-traffic areas facilitated the delivery of high volume, and high vaccination coverage.** Temporary vaccination sites staffed by mobile brigades were placed at high-traffic points within the community, including at markets, neighborhood centers, schools, and sports pavilions. These temporary sites remained active for several months and provided vaccination on a daily basis to eligible individuals. According to key informants, their prolonged presence in the community contributed to the achievement of high vaccination coverage.

- **Virtual technologies were leveraged to train vaccination team members more quickly, while also reducing training costs**. Mozambique employed virtual platforms for the training of personnel involved in the vaccination effort, reducing training costs while complying with social distancing regulations and facilitating a quicker roll out of the training sessions across the country.

- **The use of health staffs' private vehicles filled critical gaps in transportation needs**. To increase transportation capacity, respondents reported that health staff at selected sampled sites used their private vehicles, with fuel provided by the district, to transport vaccines from districts to health facilities and from health facilities to temporary vaccination sites or back to the district. This helped fill a critical gap in vehicles for vaccine distribution at health facility level.

CHALLENGES IN IMPLEMENTING THE C19 VACCINATION PROGRAM

- **Delays in funding availability and insufficient funds slowed implementation and required amendment of vaccination plans**. Key informants reported that there were significant delays in the availability of funds required to implement vaccination activities. While these were partly due to delays in disbursement, respondents flagged that the time required to comply with Mozambique's financial administration procedures was also a key bottleneck. These procedures are in place to prevent misuse of public funds and must be followed even in time of crisis. Moreover, respondents reported that even when funds became available, they often did not cover the entire planned budget. This forced the MOH to revise implementation plans, delaying the start dates of vaccination phases, revising the target populations, and at times reducing the number of vaccination teams deployed.

- **The lack of financial incentives was identified as a key factor negatively affecting motivation and participation of health workers in vaccination activities, particularly from the end of December 2021.** Health professionals involved in the vaccination effort expected to receive a per diem for every vaccination day, as commonly done for vaccination campaigns in Mozambique. However, only two facilities reported any per diem for vaccination team members during the study period of December 2021 to February 2022, and a lack of financial incentives for health workers was identified as a key pain point by respondents at implementation level as well as at higher levels of the health system. While some staff reported receiving per diem during other implementation periods, they were paid for only a small fraction of the days worked. Reportedly, this led to a reduction in the number of vaccination teams and of the vaccination team size, prompting health facilities to focus on vaccination through fixed vaccination sites rather than at temporary sites, particularly from December 2021 onwards.

- **The lack of transportation constrained vaccination activities at some sites.** In one district, respondents at two health facilities reported that on several occasions the vaccination team members assigned to a temporary site had to remain at the health facility and offer vaccines from there, due to a lack of transport to bring vaccines and other vaccination material from the health facilities to the temporary sites and back.

- **Insufficient training on the newly deployed C19 module of Mozambique's DHIS2 (SIS-MA) resulted in a lack of granular data about doses delivered.** In Nampula, our study team found that the C19 doses delivered reported to the DHIS2 were aggregated at the district level and were not recorded for individual health facilities. Respondents reported that this was due to lack of training in the newly added DHIS2 C19 module.

V

QUANTITATIVE RESULTS

STAFFING AND SERVICE DELIVERY AT SAMPLED SITES

During the initial lower-volume period of Phase I, sampled sites delivered an average of 64 doses per vaccination day, and each dose delivered required 173 minutes of labor in total, of which 27 minutes were spent on vaccine administration. During Phase I, facilities on average deployed 10 vaccination team members, equally split between regular staff and volunteers. Sampled sites delivered an average of 64 doses per vaccination day, and each dose delivered required an average of 173 minutes of total labor, considering the time spent on all activities related to the vaccination effort, such as vaccine administration, social mobilization, waste management, vaccine transportation, etc. and an average of 27 minutes for vaccine administration only. On average, rural facilities during Phase I delivered fewer doses per day (51 vs. 75 at urban facilities) and required significantly more labor to deliver each dose (285 minutes vs. 80 at urban facilities), including more time for vaccine administration only (44 vs. 12 minutes). More detail on staffing and service delivery at sampled sites during Phase I can be found in Table 3 below.

Table 3. Staffing and service delivery at sampled sites, Phase I (March-April 2021)

	Total	Urban	Rural	Maputo Province			Nampula		
				Total	Urban	Rural	Total	Urban	Rural
Number of sampled sites	20	11	9	9	6	3	11	5	6
Doses delivered (average)	889	1,225	527	1,024	1,686	141	744	610	859
Doses delivered per day (average)	64	75	51	63	82	25	65	67	64
Vaccination team members (average)	10	11	10	10	8	14	11	14	8
Health staff in vaccination team (average)	5	5	5	6	5	8	4	4	4
Volunteers in vaccination team (average)	5	6	5	3	2	5	7	10	5
Doses delivered per staff/day (average)	6	7	5	7	11	2	6	5	8
Person/minutes of labor per dose delivered, including all program activities (average)	173	80	285	136	78	250	203	82	303
Person/minutes of labor per dose delivered, for service delivery only (average)	27	12	44	24	13	46	28	11	43

During the high-volume period from December 2021 to February 2022, sampled health facilities delivered a daily average of 225 doses per vaccination day, and spent 35 minutes of labor per dose delivered. Over the three-month period, sampled health facilities delivered an average of 14,370 doses. Sampled facilities had an average of 11 vaccination team members, split across multiple vaccination teams, including 5 health professionals and 5 volunteers. This means that on average, facilities in this period deployed just one additional vaccination team member compared to Phase I. Across all sampled health facilities, administering one vaccine dose required an average of 35 minutes labor for all activities, of which an average of 6 minutes were spent on vaccine administration, for each dose delivered. More detail on staffing and service delivery at sampled sites during the December 2021 to February 2022 period can be found in Table 4.

Health facilities in urban areas administered more doses per day, with an average of 350 doses, compared to those in rural areas, which administered an average of 89 doses per day. Urban health facilities also had slightly larger vaccination teams, with an average of 11 members compared to 10 in rural areas. Urban health facilities administered three times more doses per team member per day when compared to rural locations (32 vs. 9) and administering one vaccine dose in urban areas required less time (including all activities related to the vaccination program) compared to rural health facilities (21 vs. 51 minutes).

