THE COST OF DELIVERING COVID-19 VACCINES IN VIETNAM

STUDY REPORT | AUGUST 2023

ACKNOWLEDGMENTS

This study was conducted in partnership with the National Institute of Hygiene and Epidemiology (NIHE) and Tay Nguyen Institute of Hygiene and Epidemiology (TIHE), and with the support of development partners. We wish to specifically acknowledge the valuable contributions of Nguyen Mai Khanh (NIHE), Tran Thi Hoang Oanh (TIHE), Dr. Annie Chu (WHO), Nguyen Viet Huong (UNICEF), Hanoi Health Department, Dak Lak Health Department and all the respondents who provided support and data during the implementation of this study.

The research team would also like to thank Logan Brenzel (Bill & Melinda Gates Foundation), Carl Schutte (Genesis Analytics), and Ulla Griffiths (UNICEF) for their critical review of the study protocol.

This work was made possible by funding from the Bill & Melinda Gates Foundation.

RESEARCH TEAM

This study was implemented by the Hanoi University of Public Health with support from ThinkWell. The research team consisted of:

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RECOMMENDED CITATION

Nguyen V.M., Moi, F., Boonstoppel, L., Hoang, M.V., Duong, H.T., Vien, C.C. 2023. The Cost of Delivering COVID-19 Vaccines in Vietnam. Geneva: ThinkWell.

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ABBREVIATIONS

AEFI	Adverse Event Following Immunization
C19	COVID-19
CCE	Cold Chain Equipment
CDC	Center for Disease Control
CHC	Commune Health Center
DHC	District Health Center
HPV	Human Papilloma Virus
HUPH	Hanoi University of Public Health
IEC	Information Education and Communication
MOH	Ministry of Health
NEPI	National Expanded Program on Immunization
NIHE	National Institute for Hygiene and Epidemiology
Td	Tetanus Diphtheria
TIHE	Tay Nguyen Institute of Hygiene and Epidemiology
TT	Tetanus Toxoid
UCC	Ultra-Cold Chain
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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, the Hanoi University of Public Health and ThinkWell conducted a study to estimate the cost of delivering COVID-19 vaccines in Vietnam.

METHODOLOGY

This was a retrospective, bottom-up costing study that estimated the financial and economic costs incurred by Vietnam's public health system to deliver C19 vaccines in 2021. Costs were estimated for the initial low-volume period from March to June 2021, as well as the high-volume period that started in July 2021 when eligibility for C19 vaccines was expanded to the general population. The study was conducted from the payer perspective, including costs incurred by the health service providers, the NIHE, and development partners, at all levels of the health system. Data was collected retrospectively in April-May 2022 from a purposively selected sample of 26 vaccination sites within six districts and two provinces (Hanoi and Dak Lak), as well as from the regional and national level Institute for Hygiene and Epidemiology and from development partners. The sample included facility-based sites as well as temporary sites. Costs were disaggregated across program activities and resource types to analyze cost drivers. Volume-weighted average unit costs were estimated through vertical aggregation, first obtaining a total delivery cost per dose for each immunization site including costs incurred at all levels, and then estimating the weighted average across sites with the bootstrap method. A qualitative assessment was also conducted to identify operational challenges and enabling factors in the implementation of the vaccination effort, as well as better understand financial and non-financial support provided by partners and donors and help contextualize cost findings.

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**

IMPLEMENTATION OF THE C19 VACCINATION PROGRAM IN VIETNAM

On March 8th, 2021, Vietnam launched its national C19 vaccination program, delivering C19 vaccine doses to frontline and essential workers—including healthcare workers, transport workers, teachers, prioritized government officials and the military—as well as elderly and chronic disease patients. After four months of implementation, the vaccination effort scaled up significantly in July 2021, when the target population was expanded to everyone aged 18 and older. The aim was to vaccinate 75 million people—approximately 76% of the country's total population—with 150 million doses by early 2022. In October 2021, the target population was further expanded to everyone over 12 years of age. By the end of 2021, Vietnam had exceeded its vaccination goals, with a total of 155,350,100 doses delivered, over 77 million people (78% of the country's population) vaccinated with one dose and over 69 million people having received at least two doses of the vaccine.

The C19 vaccination program in Vietnam was organized in rounds, with each national-level round corresponding to the arrival of one vaccine lot in the country. A total of 112 rounds were implemented at the national level in 2021. Vietnam deployed two vaccination strategies to deliver C19 vaccines, facility-based and temporary site delivery, and exclusively relied on its existing health workforce and volunteers. Funding for the C19 vaccination program followed the same funding flows that finance the national expanded immunization program, with additional support from WHO and UNICEF, as well as domestic donations by private citizen and organizations. Overall, additional funding for the C19 vaccination program was very limited, while financial regulations posed barriers to mobilizing additional resources at district level, and funding to compensate staff for their participation in C19 vaccinations was perceived to be inadequate given the significant additional burden.

ENABLING FACTORS IN THE IMPLEMENTATION OF THE C19 VACCINATION PROGRAM

- An effective multisectoral collaboration and health workers' commitment to reach the vaccination targets proved essential for the successful implementation of the C19 vaccination program.
- Vietnam leveraged technology to reduce the training-related burden on health workers and existing community structures to generate demand for the vaccines.
- Lockdowns implemented to slow the spread of the disease helped the vaccination program by facilitating social mobilization and microplanning efforts and increasing the pool of available volunteers.
- Initial vaccine hesitancy was quickly and effectively addressed through strengthened social mobilization and advocacy.

CHALLENGES FACTORS IN THE IMPLEMENTATION OF THE C19 VACCINATION PROGRAM

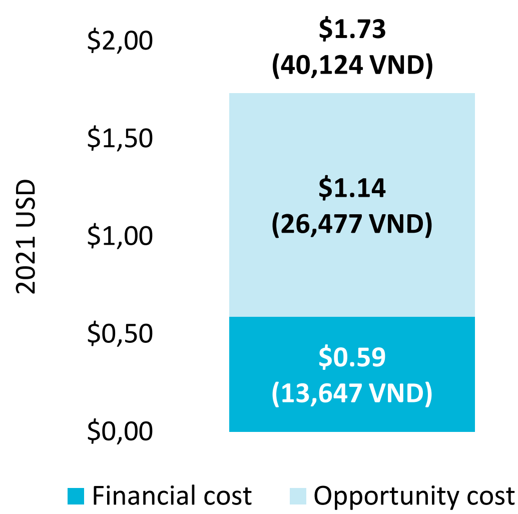
- Health workers faced long working hours with high pressure to perform, little to no time off, and for an extended period of time. This was due to:
  - The very high number of trainings held for health workers;
  - The unpredictability and high frequency of vaccination rounds, which led to inefficiencies in planning and vaccine distribution;
  - Collaboration across multiple entities, which was required to ensure smooth implementation, but further increased the workload;
  - Social distancing regulations, which increased the workload at temporary sites;
  - A new record-keeping software and a daily data reporting and verification process, which contributed to additional overtime at all administrative levels;
  - Limited cold chain capacity and lack of ultra-cold chain equipment at lower levels, which put more pressure on health workers to deliver vaccines quickly;
  - A shortage of adequate vehicles and cold boxes, which made transporting vaccines less efficient and further increase health workers' workload.

- Inconsistent and at times insufficient vaccine supply put vaccinators in the difficult position of selecting who would get the vaccine and who would not.

- Once lockdowns were lifted, health workers reported increased challenges in planning due to the sudden mobility of residents.

COST OF DELIVERING C19 VACCINES

The financial cost of delivering C19 vaccines in Vietnam in 2021 was $0.59 (13,656 VND) per dose, with injection incentives for vaccination team members representing the largest cost driver (44% of the cost per dose), followed by immunization supplies (39%). The economic delivery costs were much higher ($1.73 or 40,041 VND) per dose), due to the significant opportunity cost of labor, which made up 64% of the total cost per dose. Other opportunity costs, such as those related to existing cold chain equipment and vehicles, represented only 2% of the economic cost per dose.



The financial cost per dose is much lower than predicted by COVAX's modeled estimates ($0.73-1.85 or 16,896-42,818 VND), and also lower than the cost of delivering other vaccines estimated in previous costing studies done in Vietnam (ranging between $2.17 to $4.93 or 50,225-114,105 VND for the delivery of TT and Td vaccines, and $2.75 to $2.98 or 63,649-68,972 VND for HPV vaccines). The low financial cost found in this study reflects shortages in funding that the C19 program had to work around. The economic costs were higher, reflecting the heavy burden on the existing health system.

Our cost analysis also found that the financial delivery cost per dose through temporary sites were only 15% lower than for facility-based delivery, even though temporary sites delivered up to 3x as many doses. The economic cost per dose was even higher at temporary sites than at facilities ($1.78 vs. $1.63 or 41,198 vs. 37,726 VND), suggesting that while temporary sites were effective at vaccinating many people in a short period of time, they were very labor intensive, and their use may not be sustainable in the long run. We saw that the delivery cost per dose dropped significantly when delivery volume was scaled up, from $5.24 (or 121,280 VND) in the low-volume period to $1.65 (or 38,189 VND) in the high-volume period.

Although injection incentives were the biggest financial cost driver, amounting to $0.26 per dose delivered, staff largely considered them to be insufficient. Based on the feedback from NIHE and TIHE expert as well as based on findings from the qualitative interviews, we designed three scenarios that outline alternative compensations schemes that could have been implemented if additional funding was available to compensate staff. The scenarios—which tested the impact on cost of removing the daily cap on the incentive scheme, as well as expanding the scheme to include microplanning and record-keeping staff, led to an increase in the economic cost per dose of 32% to 92%.

KEY TAKEAWAYS

- While development partners donated over $12.6 million for the C19 vaccination program in 2021, funding still fell short. The low financial cost reported in this study masks shortages in staffing and other resources that the C19 vaccination program had to work around.
- Limited investments to expand capacity ahead of the roll-out resulted in inefficient vaccine distribution practices, greater recurrent costs, and heavy reliance on existing resources. This placed a significant burden on health workers, and caused disruptions to the delivery of other health services, the cost of which is not quantified in our study.
- Delivery through temporary sites was very labor-intensive and costly, even during high-volume periods, showing that while this strategy was effective at vaccinating the target population quickly, it cannot be sustainably employed in the long-term.

TÓM TẮT NGHIÊN CỨU

Ước tính chi phí tiêm chủng vắc xin C19 tại các quốc gia có thu nhập trung bình và thấp

Nghiên cứu này là một phần thuộc dự án đa quốc gia, cùng sử dụng những phương pháp ước tính tiêu chuẩn nhằm cung cấp các bằng chứng về chi phí tiêm chủng vắc xin C19 tại các quốc gia có thu nhập trung bình và thấp. Dự án này được thực hiện bởi Viện ThinkWell, với sự tài trợ từ Quỹ Bill & Melinda Gates, thực hiện tại Bờ Biển Ngà, Cộng Hòa Dân chủ Công-gô, Mozambique, Uganda, Việt Nam, Băng-la-đét và Phi-líp-pin.