Sampled sites in the Maputo province administered, on average, more doses per day compared to those in Nampula (255 vs. 191). This is mainly because urban health facilities in the Maputo province administered more doses than urban health facilities in Nampula (387 vs. 301). On average, health facilities in the Nampula province had slightly larger vaccination teams compared to Maputo province (12 vs. 9), but also a higher proportion of volunteers, as 58% of the team in Nampula consisted of volunteers, compared to 33% in Maputo province. Overall, health facilities in Maputo province required more labor to administer one vaccine dose–38 minutes compared to 33 minutes in Nampula. However, this was largely due to rural health facilities in Maputo province requiring significantly more labor to administer one dose when compared to all other health facilities, or 65 minutes per dose (including all activities related to the vaccination effort). Conversely, urban health facilities in Maputo province required the least amount of labor per administered dose, with only 17 minutes per dose.

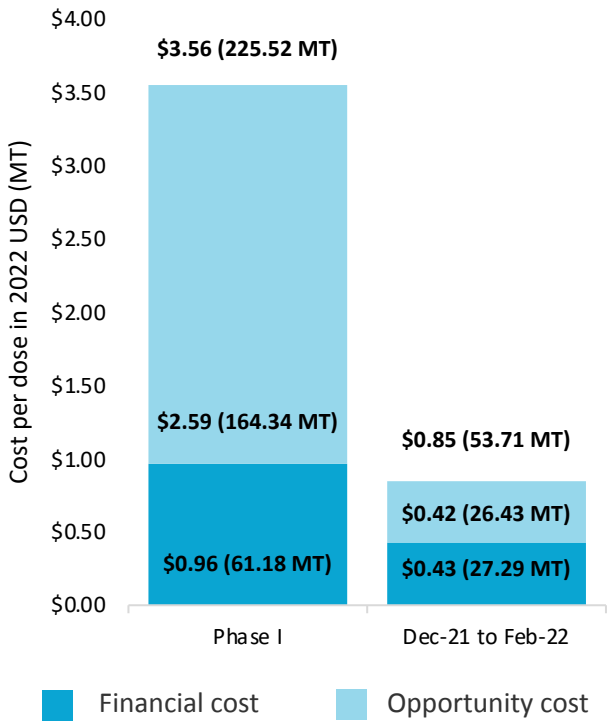
Table 4. Staffing and service delivery at sampled sites, Dec-21 to Feb-22

	Total	Urban	Rural	Maputo Province			Nampula		
				Total	Urban	Rural	Total	Urban	Rural
Number of sampled sites	27	14	13	14	8	6	13	6	7
Doses delivered (average)	14,370	22,427	5,693	16,349	24,784	5,102	12,238	19,284	6,199
Doses delivered per day (average)	225	350	89	255	387	80	191	301	97
Vaccination team members (average)	11	11	10	9	9	10	12	14	10
Health staff in vaccination team (average)	5	5	5	6	6	6	4	5	4
Volunteers in vaccination team (average)	5	5	5	3	3	4	7	9	6
Doses delivered per staff/day (average)	21	32	9	27	44	8	16	22	9
Person/minutes of labor per dose delivered, including all program activities (average)	35	21	51	38	17	65	33	27	38
Person/minutes of labor per dose delivered, for service delivery only (average)	6	4	9	8	3	13	5	5	5

C19 vaccine delivery costs per dose were significantly higher during the initial lower-volume Phase 1

The cost per dose was high in March-April 2021 (Phase I), and decreased considerably when delivery volume increased in the period between December 2021 and February 2022. The economic cost per dose was $3.56 during Phase I compared to only $0.85 during the December 2021 to February 2022 period, while the financial cost per dose was $0.96 during Phase I and $0.43 in December 2021 to February 2022, as shown in Figure 4. Phase I of the C19 vaccination program took place between March and April 2021, a period characterized by significant vaccine supply constraints. During this phase, the program focused on a small target population, which included health workers, other front-line workers and selected vulnerable populations. Due to the smaller target population and the vaccine supply constraints, this period was characterized by a much lower delivery volume when compared to December 2021 to February 2022, a period characterized by vaccine availability and mass vaccinations. During Phase I, vaccines were delivered exclusively at fixed sites, while during the December 2021 to February 2022 period both fixed sites and temporary sites were used. Moreover, during Phase I, sampled sites delivered an average of 64 doses per day, compared to 225 doses per day in the December 2021 to February 2022 period.

Figure 4. Economic cost per dose by period



The cost of administering a dose of the C19 vaccine in Mozambique is low compared to other countries

The cost of delivering C19 vaccines in Mozambique during the high-volume period December 2021 to February 2022 is lower than available estimates for C19 vaccines in other countries. A study in Vietnam found that the economic and financial cost of delivering one dose of C19 vaccine were respectively $5.24 and $2.08 per dose during the initial low-volume period, and $1.65 and $0.56 during the mass vaccination period.[8] The estimates for the low-volume period in Vietnam are higher than what we found in Mozambique for the initial low-volume period of Phase I, and estimates for the mass vaccination period are also higher than what our study found for the December 2021 to February 2022 period. This is due to Vietnam's much higher spending on health worker incentives and cold chain capacity expansion during the study period. Another study on the cost of C19 vaccine administration in Côte d'Ivoire found that the economic cost per dose was $3.16, while the financial cost was $0.67.[9] These estimates, which are for a period targeting the general population, are similar to what our study found for the initial low-volume period of Phase I, which only targeted health workers and other priority populations, and much higher than what we found for the December 2021 to February 2022 period. Although the spending levels in Côte d'Ivoire and Mozambique were similar—with little to no financial

incentives given to health professionals, minimal to no investment in the cold chain during the study period, and no additional hiring at the implementation level—sites in Côte d'Ivoire delivered fewer doses per day compared to Mozambique (55 doses per day vs. 64 and 225 in Mozambique respectively during Phase I and the December 2021 to February 2022 period), resulting in a higher cost per dose delivered.