Để biết thêm thông tin về dự án, vui lòng truy cập:

https://immunizationeconomics.org/covid19-vaccine-delivery-costing

GIỚI THIỆU CHUNG

Chiến dịch tiêm chủng vắc xin phòng COVID-19 (C19) đã đặt ra những thách thức chưa từng có, với khối lượng tiêm chủng lớn và nhiều nhóm đối tượng đích. Đại dịch C19 đã gây ảnh hưởng nặng nề tới nền kinh tế của nước ta và việc sử dụng tối ưu những nguồn lực hạn hẹp trong khoảng thời gian này là vô cùng cần thiết. Tuy nhiên, những bằng chứng về chi phí tiêm chủng của chiến dịch này còn hạn chế. Do đó, nhằm cung cấp thêm bằng chứng hỗ trợ chính phủ và nhà hoạch định chính sách trong việc lên kế hoạch và dự trù kinh phí cho chiến dịch tiêm chủng vắc xin C19, Trường Đại học Y tế công cộng đã phối hợp cùng Viện ThinkWell triển khai nghiên cứu ước tính chi phí tiêm chủng vắc xin phòng C19 tại Việt Nam.

PHƯƠNG PHÁP NGHIÊN CỨU

Nghiên cứu phân tích chi phí được thực hiện với phương pháp tính từ dưới lên (bottom-up) sử dụng số liệu hồi cứu. Nghiên cứu ước tính chi phí tiêm chủng vắc xin C19 bao gồm chi phí tài chính (financial cost) và chi phí kinh tế (economic cost) phát sinh trong hệ thống y tế công tại Việt Nam. Các chi phí được ước tính cho giai đoạn khối lượng tiêm chủng thấp, từ tháng 03 tới tháng 06 năm 2021, và giai đoạn khối lượng tiêm chủng cao khi đối tượng đích cho chiến dịch được mở rộng tới tất cả người trưởng thành trên 18 tuổi tại Việt Nam, từ tháng 07 tới hết tháng 12 năm 2021. Nghiên cứu được thực hiện với quan điểm của cơ quan chi trả (payer perspective), bao gồm tất cả các chi phí phát sinh từ cơ sở cung cấp dịch vụ y tế, Viện Vệ sinh dịch tễ Trung ương (VSDTTW/NIHE), và các đối tác phát triển, tại tất cả các cấp quản lý và triển khai. Thu thập số liệu được thực hiện từ tháng 04-05/2021, bao gồm 26 điểm tiêm từ 06 quận/huyện (Hà Nội và Đắk Lắk); và các cấp quản lý cấp quốc gia và khu vực như Viện VSDTTW, Viện VSDT Tây Nguyên (TIHE), và các đối tác phát triển (WHO, UNICEF). Các địa điểm tiêm chủng được lựa chọn trong nghiên cứu bao gồm các điểm tiêm cố định và điểm tiêm lưu động. Chi phí được phân tích theo từng hoạt động tiêm chủng và loại nguồn lực, nhằm xác định các yếu tố gia tăng chi phí tiêm chủng. Chi phí đơn vị trung bình dựa trên khối lượng tiêm chủng (volume-weighted average) được ước tính bởi phương pháp cộng dồn dọc (vertical aggregation) nhằm tính toán chi phí phát sinh tại tất cả các cấp, sau đó, chi phí theo tỉ trọng được tính trung bình thông qua phương pháp bootstrap. Phỏng vấn định tính với các cán bộ đầu mối về tiêm chủng tại các cơ sở y tế cũng được thực hiện nhằm xác định những thuận lợi và thách thức trong triển khai chiến dịch tiêm chủng C19, đồng thời, tìm hiểu rõ hơn những hỗ trợ tài chính và phi tài chính tới từ những đối tác và người ủng hộ, từ đó, đưa ra những kết luận phù hợp về kết quả nghiên cứu.

CHIẾN DỊCH TIÊM CHỦNG C19 TẠI VIỆT NAM

Bắt đầu từ ngày 05 tháng 03 năm 2021, Việt Nam triển khai chiến dịch tiêm chủng vắc xin phòng C19, và những liều vắc xin phòng C19 đầu tiên đã được tiêm cho những nhóm đối tượng ưu tiên, trong đó bao gồm lực lượng tuyến đầu phòng chống dịch (y tế, công an, quân đội, v.v..), người cung cấp các dịch vụ thiết yếu, người lớn tuổi có các bệnh lý nền, người có nguy cơ mắc cao. Sau 4 tháng triển khai, vào tháng 07 năm 2021, Bộ Y tế phát động chiến dịch tiêm chủng C19 trên toàn quốc, mở rộng nhóm đối tượng triển khai, với mục tiêu thực hiện 150 triệu liều vắc xin tới 75 triệu người trưởng thành tại Việt Nam. Tháng 10 năm 2021, nhóm đối tượng triển khai tiếp tục được mở rộng tới những người từ 12-17 tuổi. Tính tới cuối năm 2021, Việt Nam đã hoàn thành vượt chỉ tiêu đề ra khi phát động chiến dịch với kết quả tiêm được 155,350,100 liều vắc xin, với trên 77 triệu người được tiêm tối thiểu 1 liều và 69 triệu người được tiêm tối thiểu 2 liều vắc xin.

Chiến dịch tiêm chủng vắc xin C19 tại Việt Nam được tổ chức theo từng đợt tương ứng với mỗi lô vắc xin về tới Việt Nam. Trong năm 2021, tổng số 112 đợt tiêm được thực hiện. Chiến dịch được tổ chức dưới hai hình thức tiêm chủng là điểm tiêm cố định và tiêm lưu động, toàn bộ sử dụng nguồn nhân lực y tế và tình nguyện sẵn có.

Tính tới cuối năm 2021, Việt Nam đã hoàn thành vượt chỉ tiêu đề ra khi phát động chiến dịch với kết quả tiêm được 155,350,100 liều vắc xin, với trên 77 triệu người được tiêm tối thiểu 1 liều và 69 triệu người được tiêm tối thiểu 2 liều vắc xin.

Nguồn kinh phí sử dụng trong chiến dịch tiêm chủng C19 trong năm 2021 chủ yếu dựa trên nguồn lực sẵn có của Trung ương phân bổ cho CTTCMR, đồng thời, Chiến dịch tiêm chủng C19 cũng nhận được nhiều khoản đóng góp, tài trợ đến từ những đối tác phát triển quốc tế (vd: WHO, UNICEF) và từ những cá nhân, tổ chức trong nước. Nhìn chung, nguồn kinh phí dành cho chiến dịch tiêm chủng vắc xin phòng C19 còn hạn chế, đồng thời, những cơ chế tài chính hiện thời cũng tạo ra những rào cản trong khả năng huy động nguồn lực tại cấp quận/huyện và quy định về chi trả công tiêm cũng được cho là chưa đủ so với khối lượng công việc được thực hiện của cán bộ y tế.

NHỮNG THUẬN LỢI TRONG TRIỂN KHAI CỦA CHIẾN DỊCH

- Sự phối hợp hiệu quả và chặt chẽ giữa các bộ, ngành và sự quyết tâm của đội ngũ cán bộ y tế là yếu tố then chốt tạo nên sự thành công của chiến dịch.

- Việt Nam đã tận dụng công nghệ thông tin nhằm giảm thiểu gánh nặng liên quan tới tập huấn cho cán bộ y tế cũng như thiết lập cộng đồng để truyền thông và vận động người dân.

- Giãn cách xã hội trong thời gian dịch diễn biến phức tạp đem lại lợi ích cho việc triển khai của chiến dịch đối với những hoạt động vận động người dân, lập danh sách tiêm chủng cũng như lực lượng tình nguyện lớn hơn.

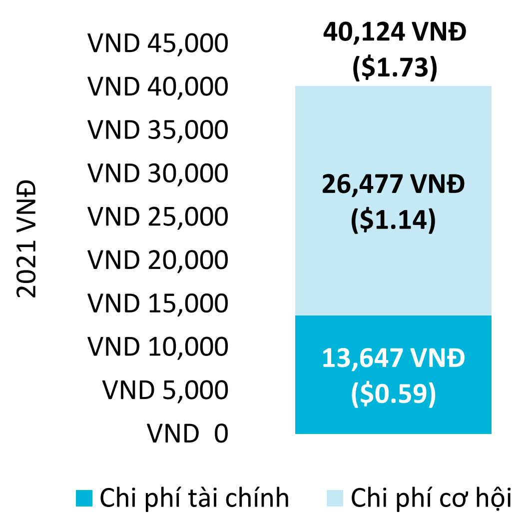
- Sự chần chừ trong việc tiêm vắc xin của người dân nhanh chóng được khắc phục thông qua những thông điệp vận động và tuyên truyền.

NHỮNG THÁCH THỨC TRONG TRIỂN KHAI CỦA CHIẾN DỊCH

- Cán bộ y tế phải đối mặt với thời gian làm việc dài và áp lực lớn, gần như không có thời gian nghỉ, trong một khoảng thời gian dài. Những lí do dẫn tới tình trạng này:
  - Số lượng buổi tập huấn nhiều
  - Các đợt vắc xin được phân bố bất ngờ và liên tục, gây khó khăn trong việc lên kế hoạch đợt tiêm và phân bổ/tiếp nhận vắc xin.
  - Sự phối hợp của các đơn vị đa ngành yêu cầu các bên làm việc nhiều hơn để triển khai được thuận lợi.
  - Quy định giãn cách xã hội yêu cầu cán bộ y tế phải làm việc nhiều hơn để tổ chức những điểm tiêm lưu động.
  - Báo cáo tiến độ tiêm hàng ngày, sử dụng phần mềm quản lý thông tin và các quy trình xác minh thông tin đã gia tăng áp lực làm việc tới tất cả các cấp quản lý và triển khai chiến dịch.
  - Thiếu hụt trang thiết bị dây truyền lạnh và tủ lạnh âm sâu ở các cấp dưới tạo nên áp lực phải sử dụng vắc xin hết nhanh nhất có thể.
  - Thiếu hụt về hòm lạnh và phương tiện vận chuyển phù hợp cũng gây nhiều khó khăn, kèo dài thời gian để tiếp nhận và vận chuyển vắc xin của CBYT.
- Nguồn cung ứng vắc xin không ổn định gây nên những khó khăn trong việc lựa chọn đối tượng tiêm
- Sau khi những quy đinh về giãn cách xã hội được chấm dứt, biến động dân cư cũng tạo nên khó khăn trong việc lên kế hoạch tiêm.

ƯỚC TÍNH CHI PHÍ TIÊM CHỦNG C19 TẠI VIỆT NAM TRONG NĂM 2021

Chi phí tài chính tiêm chủng vắc xin C19 tại Việt Nam trong năm 2021 là 13,656 VNĐ ($0.59) trên một mũi tiêm, trong đó, chi phí công tiêm cho đội tiêm chiếm 44% tổng chi phí mũi tiêm, tiếp đến là chi phí vật tư tiêm chủng (39% tổng chi phí). Chi phí kinh tế tiêm chủng lên tới 40,041 VNĐ ($1.73) trên một mũi tiêm, do phần lớn là chi phí cơ hội của nguồn nhân lực sẵn có, chiếm tới 64% tổng chi phí kinh tế. Những chi phí cơ hội khác có thể kể đến như dây chuyền lạnh và phương tiên đi lại có sẵn, chỉ chiếm khoảng 2% tổng chi phí kinh tế của mũi tiêm.



Kết quả ước tính chi phí tài chính trong tiêm chủng một mũi vắc xin trong nghiên cứu này thấp hơn nhiều so với kết quả được ước tính trong mô hình của COVAX (16,896 – 42,818 VNĐ, hay $0.73-1.85), đồng thời, kết quả nghiên cứu cũng thấp hơn những so với những nghiên cứu phân tích chi phí đã được thực hiện trước đây tại Việt Nam (từ 50,225 – 114,105 VNĐ, hay $2.17 - $4.93, trong tiêm chủng vắc xin Tt/Td và 63,649-68,972 VNĐ, hay $2.75-$2.98, trong tiêm chủng vắc xin HPV). Chi phí tài chính thấp phản ánh sự thiếu hụt kinh phí, và chiến dịch tiêm chủng phải tận dụng những sẵn có là chủ yếu. Ngoài ra, chi phí kinh tế cao cũng đồng nghĩa với việc chiến dịch tiêm chủng cũng đã tạo một áp lực lớn lên hệ thống y tế tại Việt Nam.

Kết quả nghiên cứu cũng chỉ ra rằng, chi phí tài chính khi tiêm chủng tại các điểm tiêm lưu động thấp hơn 15% so với những điểm tiêm cố định, mặc dù, tại các điểm tiêm lưu động, khối lượng tiêm chủng nhiều gấp 3 lần. Tuy nhiên, tổng chi phí kinh tế khi tiêm chủng trên một mũi tiêm tại các điểm lưu động lại cao hơn tại các điểm cố định (41,198 so với 37,726 VNĐ hay $1.78 so với $1.63). Điều này gợi ý rằng, mặc dù điểm tiêm lưu động hoạt động rất hiệu quả và có thể thực hiện khối lượng tiêm lớn, tuy nhiên, việc tổ chức những địa điểm tiêm này cần nguồn nhân lực rất lớn, và có thể không phải là một phương án triển khai bền vững trong dài hạn. Nhóm nghiên cứu cũng nhận thấy chi phí tiêm chủng giảm đi đáng kể khi khối lượng tiêm chủng tăng cao, giảm từ 121,280 VNĐ/mũi tiêm (hay $5.24) trong giai đoạn khối lượng tiêm chủng thấp xuống còn 38,189 VNĐ/mũi (hay $.165) trong giai đoạn khối lượng tiêm chủng lớn.

Mặc dù tiền thanh toán công tiêm chiếm phần lớn chi phí tài chính, khoảng 6,017 VNĐ ($0.26) trên một mũi tiêm, tuy nhiên, CBYT tham gia chiến dịch cho rằng khoản thanh toán này là quá thấp. Dựa trên ý kiến đóng góp từ Viện VSDTTW và Viện VSDTTN trong buổi họp tham vấn ý kiến chuyên gia, cũng như những câu trả lời phỏng vấn định tính từ CBYT trong quá trình thu thập số liệu, nhóm nghiên cứu đã thiết kế 03 kịch bản cơ chế thanh toán công tiêm khác nhau, từ đó ước tính chi phí tiêm chủng nếu có nhiều kinh phí hơn để thanh toán cho CBYT. Kết quả phân tích kịch bản khi thay đổi cơ chế thanh toán, loại bỏ hạn mức công tiêm tối đa một ngày, cũng như áp dụng cơ chế thanh toán cho cả những cán bộ lập danh sách và nhập số liệu, báo cáo, tổng chi phí kinh tế trên một mũi tiêm tăng từ 32% tới 92%.

KẾT LUẬN

- Mặc dù trong năm 2021 ghi nhận $12.6 triệu hỗ trợ từ các đối tác phát triển cho chiến dịch tiêm chủng vắc xin C19, kinh phí thực hiện dường như vẫn còn rất hạn chế. Ước tính chi phí tài chính từ nghiên cứu thấp, phản ánh thực tế thiếu hụt các nguồn nhân lực mới cũng như các nguồn lực khác. Trong bối cảnh đó, chiến dịch tiêm chủng C19 đã phải xoay sở và tận dụng những gì sẵn có.

- Thiếu hụt các khoản đầu tư về trang thiết bị, khả năng dây chuyền lạnh đã dẫn tới thực trạng lưu trữ, vận chuyển và phân bổ vắc xin chưa tối ưu hóa, khiến chi phí tăng cao do phụ thuộc nhiều vào cơ sở vật chất và nguồn lực hiện có. Vấn đề này đã dẫn tới tình trạng làm việc quá tải, áp lực công việc tới các CBYT, cũng như sự gián đoạn trong cung cấp các dịch vụ y tế khác, nhưng chưa được tính toán trong nghiên cứu này.

- Tiêm chủng thông qua các điểm tiêm lưu động rất tốn kém và yêu cầu nguồn nhân lực lớn, ngay cả khi khối lượng tiêm chủng lớn, từ đó có thể thấy đây là một phương án triển khai hiệu quả khi cần thực hiện rất nhanh một khối lượng tiêm chủng lớn, tuy nhiên, không thể được duy trì trong thời gian dài.

INTRODUCTION

To support the government in planning and budgeting for the COVID-19 vaccination program, Hanoi University of Public Health and ThinkWell conducted a study to estimate the cost of delivering COVID-19 vaccines in Vietnam. 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 address this knowledge gap and support Vietnam's planning and budgeting for the future of its C19 vaccination program, Hanoi University of Public Health (HUPH) and ThinkWell conducted a study to estimate the cost of delivering C19 vaccines in Vietnam in 2021. This study estimates the cost of delivering C19 vaccines through facility-based delivery and at temporary vaccination sites, in different geographic areas—urban and peri-urban districts in Hanoi and remote districts in Dak Lak—and at different levels of delivery volume. It also illustrates the vaccination delivery process, maps key program funding flows, and explores challenges and lessons learned from implementation of the vaccination effort.

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 Vietnam, Bangladesh, and the Philippines in Asia, and Mozambique, Côte d'Ivoire, the Democratic Republic of Congo, and Uganda in Africa.

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

STUDY OBJECTIVES AND METHODOLOGY

RATIONALE & OBJECTIVES

The C19 pandemic underscored the need for cost evidence on the delivery of C19 vaccines to inform an efficient allocation of available resources for health in Vietnam. In a context of pre-existing resource scarcity, the C19 pandemic's negative impact on the economy reduced available resources, while putting a tremendous burden on the health system. For this reason, evidence-based decision making became even more important to ensure optimal use of existing resources for health. However, the actual cost of delivering C19 vaccines in Vietnam is unknown. This study provides cost evidence to enable policymakers to make crucial data-informed allocation decisions.

The primary objective of this study is to estimate the cost of delivering C19 vaccines in Vietnam. The specific objectives of the study are to:

- Estimate the average cost per dose of delivering C19 vaccines in Vietnam in 2021, including through different delivery strategies, in different geographic areas, and at different levels of delivery volume;
- Map key funding sources against the different C19 vaccination program activities;
- Describe how the vaccination effort was implemented, and identify operational challenges and lessons learned.

STUDY DESIGN

This was a retrospective, bottom-up costing study that estimated the financial and economic costs of delivering C19 vaccines through Vietnam's public health system in 2021. This study estimated vaccine delivery costs, defined as the costs associated with delivering immunizations to target populations, including vaccine administration and safety supplies, but exclusive of vaccine costs. We collected costs incurred in 2021 in relation to the C19 vaccination program using a bottom-up (or ingredients-based) costing approach, complemented with the review of financial expenditure reports and budgets to fill data gaps when needed. Program-related activities (defined in Table 6 in **Annex 1**) at each administrative level were costed by measuring the quantity of the inputs (defined in Table 7 in **Annex 1**) used to implement these activities, which were then multiplied by the price of each of these inputs. We captured both the additional resources used to implement the C19 vaccination program—such as new cold chain equipment (CCE) investments, per diems, supplies and fuel—as well as an estimation of the use of existing resources—such as the cost of using existing capital items and a share of routine government health worker salaries.

The study estimates the cost for the initial low-volume period, as well as the high-volume period that started in July 2021 when eligibility for C19 vaccination was expanded to the general population, and the vaccination effort scaled up significantly. We defined the low-volume delivery period as starting with the first C19 vaccination rounds and ending when the target population was expanded to everyone above 18 years old (March to June 2021). This period was characterized by a more limited vaccine supply and a smaller target population and includes the first 5 vaccination rounds for a total of 3,593,970 doses delivered. We defined the high-volume delivery period as starting when the target population was expanded to the general population until the end of the study period (July to December 2021). The high-volume period encompasses the start of temporary site vaccinations, including 107 vaccination rounds with a total of 151,756,130 doses delivered. Our study also captured costs related to vaccine procurement, planning, social mobilization, training, and other start-up activities that took place in early March 2021 before the first vaccines were delivered.

A scenario analysis was conducted to estimate the vaccine delivery cost if additional funding was available to compensate staff for their participation in the vaccination effort. Following recommendations from immunization experts at the National Institute for Hygiene and Epidemiology (NIHE)—which is the institute that manages the national immunization program—and Tay Nguyen Institute of Hygiene and Epidemiology (TIHE)—a regional office of the NIHE situated in Dak Lak—we estimated additional delivery costs associated with three different compensation schemes for vaccination team members and other staff involved in the vaccination effort. Assumptions for each scenario were based on in-depth interviews with staff involved in the vaccination program and discussion from an expert meeting with NIHE and TIHE experts.

The study was conducted from the payer perspective, including costs incurred by the health service providers, the NIHE, and development partners, at all levels of the health system. At the national level, we included costs incurred by the NIHE and the TIHE, as well as from two key partner organizations, the United Nations

Children's Fund (UNICEF), and the World Health Organization (WHO). At lower levels, we included costs incurred at provincial Centers for Disease Control (CDC), at district health offices, and at vaccine delivery sites. We excluded costs incurred by the Ministry of National Defence, which contributed significantly to vaccine storage and distribution activities, as the cost data incurred by this ministry could not be obtained by the research team due to confidentiality. At implementation level, contributions from all entities, public and private, were channeled through vaccination sites, and therefore fully captured by our study. At national level, contributions that were not channeled through the Ministry of Health were not captured. As these were largely small and one-off in nature, we are confident that their exclusion does not significantly affect our results.