The financial cost per dose found in our study is also significantly lower than projected by the COVAX model. The COVAX Readiness and Delivery Working Group on Delivery Costing estimated that the financial cost of vaccine administration in Mozambique to fully vaccinate with two doses 70% of the country's population would range from $1.08 to $2.56.[10] This is far higher than what our study found for the high-volume period—which is most comparable to COVAX estimates as it targeted the general population—but also slightly higher than the cost found by our study for Phase I, during which a very small share of the population was vaccinated. The COVAX model assumed that between 0-10% of the existing workforce would be redeployed for C19 vaccine delivery, with the remainder of the work being implemented by newly hired health workers—a key cost driver. However, we did not find any records of additional hiring at implementation level. Another major cost driver in the COVAX model was the assumption that 15-50% of the doses would be delivered through temporary sites, while the rest would be administered through fixed sites, and that staff at temporary sites would receive per diem. However, although Mozambique used temporary sites to deliver C19 vaccines during the study period, virtually no per diem were given to health workers.

The economic cost of delivering C19 vaccines during the high-volume period December 2021 to February 2022 is lower than existing estimates for vaccination campaigns in Mozambique. The economic cost is low compared to existing evidence for Mozambique. A study on the feasibility of a mass vaccination campaign with two doses of oral cholera vaccine (OCV) [11] estimated the economic cost at $1.53 per dose or $3.05 per fully vaccinated person[iv]. This is lower than what was found by our study for the low-volume period of Phase I, but higher than estimates for the higher-volume period of December 2021 to February 2022. The OCV estimate also includes the cost of international vaccine transport, which accounted for 38% of total costs and was excluded in our study. The estimate was based on a small-scale demonstration project targeting only one neighborhood in Beira, Sofala Province. Other literature on vaccine distribution costs in Mozambique includes vaccine costs or focuses on specific components of administration costs (e.g., only supply chain or transportation), making it not comparable to our findings.[12,13,14]

Paid labor is the key cost driver among economic costs, making up 37%-64% of the cost per dose

During Phase I, labor costs accounted for 64% of the economic cost per dose, consisting entirely of salaries for existing staff. Opportunity costs accounted for the great majority of the economic cost per dose during Phase I (over 73%). This was largely due to paid labor, which during Phase I represented a much larger share of the economic cost per dose (64%, compared to 37% in the December 2021 to February 2022 period) and amounted to $2.27. No financial labor costs were recorded, as no additional health staff were hired for the C19 vaccination program. During Phase I, sampled sites deployed a similar amount of vaccination team members when compared to the higher-volume period of December 2021 to February 2022 (an average of 10 vs. 11 vaccination team members) but delivered far fewer doses per vaccination day (an average of 64 vs. 225 doses per day).

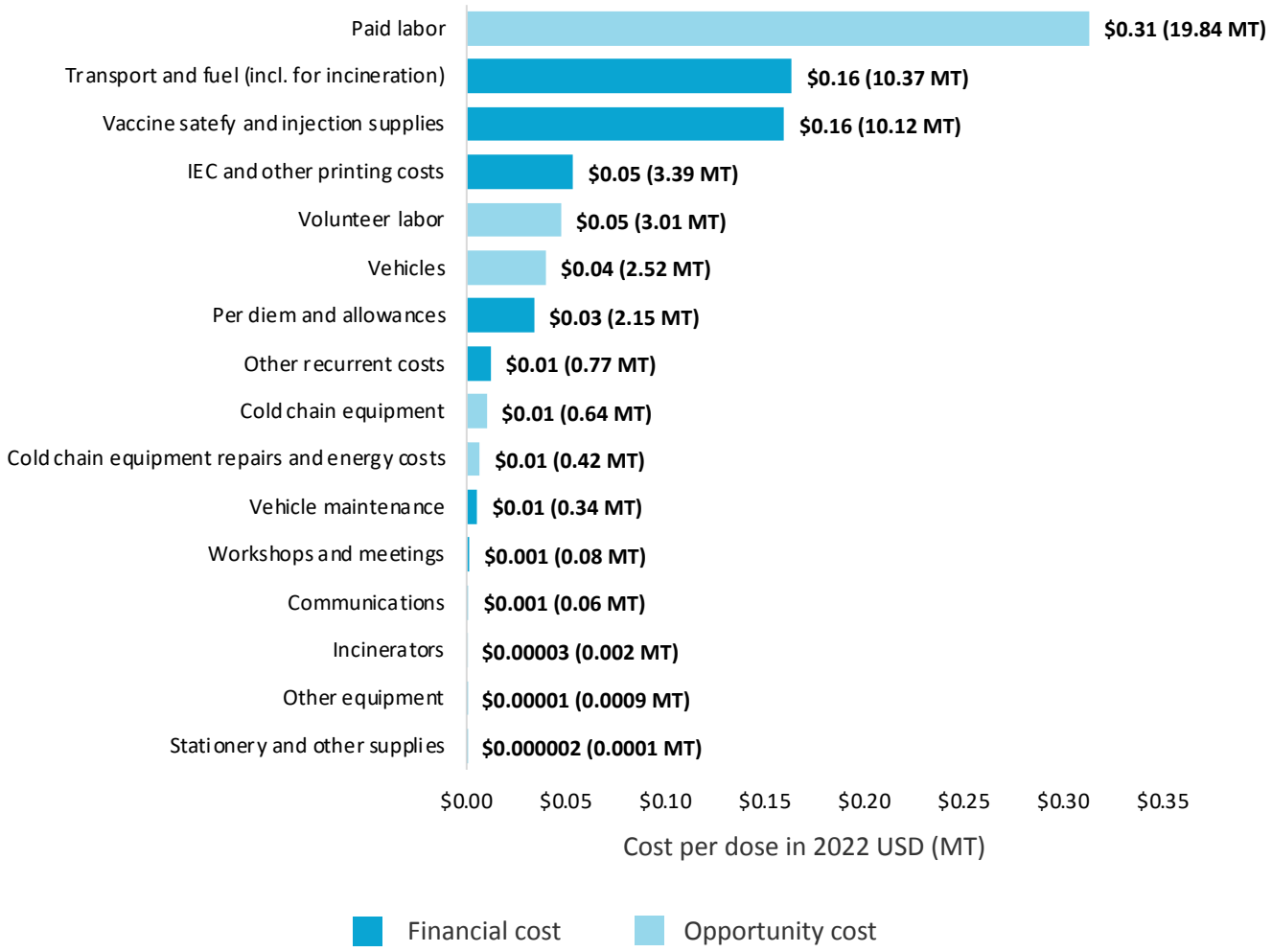
This also meant that during Phase I delivering one dose of C19 vaccine was associated with more labor when compared to the December 2021 to February 2022 period, an average of 173 vs. 35 minutes for all activities related to the C19 vaccination program and an average of 27 vs. 6 minutes for vaccine administration only. The second-largest cost driver during this period were vaccine injection and safety supplies (9% of the economic cost per dose), followed by volunteer labor (7%). Although usually a large cost driver of delivery costs for vaccination campaigns, per diems and allowances amounted to only a small part (3%) of the cost per dose, as only three health facilities reported receiving per diem for vaccination team members during Phase I.