The costing study was complemented by a qualitative assessment to analyze the operational and financial challenges that government officials and health staff encountered during the implementation of the C19 vaccination program, and to map funding flows. We conducted qualitative interviews with officials at the national, provincial, and district levels and with health staff at implementation level. The interviews were meant to obtain a better understanding of the implementation of the C19 vaccination program, and identify challenges and lessons learned, as well as to map funding sources and flows for the C19 vaccination program at all administrative levels and, where possible, identify how specific program activities were funded.

The study was designed and conducted in collaboration with the NIHE. The study team sought and obtained support and feedback from the NIHE throughout the implementation of this study. At the beginning, the research team shared the study protocol with experts at the NIHE and organized a kickoff meeting to discuss the study methods and approach. Once the study had been endorsed, the study team collaborated with the NIHE to define the study sample. On April 11th, 2023, the study team held a meeting in Hanoi to present preliminary findings and seek validation from national and provincial level vaccination experts. The meeting included experts from the NIHE and TIHE, health economists and researchers from Hanoi University of Public Health, Hanoi University of Pharmacy, and other research institutes. The preliminary findings presented at the meeting were positively received by participants. Additional information about the organization of the C19 vaccination program shared during the meeting, as well as suggestions to explore the impact on the unit cost of potential changes to health worker's compensation scheme were incorporated into the analysis following this validation meeting and are presented in this report.

The methods for this study went through the Hanoi University of Public Health ethical review process. The study protocol was approved by the Institutional Review Board at Hanoi University of Public Health on March 11th, 2022. The approval application number was No. 022-064/DD-YTCC.

SAMPLING

Our sample includes 26 vaccination sites, in the provinces of Hanoi and Dak Lak, as well as all relevant district, provincial, regional and national level offices, and two development partner organizations. Four-stage purposive sampling was employed to select study sites from all levels of the health system. In collaboration with the NIHE, we selected two provinces: the predominantly urban province of Hanoi—located in the north of the country—and the rural province of Dak Lak, situated in the central highlands region. A total of 6 districts were selected across the two provinces, 2 urban and 2 peri-urban districts in Hanoi, and 2 remote districts in Dak Lak. The sample was mainly drawn from the Hanoi province, to shorten overall data collection time and comply with C19 travel restrictions. We then sampled one commune in the remote districts, two communes in the urban districts, and three communes in the peri-urban districts, and collected data from all vaccination sites in each sampled commune. Vaccination sites included both health facilities (commune health centers and district health centers) and temporary sites. A total of 38 study sites, including 26 vaccination sites and 12 government offices across all administrative levels were included in the study, as described in Table 1 below. The two main national-level development partner organizations—WHO and UNICEF—were also included in the study. The interviews for the qualitative assessment were conducted at a subset of sites, for a total of 16 in-depth staff from study sites at all levels.

Table 1. Study sample

Level		Number of sites			Sampled sites - cost data	Sampled sites - qualitative data
Administrative sites	National/Regional	4			4	4
	Provincial	2			2	2
	District	Urban (n=2)	Peri-urban (n=2)	Remote (n=2)	6	6
Subtotal					**12**	**12**
Vaccination sites	Communes	Urban (n=4)	Peri-urban (n=6)	Remote (n=2)	10	4
	Facility-based sites	5	8	1	14	
	Temporary sites	4	6	2	12	
Subtotal					**26**	**4**
Grand total					**38**	**16**

DATA COLLECTION

Data for both the costing and the qualitative assessment were collected through in-person interviews at all sites, between April and May 2022 from vaccination sites and government entities, and in August-September 2022 from development partners. After a 1-day data collectors' training, a team of four researchers was deployed to conduct in-person interviews at all government sites. The cost data was collected using a tool developed by the research team in Microsoft Excel. The tool was piloted before data collection and updated as needed during the data collection. During the same data collection visits, researchers also administered an open-ended semi-structured questionnaire to collect qualitative data from a subset of sites. For the qualitative component, the research team interviewed the C19 vaccine program focal point at all levels, except at implementation level where the health facility manager was interviewed if available. The interviews were recorded and transcribed in Vietnamese. Detailed notes were taken by the interviewer when respondents did not consent to being recorded. The transcripts were reviewed, synthesized, and translated into English by the research team. Two representatives from national-level development partner organizations (WHO and UNICEF) were also interviewed in person in Hanoi.

Cost data were collected from financial records as well as from interviews with health staff. Financial expenditure reports for 2021 were the main data source for injection incentives, fuel expenditures, some printing expenditures, and to obtain the annual salaries and benefits of health staff involved in the vaccination program. Inventory records were used to obtain acquisition cost and year, as well as brand and model for vehicles, cold chain equipment, and other equipment used for the C19 vaccination program. Publicly available tender prices for vaccine administration and safety supplies were used as a source to obtain the price of supplies. Information about how health staff spent their time, and on quantities used for resources of which there was no written record, was obtained through detailed interviews with staff.

Data collection was followed by a thorough data validation and cleaning process. After data collection, one researcher reviewed all data sheets to check for completeness and to identify and verify potential outliers (e.g., on data such as hours worked by health staff, purchase costs and acquisition of cold chain equipment and vehicles, quantity of immunization supplies used, etc.). If any issues were identified, the data sheets were reviewed by the data collector who filled in that data sheet, and if needed further verification was conducted directly with the respondent from the relevant study site. If after following up with the respondent some data still could not be obtained, assumptions were made to impute the data from the same site or other sites, as detailed in Table 5 in **Annex 2**.

DATA ANALYSIS

For each site, costs were estimated and allocated to each resource type, program activity, delivery strategy, type of cost (financial or opportunity cost), and by time period. For resources that were shared across the health system, we estimated what proportion of the resource was used for the C19 vaccination program to allocate part of the cost. Similarly, costs for resources shared across immunization sites in the same commune were allocated to each site based on the number of C19 vaccine doses delivered. More detail about all allocation assumptions can be found in **Annex 2.**

All costs are presented in 2021 USD. Costs were converted from Vietnamese Dong (VND) to US Dollars (USD) using a conversion of 1 USD = 23,145 VND (State Bank of Vietnam on 30/12/2021). The depreciation of existing capital items was calculated based on the acquisition year, the acquisition cost, and useful life of the item, using a 3% discount rate. The depreciation cost was converted to 2021 using the consumer price index published by the General Statistics Office of Vietnam.[1] The number of useful life years used for the depreciation calculations was based on guidelines from the Vietnamese Ministry of Finance.[2] For newly acquired equipment, straight-line depreciation was applied.

When comparing our findings to those of other studies, we first converted the other studies' findings into 2021 USD. First, we converted their unit costs back to VND using the exchange rate for the study year, using the conversion rate reported in the study or the World Bank's conversion rate.[3] if not reported. Then, we adjusted for inflation between the study year and 2021, using Vietnam's CPI index by Vietnam GSO, and finally converted back to USD using conversion rate of 23,145 VND = 1 USD.

The full cost per dose for each immunization site was estimated through vertical aggregation. The cost per dose for each study site at each level (implementation, district, provincial, regional, national) was estimated by dividing the total cost incurred at that site by the total number of vaccine doses delivered at the site. Then, the total delivery cost per dose for each immunization site was obtained aggregating vertically: the cost per dose for the implementation site was added together with the cost per dose for the district, province, and region in which the implementation site is located, as well as the national level cost per dose.

The average cost per dose delivered across our sample was estimated with the bootstrap method using STATA 17. The average costs and confidence intervals were estimated based on bootstrap results of 500 runs. The bootstrap was done in STATA 17, using the *bsample* package. More information about the bootstrap methods can be found in **Annex 3**. The variance of the mean cost per dose was then calculated based on the formula for the variance of a ratio, as the cost per dose is equivalent to the ratio between total cost and total volume delivered. The following formula was used to estimate the variance:

$$V\left({}^{X}/_{Y}\right) = E\left({}^{X^2}/_{Y^2}\right) - \left[E\left({}^{X}/_{Y}\right)\right]^2$$

Where X represents the total cost, Y represents the total volume, E is the expected value (mean) and V represents the variance. Confidence intervals were then estimated according to the following formula:

- Lower 95% CI: E(X/Y) - 1.96 * V(X/Y)/square root (number of observations)
- Upper 95% CI: E(X/Y) + 1.96 * V(X/Y)/square root (number of observations)

LIMITATIONS

The cost estimates in this study were drawn from a small sample size. Our study includes a total of 26 immunization sites, located in 6 districts in 2 provinces, out of 63 provinces in the country. While we included sites located in urban, peri-urban, and remote districts to capture the expected variability across different settings, the overall sample size is relatively small, and this limits the generalizability of our results.

Contributions from the military forces could not be included, which means that cost results are underestimated. According to respondents interviewed at national and regional level, Vietnam's military forces may have supported the transportation, distribution, and storage of up to 50% of all C19 vaccine doses delivered during the high-volume period in 2021. As these contributions were deemed to be confidential, the research team could not obtain any data to estimate or impute their magnitude.

The evidence from our study reflects how the C19 vaccination program operated in 2021, which may not be generalizable to the current context of the program. Our study time frame captures all costs related to the C19 vaccination activities that took place in 2021, when the C19 vaccination program was first launched and scaled up significantly, and during which the majority of C19 vaccine doses were delivered. However, the C19 vaccination program underwent significant changes in 2022, including an additional expansion of the target population to everyone over 2 years old and a further integration into the routine immunization program. Therefore, the results of our study might not be an adequate reflection of the current cost structure of the program.

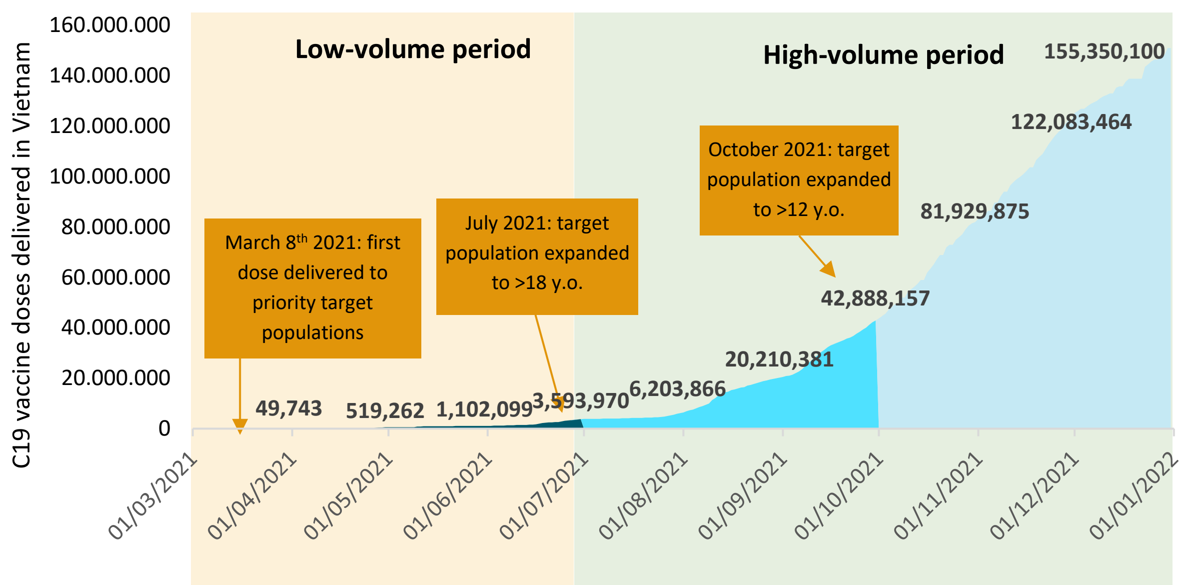
Screening before C19 vaccinations at a health facility in Vietnam.

THE C19 VACCINATION PROGRAM IN VIETNAM

OVERVIEW OF THE C19 VACCINE ROLL-OUT

On March 8th, 2021, Vietnam launched its national C19 vaccination program,[i] initially targeting priority populations, and progressively expanded its target population, reaching 77 million people by the end of 2021. A few days after the Ministry of Health's approval of the national C19 vaccination plan, Vietnam begun delivering C19 vaccine doses to frontline and essential workers—including healthcare workers, transport workers, teachers, prioritized government officials and the military—as well as elderly and chronic disease patients. After four months of implementation, the vaccination effort scaled up significantly in July 2021, when the target population was expanded to everyone aged 18 and older. The aim was to vaccinate 75 million people—approximately 76% of the country's total population—with 150 million doses by early 2022. In October 2021, the target population was further expanded to everyone over 12 years of age. By the end of 2021 Vietnam had exceeded its vaccination goals, with a total of 155,350,100 doses delivered, over 77 million people vaccinated with one dose and over 69 million people having received at least two doses of the vaccine.[4]

Figure 1. C19 vaccine doses delivered in Vietnam in 2021[5]



[i] The Vietnamese C19 vaccination program is referred to as "chiến dịch tiêm chủng", which translates as "vaccination campaign". However, this report uses 'program' to refer to the entire program covering all delivery strategies, to avoid confusion with the term 'campaign' as a delivery strategy distinct from others such as continued facility-based delivery.

MANAGEMENT OF THE C19 VACCINATION PROGRAM

Vietnam's C19 vaccination program was managed and implemented leveraging existing structures and resources established to implement the National Expanded Program on Immunization. Vietnam's National Expanded Program on Immunization (NEPI) was first implemented in 1981, and its Central Office is housed within the National Institute of Hygiene and Epidemiology (NIHE). It manages the delivery of routine childhood vaccinations as well as other vaccines throughout the country, through a layered structure that comprises three regional NEPI offices (the regional level), Departments of Preventive Medicine at each province's Center for Disease Control (the provincial level), District health centers (DHCs, the district level) and commune health centers (CHCs, the service delivery level). To implement the C19 vaccination program, Vietnam leveraged NEPI human resources and structures to implement and manage the vaccination effort, including for vaccine distribution and storage, trainings, record-keeping and reporting, and service delivery.

Table 2. Government entities involved in the C19 vaccination program

Entity	Responsibilities in the C19 vaccination program
Ministry of Health	Approval of policy, protocol, vaccine products, vaccination strategies, vaccination delivery plans, vaccine procurement and distribution plans; coordinating the overall program performance.
NEPI central and regional offices	Technical consultation, overall program management (e.g., development and implementation of guidelines on training, supervision, reporting), vaccine procurement and distribution processes and vaccine quality control.
Provincial CDCs	Managing the implementation of C19 vaccinations at all districts within the province; receiving vaccines from the NEPI national or regional offices, storing and delivering vaccines to lower administrative levels.
District health centers	Managing the implementation of C19 vaccinations at all communes within the district; receiving vaccines from the provincial CDCs, storing and delivering vaccines to commune health centers as well as administering C19 vaccines at the district health center's general clinic.
Commune Health centers	Microplanning, storing and administering vaccines, and reporting on vaccine delivery performance

C19 VACCINE STORAGE AND DISTRIBUTION

Vietnam was quick to approve new C19 vaccine products as soon as they were WHO prequalified, in order to facilitate a speedy roll-out. As of November 2021, a total of nine C19 vaccine products had been approved by Vietnam's Ministry of Health, including some requiring ultra-cold chain (UCC) (Box 1). The approval of multiple vaccine products helped ramp up supply rapidly, however, it also posed challenges in the implementation of the program. Health workers had to work with different storage requirements and vaccine administration protocols, and follow specific guidelines around vaccine product compatibility when administering the second dose.

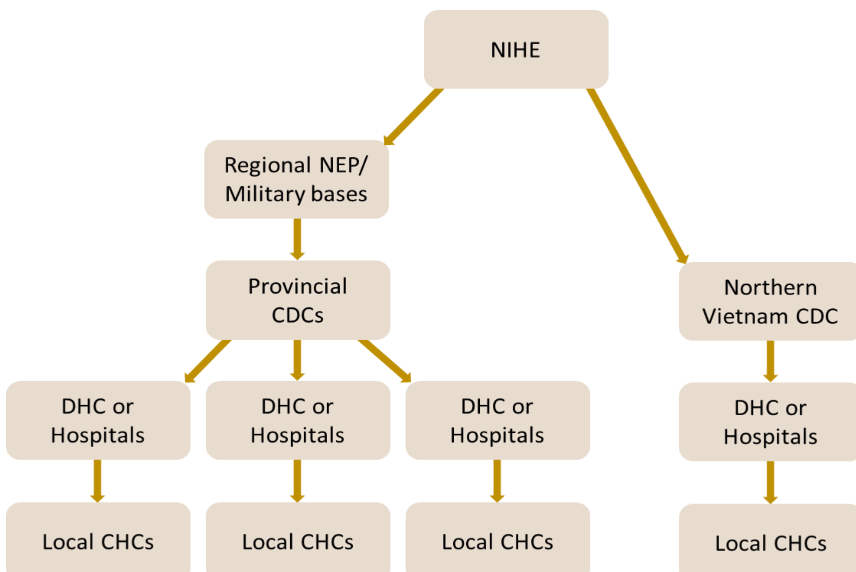
Additionally, the use of vaccines requiring UCC storage meant that UCC capacity had to be expanded at national level, while the lack of UCC at implementation level meant that vaccines had to be delivered quickly after defrosting.

Upon arrival in the country, vaccines were collected and inspected by the NIHE, and then distributed down to lower administrative levels. The NIHE—which is located in Hanoi—would distribute vaccines directly to the provincial CDCs in northern of Vietnam, while for other provinces, vaccines would first be delivered to NEPI regional offices, and then to provincial CDCs. In each province, vaccines would then be delivered to district health centers, or collected by district staff from the provincial CDC cold storage. Commune health centers (CHCs) would then collect vaccines from their district health office on a daily basis and deliver the vaccines within the same day, due to limited storage capacity at health facility level.

Box 1. C19 vaccine products approved for use in Vietnam

- **Covaxin** (of Bharat Biotech Int.)
- **Abdala** (of AICA Laboratories)
- **Hayat-Vax** (of Sinopharm CNBG & G42)
- **Janssen** (of Johnson and Johnson)
- **Spikevax** (of Moderna)
- **Vero-Cell** (of Sinopharm)
- **Comirnaty** (of Pfizer BioNTech)
- **Sputnik-V** (of Gamalaya)
- **A2D1222** (of AstraZeneca)

Figure 2. Vaccine distribution flow



C19 vaccine distribution was supported by the military force of the Ministry of National Defense. The NIHE faced unprecedented challenges in distributing large volumes of vaccines across the country. As part of a cross-sectoral effort to mitigate the impact of the pandemic, the Ministry of National Defense (MoND) supported the NIHE in vaccine transportation, storage, and distribution. The contribution of the MoND was most significant during the high-volume period, however, their support differed significantly across regions and provinces, and its cost could not be evaluated for this study due to data confidentiality. The Director of TIHE estimated that military contributions in the Highlands region—which the TIHE supervises and that includes 5 provinces, Dak Lak among them—may be estimated as a quarter of TIHE's transportation costs, as their support was requested for selected rounds during the high-volume period, and the MoND did not provide any support for vaccine storage. At the national level, the MoND's contributions were more difficult to estimate, as they supported the entire transportation process, from ports/airports to localities, also providing storage for vaccines in intermediate warehouses.

IMPLEMENTATION OF THE C19 VACCINATION ROUNDS

The C19 vaccination program in Vietnam was organized in rounds, with each national-level round corresponding to the arrival of one vaccine lot in the country. Rounds could last from 1 to 15 days, and during the highest volume period, a new round could start while the previous round was still ongoing. Between March and December 2021, a total of 112 rounds were implemented at the national level. At implementation level, vaccination rounds were numbered based on the times a vaccination site was allocated C19 doses, as not all sites were allocated vaccines every time a vaccine lot arrived in the country.

Vietnam deployed two vaccination strategies to deliver C19 vaccines, facility-based and temporary site[ii] delivery. At the start of each round, each vaccination site determined which delivery strategies would be employed, based on the number of people expected to be vaccinated in that round, the number of doses allocated to the site, and the availability of health staff. Facility-based delivery was conducted at district and commune health centers, hospitals, immunization clinics, general health clinics and other facilities that had qualified staff to provide vaccination services. Temporary sites were implemented for large volume vaccination rounds, when the target population was expected to be too large to accommodate them at the premises of the health facility. In some cases, temporary sites were also set up during lower volume rounds when a health facility was too small to accommodate a waiting area complying with social distancing regulations. Examples of temporary sites included schools, office buildings, industrial areas, stadiums, or social centers. Temporary sites were staffed by vaccination teams pooled from several facilities, district and commune health centers. Facility-based immunization sites would usually be staffed by one vaccination team, while temporary sites would normally have more than one team working in parallel.