[iv] Those results were originally reported in 2004 USD. We present here all the results from other studies in 2022 USD. To inflate costs from the year originally reported to 2022, we used the annual inflation rate of the Consumer Price Index (CPI) from the IMF.

During the December 2021 to February 2022 period, the cost of paid labor amounted to $0.31 per dose or 37% of the cost per dose. This constitutes the largest component of the economic cost per dose delivered, as shown in Figure 5. As in Phase I, there was no additional hiring for the C19 vaccination program during this period, thus no financial labor costs were recorded. The second-largest cost driver for C19 vaccination during the period of December 2021 to February 2022 was transportation and fuel, at $0.16 per dose—mainly for service delivery at temporary sites and through outreach, and for vaccine distribution. Transportation and fuel represent a much higher share of the cost compared to Phase I (19% vs. 3%), as during Phase I vaccines were only delivered at fixed sites.

Vaccine injection and safety supplies were also a significant cost driver during the December 2021 to February 2022 period, accounting for 19% of the economic cost per dose. Similar to Phase I, only two health facilities reported receiving per diem for vaccination team members during this period, thus per diems and allowances amounted to only 4% of the cost per dose.

Figure 5. Staffing and service delivery at sampled sites, Dec-21 to Feb-22

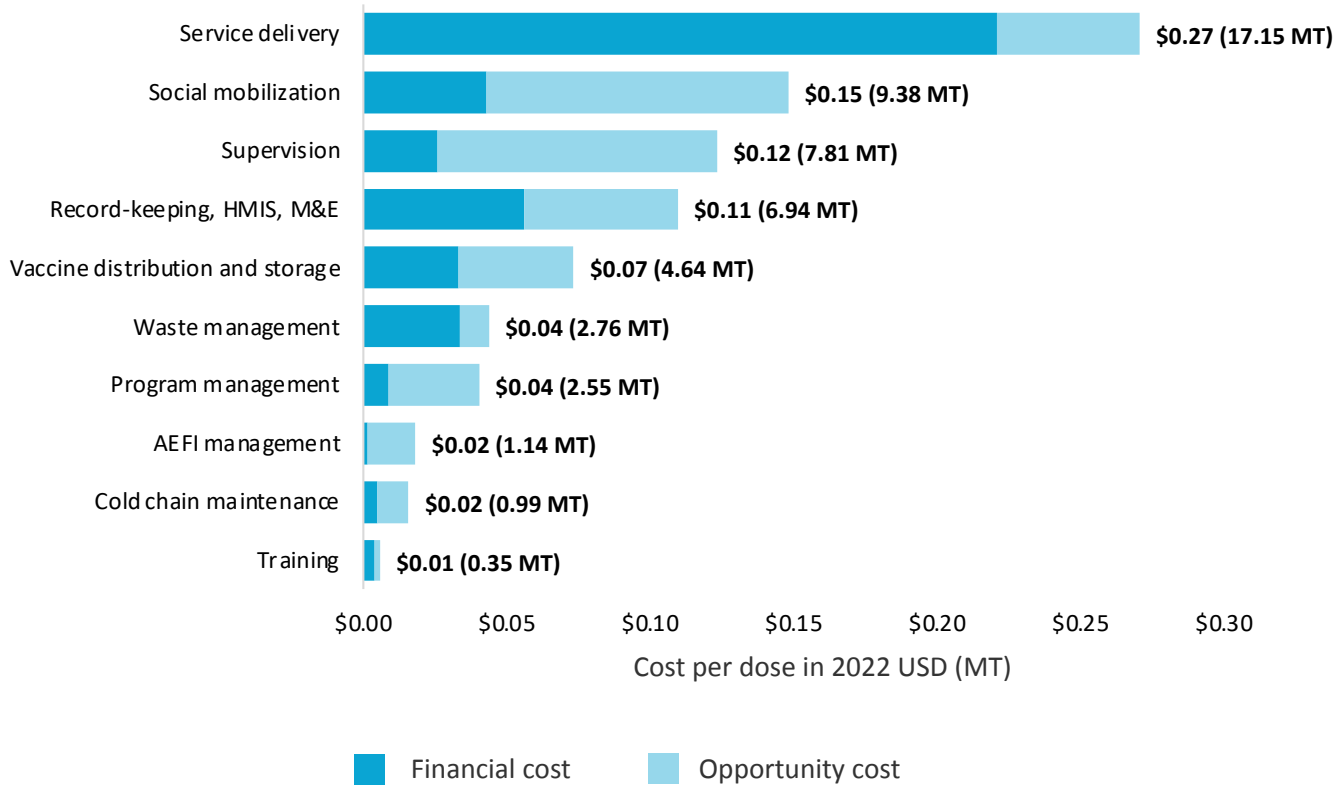


Most costs went towards social mobilization and service delivery

Social mobilization was the key cost driver during Phase I, accounting for 23% of the cost per dose or $0.83. During Phase I, most of the cost per dose went towards social mobilization, which accounted for a much larger share of the cost per dose when compared to the December 2021 to February 2022 period (23% vs. 17%). This is not surprising, as social mobilization activities are likely to be more frequent when a vaccine is first introduced. Service delivery was the second largest cost activity accounting for 20% of the cost per dose in Phase I or $0.71 per dose. Supervision also accounted for approximately 20% of the economic cost per dose during Phase I, or $0.70.

During the December 2021 to February 2022 period, most costs went towards service delivery, which accounted for $0.27 or 32% of the economic cost per dose (Figure 6). During this period, service delivery was also the key cost driver when only looking at financial costs. This is in line with what is commonly found in the literature on immunization delivery costing studies, as service delivery is often the largest cost activity. Approximately 82% of service provision costs are financial costs, with the majority related to transportation and vaccine injection and safety supplies. Social mobilization followed as the second most significant cost activity, at $0.15. Costs related to social mobilization and supervision were mostly made up of salaries for existing staff (opportunity costs). Training cost represented the smallest cost activity, accounting for only 0.7% of the economic cost per dose, or $0.01 per dose. While training costs often represent a larger share of the cost per dose for the delivery of newly introduced vaccines, Mozambique leveraged virtual technologies to conduct trainings down to the district level, and virtually no financial expenses were incurred for trainings at health facilities.

Figure 6. Economic cost per dose by activity, Dec-21 to Feb-22



Start-up costs were low due to little investment during the study period

During the study period (until February 2022), we recorded a total of $38,885 for national-level startup economic costs, with 95% of these costs coming from donor contributions. As shown in Table 5, out of the total startup costs, $36,184 or 93% were financial costs, primarily related to national-level training and program management. We defined initial start-up costs as those costs incurred 30 days before the start of vaccination activities until the end of the study period (February 2022), related to inputs and activities specifically associated with the introduction of the new C19 vaccination program. Startup costs related to the introduction of a new vaccine typically include costs related to training health workers (such as rental of training venue, refreshments for trainees, and sometimes travel and per diem expenses), program management (including development of new guidance and protocols, and initial planning of the vaccine roll out), and acquisition of additional cold chain equipment. Our study found very little training-related financial costs, and did not find any costs related to expanding the cold chain or acquiring new vehicles during the study period (until February 2022), although respondents indicated newly purchased cold chain equipment being deployed after that. At lower administrative levels, the weighted average startup costs were lower, as shown in Table 6, with an average of $4,272 at the provincial level, $1,278 at the district level, and $108 at the health facility level.

Table 5. Economic cost per dose by activity, Dec-21 to Feb-22

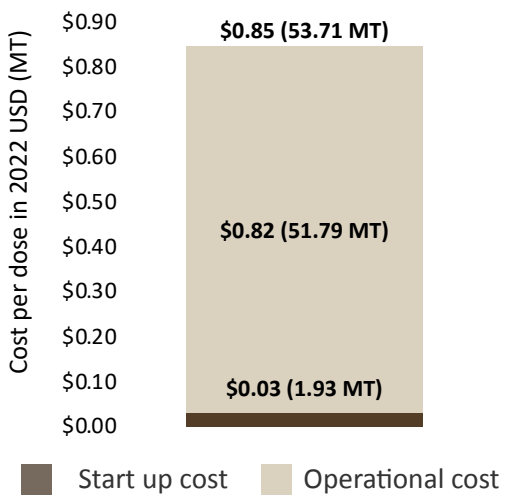
Level	Financial costs	Opportunity costs	Economic costs
Donors*	$36,184	$402	$36,586
MOH	$0	$2,299	$2,299
Total national level	**$36,184**	**$2,701**	**$38,885**

Table 6. Economic cost per dose by activity, Dec-21 to Feb-22

Level	Financial costs	Opportunity costs	Economic costs
Provincial	$3,655	$617	$4,272
District	$1,138	$139	$1,278
Health Facility	$12	$96	$108

The startup costs represented about 2-4% of the economic cost per dose during the study periods. For Phase I, startup costs accounted for only 2% of the economic cost per dose, which corresponds to $0.07, while in the December 2021 to February 2022 period, they accounted for 4% of the cost per dose, which corresponds to $0.03 as shown in Figure 7.To estimate startup cost per dose, we annualized these costs based on each item or activity useful life, and then apportioned the annualized costs across the two study periods, as described in **Data analysis** section. Costs related to equipment acquired during the implementation of the C19 vaccination program but only deployed to study sites after the study period were excluded from our analysis

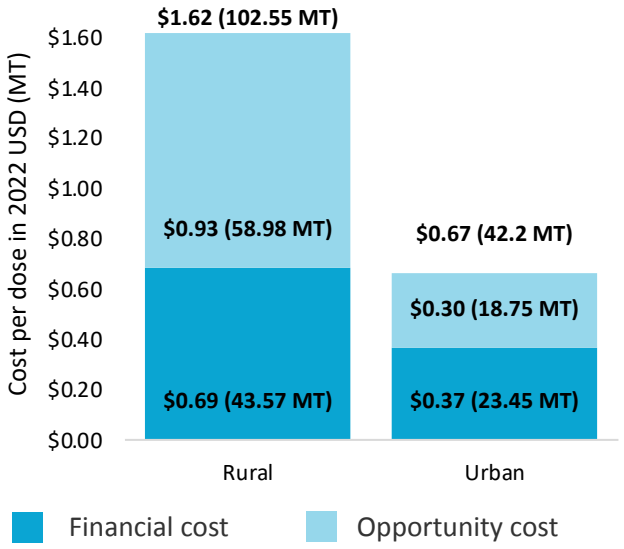
Figure 7. Start-up and recurrent costs per dose, Dec-21 to Feb-22



Vaccinating in rural areas was more expensive than vaccinating in urban areas due to lower volume delivered

Rural areas recorded a higher economic cost ($1.62) compared to urban areas ($0.67), during the December 2021 to February 2022 period (Figure 8). A similar pattern was also observed when comparing the cost per dose at rural and urban health facilities during Phase I, with an economic cost per dose of $4.53 for rural areas versus $3.17 for urban areas. Both during Phase I and in the December 2021 to February 2022 period, the cost structure was similar in rural and urban health facilities, though vaccinating in rural areas required significantly more labor. In December 2021 to February 2022, each dose delivered in rural areas required an average of 51 minutes vs. 21 in urban areas for all activities required for the vaccination program, and an average of 9 minutes vs. 4 for vaccine administration only.