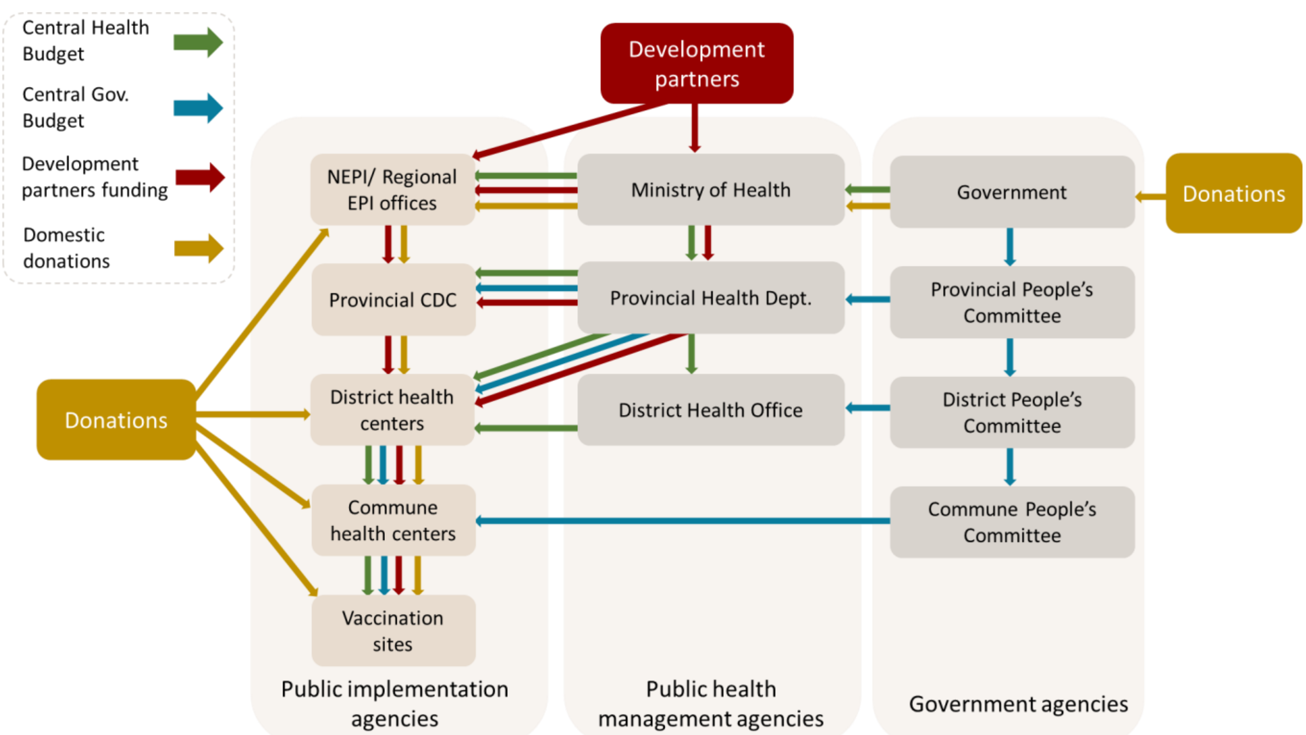
Before the start of each round, communes would estimate the required number of vaccination teams based on the number of vaccine doses to be delivered and available health workers. A standard team would consist of 6 staff: a crowd controller, a welcomer, a screener/advisor (normally a doctor, who would conduct a quick medical consultation and advise beneficiaries on the benefits of the vaccine and potential side effects, as well as provide information on what do to in case of an adverse event), a vaccinator, a data entry officer, and a post-vaccinator monitor. If there were not enough health workers available, welcomers would also work as crowd controllers and post-vaccinator monitors would also work as data entry officers.

[ii] In Vietnamese, these were called "tiêm lưu động" which literally translates to "mobile vaccination site."

FINANCING & IN-KIND DONATIONS FOR THE C19 VACCINATION PROGRAM

Following the same funding flows that finance the NEPI, government funding supported the C19 vaccination program through the central government's budget for health, and through the central government's budget for local governments. The central government's budget for health (as shown by the green arrow in Figure 3) covers core expenses such as health workers' salaries, vaccine procurement, logistics, and for the C19 vaccination program it also covered performance-based injection incentives for vaccination team members. The central government's budget for local governments (the blue arrow in Figure 3) is used by local governments to supplement health expenditures to varying degrees across the country, based on local needs and the availability of funds.[6] For the C19 vaccination program, key contributions financed by local governments' budgets included funding financial incentives for health and support staff who were not eligible to receive injection incentives. Additionally, some implementation sites reported receiving funding from local governments to supplement the central government budget for vaccine transport, trainings, microplanning, social mobilization, waste management, and supervision activities.

Figure 3. C19 vaccination program funding flow (financial and in-kind donations)



WHO and UNICEF were the main development partners to support the C19 vaccination program through financial and in-kind donations, mostly at the national level. Contributions from WHO and UNICEF were used to support the development of guidelines, as well as to finance supervision activities, national level trainings, and social mobilization and advocacy activities. Some of these donations were channeled down to lower administrative levels to support the implementation of sub-national activities, such as microplanning, social mobilization and service delivery. WHO and UNICEF also provided in-kind donations, including vaccines (both through COVAX and by facilitating bilateral donations from foreign governments), immunization supplies, and cold chain equipment. Financial donations were channeled through the Ministry of Health or directly through the NEPI (the red arrow in Figure 3), and in-kind donations of cold chain equipment, vaccines and immunization supplies were delivered to the NIHE. In some cases, in-kind donations from UNICEF were delivered directly to the remote areas where the equipment was needed, and installation support was also provided. In provinces outside our study sample, there may have been other contributions from development partners that are not captured by our study as they were channeled directly to subnational authorities or to non-governmental organizations.

The C19 vaccination program also benefited from domestic donations by private citizens and organizations. Domestic donations were made on an ad-hoc basis to meet the specific needs of C19 vaccination program, such as transport of vaccines by plane, immunization supplies and personal protective equipment, food and drinks for local health staff, and equipment for vaccination sites (such as vaccination trolleys, oxygen tanks, and blood pressure machines). Some domestic donations were centralized through the COVID-19 Fund, created by the government to receive donations from private citizens via bank transfer or text message. The fund was used to support C19 prevention, containment, and treatment activities, and in relation to the C19 vaccination program was used mainly to finance the procurement of vaccines.

Funding to compensate staff for their participation in C19 vaccinations was perceived to be inadequate given the significant additional burden. Vaccination team members received a performance-based injection incentive of approximately $0.30 per dose delivered, capped at a maximum of ~$6.30 per member per day (equivalent of 20 doses/member/day).[7] Other health and support staff that were not members of vaccination teams, such as those preparing the vaccination site ahead of vaccination days, or those that drafted reports on the number of doses delivered, were not eligible for any financial incentives specific to the C19 vaccine roll-out. During the high-volume delivery period, when high pressure and consistently long working hours were reported, the financial incentives received per dose delivered were very low and were perceived by health staff to be insufficient. Additionally, as funding was very limited, these incentives were often only provided to vaccinators. Other staff that provided support before, during and after the vaccination days were often not compensated.

Overall, additional funding for the C19 vaccination program was very limited, while financial regulations posed barriers to mobilizing additional resources at district level. In general, C19 prevention activities such as contact tracing and quarantining were prioritized over vaccination for the additional funding that was available, as containing the spread of the disease was considered a higher priority. Immunization sites in our sample indicated that they had received very limited or no additional funding to implement the C19 vaccination program. As a consequence, there was no funding for large scale recruitment of additional health workers to support the vaccination effort, and only very limited funding to expand cold chain capacity, as well as to hire additional vehicles for vaccine transportation.

Respondents at district level also reported that the resource scarcity was further exacerbated by strict financial regulations, which created barriers to mobilizing additional funds independently or receiving in-kind donations from domestic donors.

Registration for C19 vaccinations at a health facility in Vietnam.

STAFFING AND SERVICE DELIVERY AT THE SAMPLED SITES

On average, each sampled delivery site had 30 vaccination team members, including 9 regular staff and 21 additional staff (Table 3). Among the 21 additional staff recruited at vaccination sites, 14 were paid staff mobilized from other entities, including government agencies or private health facilities, and 7 of them were volunteers. On average, each sampled site had 7 vaccinators, and each vaccinator delivered an average of 53 doses per day, which translates to an average of 18 doses delivered per vaccination team member per day. Across our sample, each C19 vaccine dose delivered was estimated to require 28 person-minutes of labor, as shown in Table 3 below. Additional descriptive statistics about the sampled sites can be found in Table 10 in **Annex 4**.

Table 3. Staffing and service delivery at the sampled sites

	Volume weighted average (rounded)						
	All	Facility-Based	Temp. sites	Hanoi			Dak Lak
				All	Urban	Peri-Urban	All/ Remote
Number of sites	26	14	12	23	9	14	3
Vaccination team members	30	17	43	30	31	29	25
Regular staff	9	10	7	9	11	6	8
Additional staff	21	7	36	22	20	23	17
Mobilized paid staff	14	4	24	14	14	14	12
Volunteers	7	2	12	7	6	9	6
Vaccinators	7	2	13	8	7	9	2
Doses delivered per vaccinator/day	53	57	49	49	52	45	119
Doses delivered per vaccination team member/day	18	26	9	18	16	21	11
Person-minute spent to deliver one dose	28	15	42	29	35	22	22

Temporary sites in our sample had larger vaccination teams and more vaccinators, but delivered fewer doses per vaccinator, and overall utilized more labor for each dose delivered. Most temporary sites were set up during the high-volume period of the vaccination effort to increase delivery capacity. Therefore, on average they had more staff, 43 vaccination team members vs. 17 at facility-based sites, and more vaccinators, an average of 13, compared to 2 vaccinators in facility-based sites in our sample. Temporary sites in our sample also recruited more additional staff than facility-based sites, an average of 36—of which 24 were paid staff from other sites and 12 were volunteers—compared to only 7 additional staff in facility-based sites—4 paid staff and 2 volunteers. However, the delivery capacity per vaccinator at temporary sites was lower than at facility-based sites, with vaccinators delivering on average 49 dose per day at temporary sites compared to 57 doses per day at facility-based sites. Moreover, each dose delivered at temporary sites on average required significantly more labor than doses delivered at facility-based sites, with 42 person-minutes needed for each dose at temporary sites compared to only 15 at facility-based sites. This is partly explained by the additional labor required at temporary sites on a daily basis to set up large waiting areas that complied with social distancing regulations and by the additional staffing required to manage much larger crowds.

Sampled sites in Hanoi had larger vaccination teams, more regular staff, and more additional staff compared to sampled sites in Dak Lak province. Additionally, sites in Hanoi had more vaccinators, an average of 8 compared to only 2 in Dak Lak. Within Hanoi, urban areas had slightly more staff than peri-urban areas (31 vs. 30 vaccination members), but fewer vaccinators (7 in urban areas vs. 9 in peri-urban areas). On average, each vaccinator in Dak Lak delivered more than twice as many doses per day compared to vaccinators in Hanoi (119 doses vs. 49 doses). However, the difference in person-minutes spent on each dose delivered at the two provinces was not as marked, with 29 person-minutes in Hanoi compared to 22 person-minutes in Dak Lak, due to the fact that vaccinators represented a much larger share of the vaccination team in Hanoi. In both provinces, two thirds of the additional staff were paid staff mobilized from other facilities, while the remaining one third were volunteers.

Screening before C19 vaccination at a health facility in Vietnam.