Figure 8. Economic cost per dose by geographic area, Dec-21 to Feb-22



The higher cost in rural areas is likely due to the significantly lower volume delivered. Rural health facilities delivered much fewer C19 vaccine doses per vaccination day, with an average of 89 doses in rural areas compared to 350 doses in urban areas during the December 2021 to February 2022 period and 51 vs. 75 in Phase I. As the cost structure was similar across rural and urban sites, this suggests that the lower volume delivered is driving the higher delivery cost per dose.

This is also supported by the inverse relationship between the economic cost per dose and the volume delivered found across the sample and shown in Figure 9, where each dot represents a sampled health facility. These results are in line with the immunization delivery cost literature, which often finds an inverse relationship between the volume delivered and the cost per dose due to economies of scale: as a health facility administers more doses, the cost for each dose delivered tends to decrease, as fixed costs are spread across more doses.

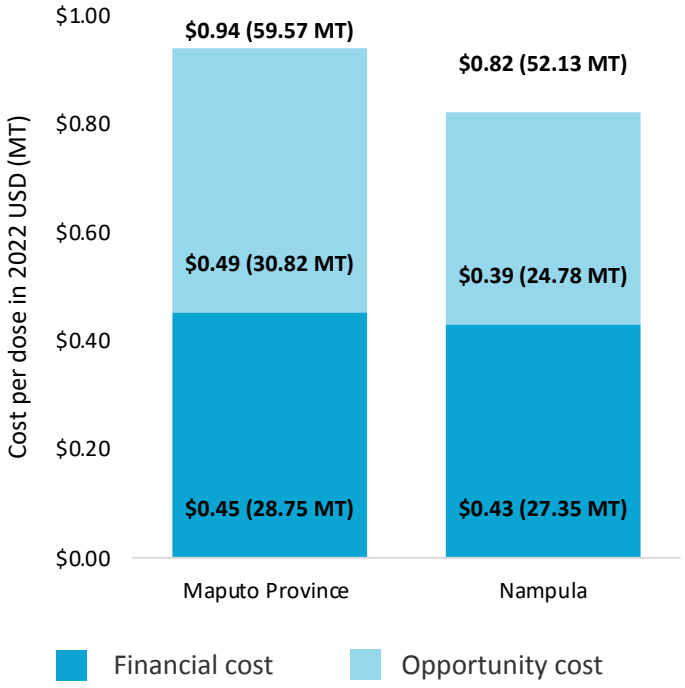
Figure 9. Relationship between volume delivered and economic cost per dose, for rural and urban sites (Dec-21 to Feb-22)

Delivery costs were similar, but the cost structure differed slightly across the two provinces

In Phase I, the economic cost per dose across the two provinces was similar but Nampula reported higher financial costs largely due to per diem costs. The economic cost per dose was $3.63 for Maputo province and $3.69 for Nampula. The volume delivered on average per day across the two provinces was also similar, with 63 doses per day in Maputo province, and 65 doses per day in Nampula. However, labor costs were greater in Maputo in Phase I, also due to much higher labor costs at district level in Maputo province. Conversely, during Phase I the financial cost per dose was considerably higher in Nampula at $1.25 per dose compared to $0.79 in Maputo province. This difference is largely driven by the higher financial cost per dose at implementation level for health facilities in Nampula: the only facilities that received any per diem during Phase I were all located in Nampula, and per diem alone account for $0.23 per dose in Nampula, while no per diem costs were recorded in Maputo province.

During the higher volume period of December 2021 to February 2022, Maputo province recorded a higher economic cost per dose compared to Nampula, with $0.94 vs. $0.82, mainly driven by greater use of labor. While the financial cost per dose was similar across the two provinces, opportunity costs were higher in Maputo province, with a cost per dose of $0.49 vs. $0.39 in Nampula, as shown in Figure 10. While sampled facilities in Maputo province delivered more doses per vaccination day, an average of 255 vs. 191 in Nampula, each dose delivered in Maputo province required more labor, resulting in a higher labor cost per dose in Maputo province. Facilities in Maputo province required an average of 38 minutes per dose compared to 33 minutes in Nampula for labor for all C19 program activities and 8 vs. 5 for service delivery only. The higher labor requirements in Maputo province are due to the significantly higher labor requirements at rural facilities, where delivering one dose required an average of 65 minutes (for all activities), compared to 17 in urban facilities in Maputo province. Therefore, economies of scale due to the higher volume delivered in Maputo province did not offset the higher labor costs due to the greater labor requirements of delivering one dose in rural areas in Maputo province, resulting in a higher cost per dose in Maputo province when compared to Nampula.

Figure 9. Economic cost per dose by province, Dec-21 to Feb-22



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KEY TAKEAWAYS

The results of this study provide valuable evidence for policymakers in Mozambique and worldwide. Findings from this study can help inform the planning, budgeting, and resource allocation decisions for future phases of the C19 vaccine program in Mozambique. Given the very limited literature on immunization delivery costing in Mozambique, these findings can also inform future vaccination campaigns and vaccine introduction efforts in both emergency and routine contexts.

Based on our study's results, we draw the following takeaways for policymakers:

Although donors and partners supported key areas of the vaccination effort, funding still fell short.

Although COVAX estimated funding needs for C19 vaccine delivery in Mozambique to be between $28-$66 million[15], we found only $22 million in donor support for vaccine delivery during this period. Donors supported in critical areas such as training, development of guidelines, social mobilization, per diem for health workers, and vaccine transportation and distribution. Nonetheless, funding still fell short, even in areas that were supported by donors like transport and per diem. In particular, insufficient per diem for vaccination team members were found to be a critical pain point in our study as well as in other analyses.[16]

Even where funding was available, delays in disbursements and release of funds disrupted program implementation.

There were significant delays in disbursement and release of funds. For instance, while donor-funded cold chain equipment was in the process of being procured, no new equipment had actually been deployed by the end of our study in February 2022, when the largest campaigns had already been completed. Furthermore, local financial management procedures delayed the release of funds. Delays and lower than expected funding disrupted program implementation, as program managers had to postpone the start dates for vaccination rounds and phases and redesign plans to accommodate lower budget availability. Therefore, to ensure the timely availability of funds, donors and other partners need to speed up their own disbursement procedures, and support governments in adapting public financial management procedures in emergency settings.

The low financial cost per dose found in the study reflects the inadequacy of available resources, rather than low financial requirements to support C19 vaccination.

Financial costs were low mainly due to limited additional investments to support the program's implementation. Financial incentives for health workers were virtually non-existent, volunteers made up half of the vaccination teams as there was no funding to hire additional staff, and personal vehicles were used as there was a shortage of vehicles to transport vaccines to temporary posts. This low level of financial investment combined with the high volume of doses delivered explains the low cost per dose found in our study. While the health system could be stretched and delivered successfully in a moment of crisis, these practices would not be unsustainable in the long term, as future vaccination campaigns are not likely to count on the same level of political prioritization.

Since no additional health workers were hired to carry out C19 vaccination, the pressure to achieve high vaccination coverage within a short period of time might have impacted the provision of other health services.

None of the study's health facilities reported hiring new staff, and each location deployed an average of 5 health workers for C19 vaccination every day. Due to its critical shortage of human resources for health (HRH), Mozambique was on the WHO health workforce support and safeguard list before the C19 pandemic, and remains on this list in 2023.[17,18], Therefore, the absence of staff at health facilities likely had a negative impact on the delivery of other health services. While our findings do not quantify the impact of the C19 vaccination program on the provision of other health services, evidence shows that coverage rates for routine immunization vaccines continued to drop during the study period.[19]

Our study found relatively high cost levels during Phase I, when a small priority group was targeted, suggesting a need to rethink delivery strategies to ensure cost-efficiency in future implementation phases.

As is typically found in immunization cost studies, the results of this study showed that at higher volumes of doses delivered, the cost per dose was lower. For example, large and urban facilities were able to deliver vaccines in a more cost-efficient manner, compared with smaller or rurally located facilities that delivered fewer vaccines. The mass vaccination period from December 2021 to February 2022 also demonstrated to be considerably more cost-efficient than the earlier period during which delivery volume was low. These findings have significant implications for current and future phases of the C19 vaccination program. As current and future target populations are significantly smaller, and vaccination sites are unlikely to deliver a high volume of C19 vaccines doses, costs could be kept low either by integrating delivery with other health services targeting the same priority populations or by implementing periodic mini campaigns.

Despite the significant resource constraints, Mozambique achieved high vaccination coverage thanks to political prioritization and the dedication of health workers.

By the end of the study period in February 2022, Mozambique had vaccinated over 70% of its target population with at least one dose, outperforming most sub-Saharan African countries. Key informants highlighted how the involvement of top levels of the government facilitated program implementation: on the one hand, it increased visibility among the target population thus generating demand for the vaccine, and on the other hand, it ensured clear political prioritization at all administrative levels. Furthermore, despite the lack of financial incentives, health workers remained committed to the C19 vaccination program and were resourceful in finding solutions to problems as they arose.

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ANNEXES

ANNEX 1. PROGRAM ACTIVITIES AND RESOURCE TYPES

Table7. Definitions of program activities

Activity	Description
Program management	Planning, budgeting, managing the C19 vaccination program
Vaccine collection, distribution, and storage	Collecting vaccines at the airport or other distribution points, storing vaccines in national or provincial cold stores, distributing vaccines down to district, facilities and to delivery sites
Cold chain maintenance	Maintaining and repairing the cold chain for the purpose of the C19 vaccine roll-out
Training	Attending and/or providing C19 vaccination-related training, including topics such as administering vaccines, storage and logistics, record keeping, pharmacovigilance, social mobilization, planning, supervision, etc.
Social mobilization and advocacy	Mobilizing and sensitizing the community and households, conducting social mobilization events, and advocating for C19 vaccination
Supervision	Supervising subordinate or peer health or community workers
Service delivery	Administering the vaccine to people within the hospital/facility/compound, during outreach (outside the facility) or using a medical mobile unit
Waste management	Time and resources spent on disposing sharps and infectious non-sharp wastes
AEFI management	Following up on post-vaccination events following C19 vaccine administration
Record-keeping, HMIS, monitoring and evaluation	Data entry and analysis, reporting, monitoring

Table 8. Definition of resource types

Resource types	Definition	Financial vs. Opportunity cost	Startup vs. Operational cost
Recurrent resource types			
Paid labor	Share of the salary paid to health workers and government employees proportional to the time they spent working on activities related to the C19 vaccination program	Opportunity cost	Operational, unless related to startup activities
	Salary paid to new employees hired specifically for the C19 vaccination program	Financial cost	Operational, unless related to startup activities
Volunteer labor	Value of voluntary work (performed by medical students, local youth, retired health staff, community representatives etc.) for vaccination team members who do not receive a regular salary. This cost was calculated based on the working hours of each volunteer and valued at a minimum wage for the public sector	Opportunity cost	Operational, unless related to startup activities
Per diem and travel allowances	Daily allowances and/or subsidies and travel allowances paid to regular employees and volunteers for participation in activities related to the C19 vaccination program	Financial cost	Operational
Vaccine injection and safety supplies	Cost of vaccine injection and safety supplies and personal protective equipment	Financial cost	Operational
Stationery and other supplies	Cost of stationery and other supplies used for the C19 vaccination program	Financial cost	Operational
Transport and fuel	Cost of bus fare, plane travel, boat travel/hire vehicle hire and fuel for C19 vaccination program activities that required travel (supervision, training, vaccine collection, distribution, etc.) Costs of fuel used in incinerators for the C19 vaccination program specifically Additional fuel costs for the waste disposal incinerator related to C19 vaccine waste management	Financial cost	Operational
	Portion of fuel costs for the routine waste disposal incinerator that was used in relation to C19 vaccine waste management	Opportunity cost	Operational
Vehicle maintenance	Cost of vehicle maintenance carried out specifically for the C19 vaccination program during the study period	Financial cost	Startup
	Routine vehicle maintenance carried out during the study period	Opportunity cost	Operational
Cold chain equipment repairs and energy costs	Cost of cold chain equipment repairs carried out specifically for the C19 vaccination program during the study period	Financial cost	Operational
	Routine maintenance or repairs cost of cold chain equipment used for C19 vaccine delivery The energy cost for the cold equipment is the storage room energy bill (if available)	Opportunity cost	Operational