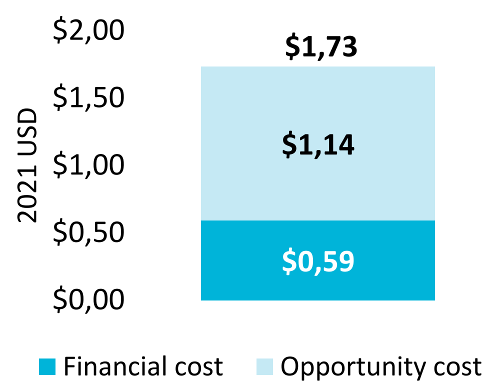
THE COST OF DELIVERING C19 VACCINES

The average economic cost per dose is $1.73, which is less than for the delivery of routine vaccines in Vietnam

We estimated the average economic cost per dose for delivering C19 vaccines to be $1.73, mostly driven by recurrent labor costs. As shown in Figure 4, labor and other opportunity costs represent 66% of the economic cost per dose, or $1.14. Financial costs are $0.59 or 34% of the economic cost per dose. Over 98% of the economic cost per dose were recurrent costs ($1.70), while capital costs represented less than 3% of the cost per dose ($0.04). The share of opportunity cost in our study is similar to that estimated for C19 vaccine delivery in Kenya,[8] while it is significantly higher than estimated for routine HPV vaccine delivery in Vietnam, where the opportunity cost ranged between 19-22% depending on the delivery strategy used.[9] This indicates that when compared to other vaccination programs, the C19 program relied more heavily on existing resources.

These findings show lower costs compared to previous vaccine delivery costing studies done in Vietnam.[iii] According to a previous study on the cost of delivering TT to women of childbearing age (15 to 36 years old), the average economic cost per dose ranged from $2.17 and $2.33 respectively for school-based and facility-based delivery, to $4.93 for outreach.[10] Another study on the cost of delivering HPV vaccines to 10-year-olds in Vietnam found the economic cost per dose ranged from $2.75 (for facility-based delivery) to $2.98 (for school-based delivery).[11]

Figure 4. Economic cost per dose



There is little evidence on the economic cost of delivering C19 vaccines to compare our economic cost per dose to. At the time of publication, this is one of few studies on the cost of delivering C19 vaccines internationally. In a study conducted in Kenya.[12] the authors used an activity-based approach to estimate the incremental cost of introducing C19 vaccines, with different coverage scenarios (30%, 50%, 70% and 100%). Their findings suggest that the economic delivery cost of C19 vaccines in Kenya could range somewhere between $7.17 to $12.22 per person vaccinated with 2 doses (2021 US dollar, respectively for 100% and 30% coverage).

[iii] The cost findings from other studies were adjusted to 2021 USD for this comparison. See 'Data analysis' for more details.

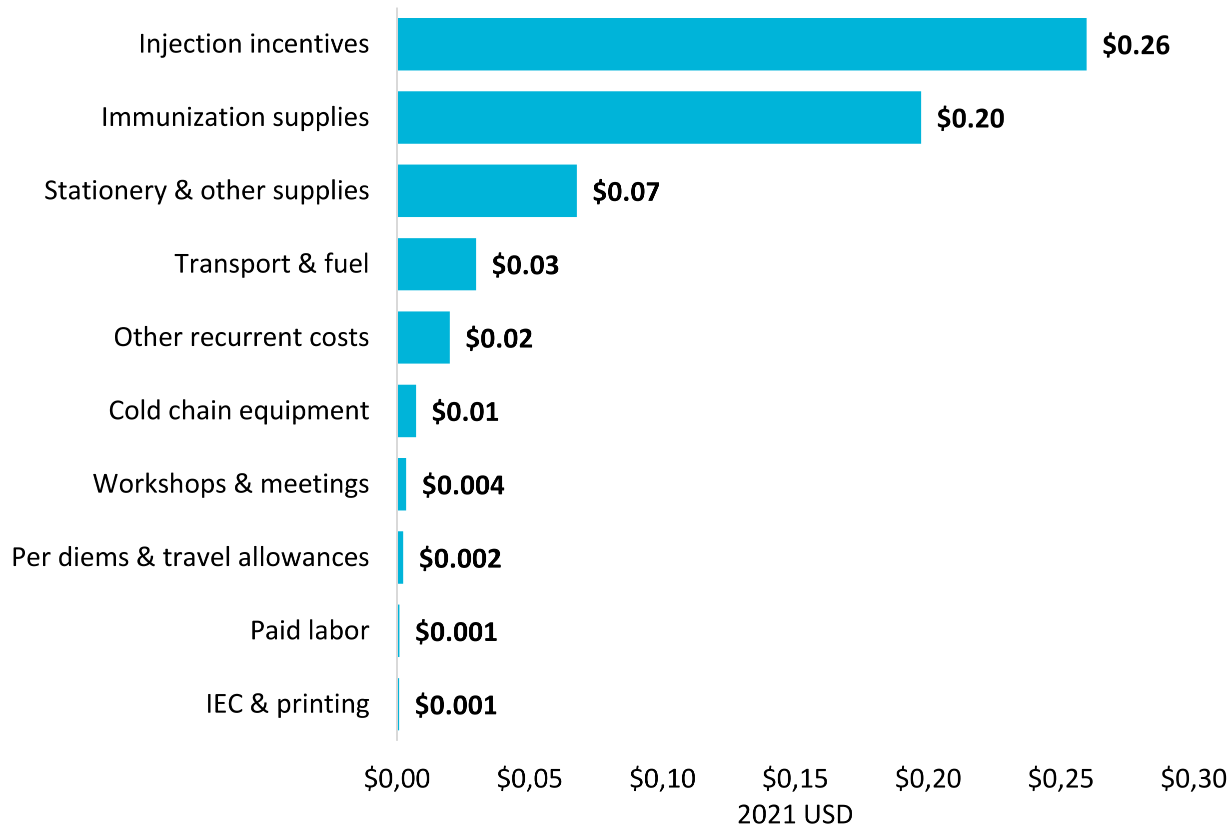
The financial cost of delivering one dose of C19 vaccine is $0.59, far below what COVAX estimated ($0.73-1.85)

This study finds that the financial cost of delivering C19 vaccines is $0.59 per dose, while COVAX had estimated the delivery cost to be 0.3 to 2.2 times higher. The COVAX Readiness and Delivery Working Group on Delivery Costing estimated the financial delivery cost in Vietnam to range between $0.73 and $1.85. The lower estimate assumed that 10% of existing workforce would be leveraged for C19 vaccine delivery, and 85% of doses would be delivered at fixed site, with the remainder delivered through outreach. The higher estimate assumed that 0-5% of the workforce would be reallocated to C19 vaccine delivery and that half of the doses would be delivered through fixed sites, and half through outreach.[13] In reality, Vietnam delivered 71% of the doses through temporary sites, which in the COVAX model would have driven up per diems and the need for additional staff. However, almost all of the paid staff working on C19 vaccinations in Vietnam were leveraged from the existing workforce, which explains why the unit cost of delivery is lower than the estimate from the global level model.

The financial cost per dose is driven by injection incentives (44%) and immunization supplies (39%)

The financial unit cost of delivering C19 vaccines is driven by costs for injection incentives ($0.26 per dose), immunization supplies ($0.20), and stationery and other supplies ($0.07), as shown in Figure 5. Even though they represent a large share of financial costs, injection incentives were perceived by implementation staff to be insufficient compared to the additional workload entailed by the C19 program. Over 90% of financial costs went towards service delivery activities—which include labor for administering vaccines, supplies, injection incentives, and all other resources used during vaccination sessions. Although it is common for immunization costing studies to find that service delivery makes up the largest share of the financial delivery cost, the share found in this study is particularly high. For example, a previous study conducted in Vietnam on the cost of delivering TT to women of childbearing age (15 to 36 years old) found that at implementation level service delivery was the key cost driver and accounted for slightly over 70% of total fiscal costs,[14] much less than the 90% found by our study. While our estimates include costs incurred at all levels, as all service delivery costs are incurred at implementation level, if only looking at costs incurred at that level, the difference would be even greater.

Figure 5. Financial cost per dose, by resource type



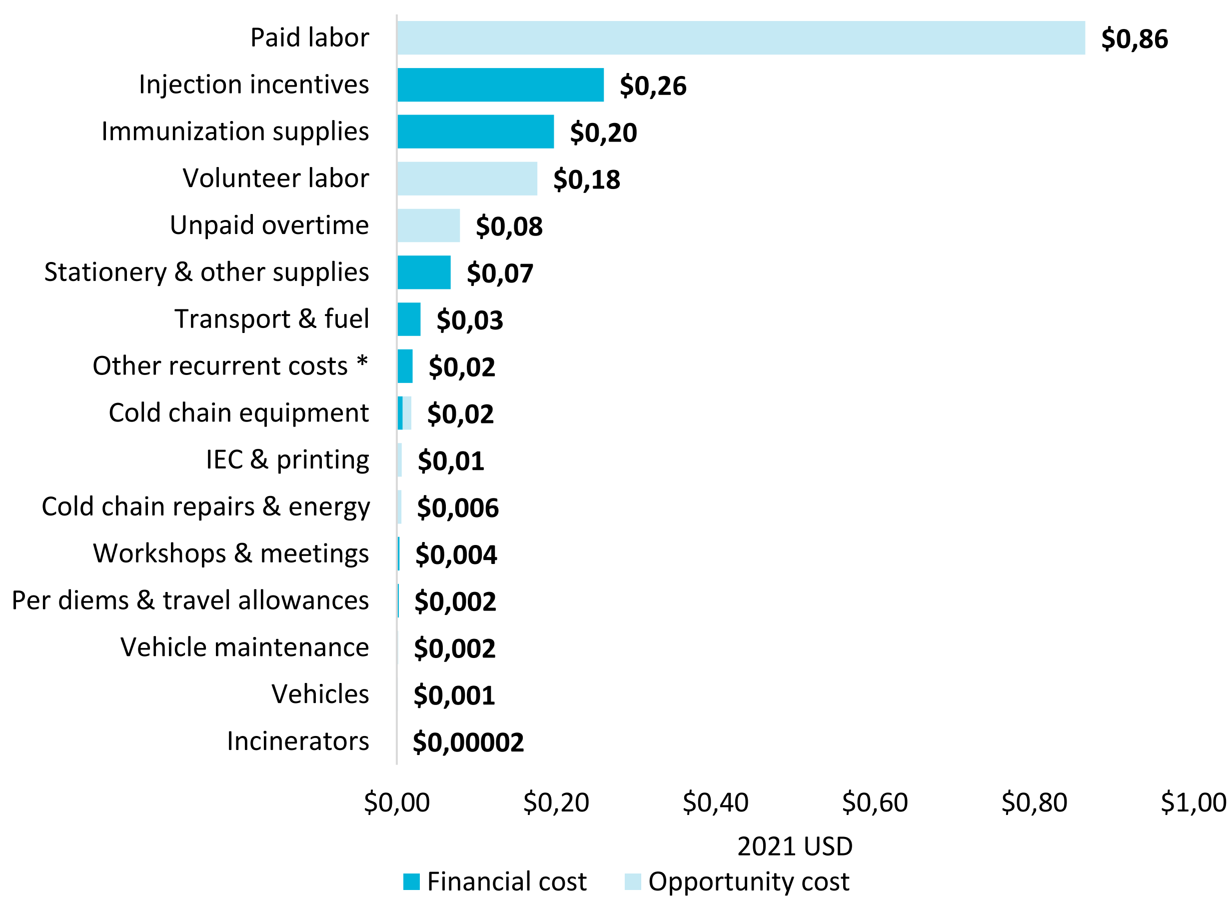
Other recurrent costs include development of guidelines and policies and vaccine acquisition costs at National level, waste disposal (for a third party) at district level, sugar drinks for vaccine recipients, etc.