Resource types	Definition	Financial vs. Opportunity cost	Startup vs. Operational cost
IEC and other printing costs	Cost incurred specifically for the C19 vaccination program based on national-level financial reports	Financial cost	Operational, unless related to startup activities
Workshops and meetings	Cost incurred specifically for C19 vaccination workshops and meetings (e.g. venue hire, refreshments, mobile data for virtual meetings)	Financial cost	Operational, unless related to startup activities
Other recurring cost	Other financial expenditures that are not included in the above categories	Financial cost	Operational
Capital items			
Cold chain equipment	Depreciation costs of existing cold chain equipment used for C19 vaccine storage at study sites at all administrative levels	Opportunity cost	Operational
	New cold chain equipment purchased and used during the study period for the C19 vaccination program	Financial cost	Startup
Vehicles	Depreciation costs of existing vehicles used for C19 vaccination activities at study sites	Opportunity cost	Operational
	New vehicle(s) acquired and used during the study period for the C19 vaccination program	Financial cost	Startup
Incinerators	Depreciation costs of existing incinerator(s) used to dispose of C19 vaccination waste at study sites	Opportunity cost	Operational
	New incinerator(s) acquired and used during the study period for the C19 vaccination program	Financial cost	Startup

ANNEX 2. MISSING DATA ASSUMPTIONS

Missing data	Methods
Quantities used for vaccine safety and injection supplies and personal protective equipment (PPE)	Estimated based on the average vaccine safety and injection supplies and personal protective equipment (PPE) used per dose administered in 5 study sites in one district
Quantity of AEFI kits used	Estimated based on the quantity of doses administered at a ratio of 1 AEFI kit for every 1,000 doses administered, based on 5 study sites in one district
Fuel used	Distance traveled as reported by the interviewees, multiplied by a consumption factor of 0.2 liters of fuel per km (Source: Nampula's Provincial Department of Planning and Cooperation)
Share of registers and other recordkeeping material printed in 2021 that was used during each study period	The district health directors reported in April 2023 that they had not received new shipments of registers and other recordkeeping materials since the initial printing done in 2021. Therefore, it was conservatively assumed that the material initially printed in 2021 had been used from the beginning of C19 vaccination until April 2023, and the share of material used during each study period was calculated proportionally to the number of doses delivered in each period

ANNEX 3. ALLOCATION RULES

Allocation of shared resources used for the C19 vaccination program: Resources shared between the C19 vaccination program and the health system were allocated based on indicators that best reflected how the resource was used.

Resource type	Allocation method
Paid labor	Allocated based on self-reporting by the interviewed staff
Fuel for transport	Collected data on the specific amount of fuel used for each program activity. In cases where it was not possible to provide the amount for each activity, the total fuel amount used for C19 vaccination was allocated in proportion to the percentage of working time related to program activities that required transportation, including supervision, training, distribution, and vaccine collection
Cold chain equipment	Allocated to the C19 vaccine program based on the share of equipment's capacity used for C19 vaccine storage, as reported by interviewees at each study site

Allocation of startup costs between study periods: startup costs were allocated to the two study periods (Phase I and December 2021 to February 2022) based on the following allocation rules:

Cost	Allocation Method
Printing of registers and other record keeping material	Allocated based on the volume of doses administered per vaccination period
Labor and other costs related to preparatory activities	Costs related to staff time and other inputs used for preparatory activities (such as training, planning meetings, social mobilization) were allocated based on the duration of each analysis period as a percentage, assuming a 1-year lifespan for the activity

ANNEX 4. TERMS OF REFERENCE FOR SUB-COMMITEES INVOLVED IN THE C19 VACCINE INTRODUCTION

Sub-Committee	Role in the roll out of the C19 vaccination program
Planning and implementation	**Service Delivery**: Update infection prevention and control protocols, including on the use of appropriate personal protective equipment, to reduce the risk of exposure during vaccination sessions. **Training and Supervision**: Develop a training plan to prepare for the introduction of the C19 vaccine, including identification of participants, topics, training partners, and training methods (in-person or virtual), taking into account WHO's guidance. **Monitoring and Evaluation**: Develop or adapt an existing monitoring and surveillance framework with a set of recommended indicators (coverage, acceptability, disease surveillance, etc.) for the C19 vaccine. Determine whether record-keeping and reporting will be at the individual level or aggregated, and to what extent existing instruments and systems can be leveraged. **Safety Surveillance**: (1) Ensure that there are documented guidelines, procedures, and tools for planning and conducting vaccine pharmacovigilance activities. Ensure presence of competent and trained personnel to carry out surveillance activities; (2) expedite the training of the committee responsible for managing adverse events following vaccination to review the safety data of the C19 vaccine; (3) identify provisions that require manufacturers to implement risk management plans and collect and report data on the safety of the C19 vaccine to the National Regulatory Authority; and (4) plan for active surveillance of adverse events related to the C19 vaccine.
Logistics and Cold Chain Sub-Committee	**Vaccine Cold Chain and Logistics:** Strengthen the national logistics task force by providing appropriate terms of reference and standard operating procedures to coordinate the C19 vaccine delivery and the delivery of ancillary products, with support from UNICEF in assessing the cold chain readiness.
Advocacy, social mobilization, communication Sub-Committee	**Demand Generation and Communication:** Develop a demand generation plan (utilizing tools for increasing awareness, effective communication, social mobilization, risk and safety communication, community engagement, and training) to build confidence, acceptance, and demand for C19 vaccines.

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