People waiting to receive C19 vaccines at a temporary vaccination site in Vietnam.

Paid labor accounts for half of the economic cost per dose

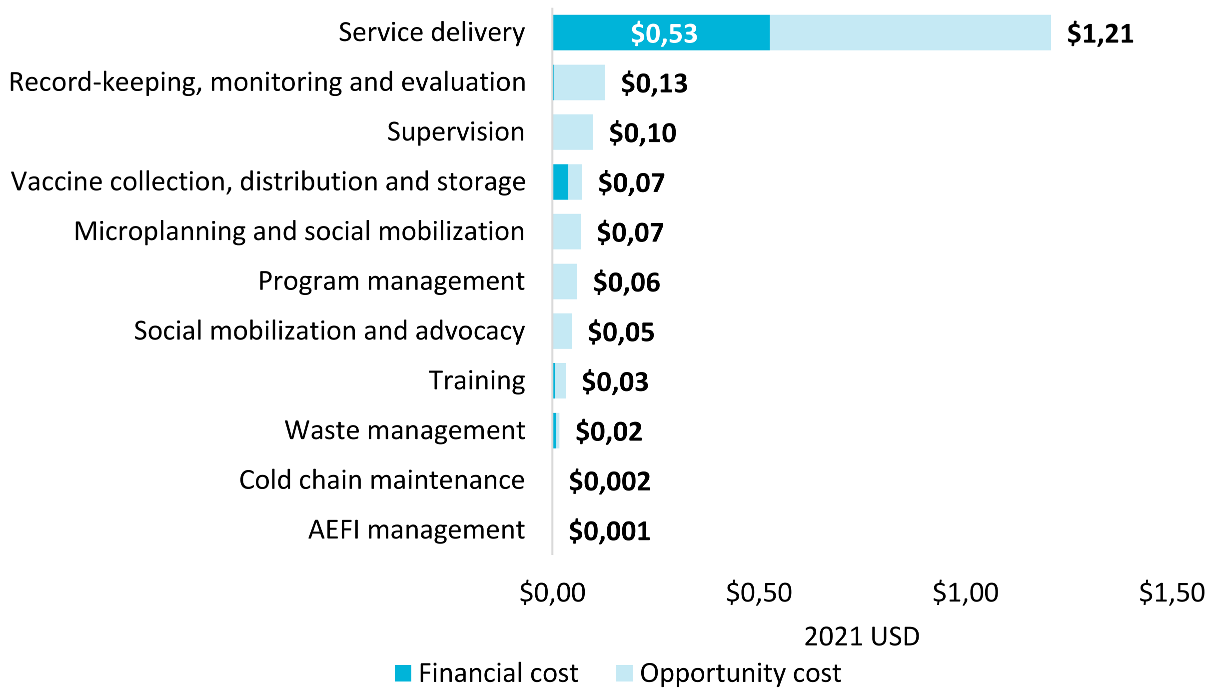
Paid labor was by far the biggest cost driver, followed by injection incentives, volunteer labor, and immunization supplies, as shown in Figure 6. Paid labor, which includes a share of the salary of health staff proportional to the time they spent on C19 vaccination activities, was estimated to be $0.86 per dose. In addition to that, the cost per dose of unpaid overtime by health staff was estimated to be $0.08, while the value of volunteers' labor was estimated at $0.18, bringing the overall cost per dose for all labor-related costs to $1.12, which represents 64% of the economic cost per dose. This is in line with the literature on vaccine delivery costs in Vietnam: a previous study on the cost of delivering HPV vaccines showed personnel costs as the main cost component, accounting for 51% of delivery cost,[15] while a study on the cost of delivering TT to women of childbearing age (15 to 36 years old), found paid labor to account for 83% of total costs at implementation level.[16] Most of this labor was for service delivery, which represents 70% of the economic delivery costs (or $1.21), as shown in Figure 7.

Figure 6. Economic cost per dose, by resource type



** Other recurrent costs include development of guidelines and policies and vaccine acquisition costs at national level, waste disposal (for a third party) at district level, sugar drinks for vaccine recipients, etc.*

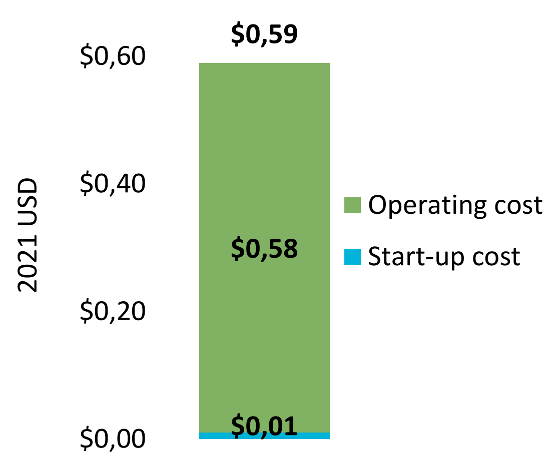
Figure 7. Economic cost per dose, by program activity



Start-up investments are a very small share of the cost per dose, due to the high delivery volume

Start-up costs represent approximately 0.4% of the financial cost per dose. These initial investments, together with start-up costs captured at other administrative levels, amounted to a financial cost of $0.01 per dose, approximately 0.4% of the overall financial cost per dose. Operating costs were estimated at $0.58 and represent 99.6% of the financial cost per dose (Figure 8). Our results differ from previous findings on the introduction of the HPV vaccine in Vietnam, which found start-up costs to be largest component of total financial cost, which is explained by the much higher delivery volume of the C19 vaccination program.[17]

Figure 8. Financial start-up vs. operating cost per dose



At the national level we recorded $7,721,260 in total economic start-up costs, including costs incurred by the NIHE as well as by donors. Of these, $7,689,399 were financial costs, mostly related to investments into expanding cold chain capacity, as well as for the purchase of vehicles and incinerators, and for financing workshops and trainings. At regional level (TIHE), total financial start-up costs were $1,247 (Table 4). At lower levels, weighted average financial start-up costs were $666 (provincial level), $893 (district level), and $2 (implementation sites).

Table 4. Weighted average start-up costs by level

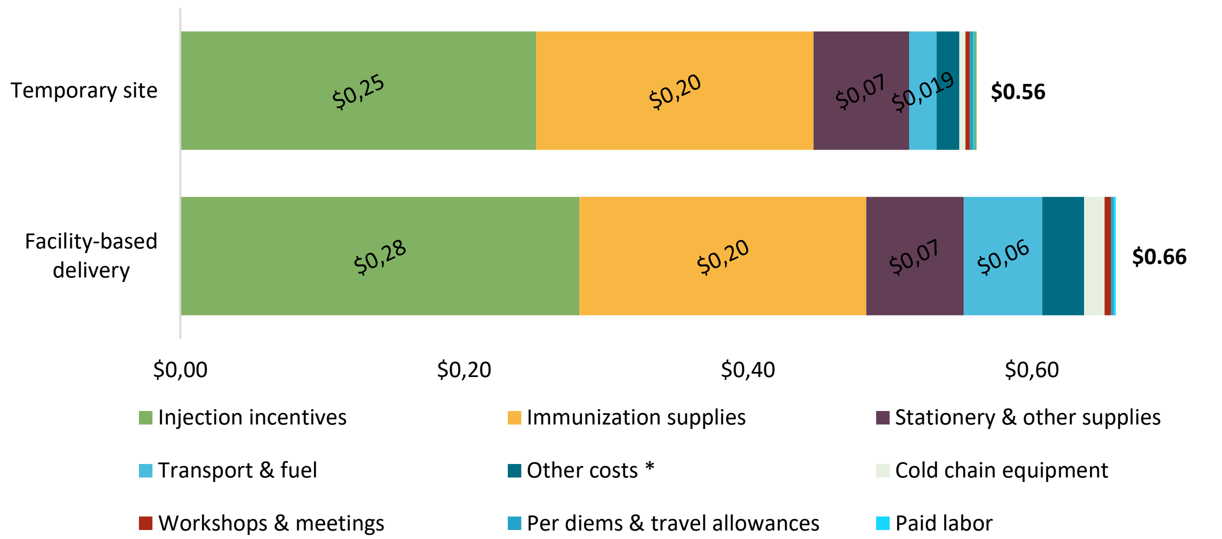
	Financial start-up costs ($)	Opportunity start-up costs ($)	Total start-up costs ($)
Donors*	7,689,399	31,861	7,721,260
National (NIHE)*	-	1,610	1,610
Regional (TIHE)*	1,247	2,667	3,915
Provincial	666	469	1,135
District	893	2,026	2,919
Implementation	2	712	713

* Total costs are presented for donor contributions, national level (NIHE), and regional level (TIHE).

Though temporary sites delivered up to 3x as many doses, the financial delivery costs per dose were only 15% lower than for facility-based delivery

Temporary sites on average delivered more doses during the study period—19,772 doses vs. 7,062 doses at facility-based vaccination sites. Despite the greater delivery volume, economies of scale were limited, as financial costs at facility-based sites were only slightly higher compared to temporary sites, $0.66 and $0.56 respectively. Injection incentive costs per dose were higher for facility-based delivery ($0.28 vs. $0.25 at temporary sites), and facility-based sites also had higher transport fuel costs ($0.06 vs. $0.02), as shown in Figure 9 below.

Figure 9. Financial cost per dose across delivery strategies, by resource type



** Other costs include the following resource types: vehicles; incinerators, development of guidelines and policies and vaccine acquisition costs at national level, waste disposal (for a third party) at district level, sugar drinks for vaccine recipients, etc.*

When including the cost of existing resources, delivering vaccines at temporary sites is more expensive than at facilities

The economic cost of delivering vaccines at temporary sites was $0.15 per dose more than delivering vaccines at health facilities, and higher total opportunity costs were not offset by the larger delivery volume. As shown in Figure 10, facility-based delivery was estimated to be $1.63 per dose, while delivery at temporary sites was estimated to be $1.78 per dose, with the difference driven by higher opportunity cost at temporary sites ($1.22 vs $0.97).

Higher delivery costs at temporary sites were driven by volunteer labor costs ($0.24 vs $0.03) while paid labor costs were similar ($0.87 vs $0.85) across the two strategies, as shown in Figure 11. This is likely due to temporary sites requiring more staff to deliver a much larger volume than facility-based sites, as larger crowds at temporary sites required more volunteers for roles such as welcomers and crowd-controllers (12 volunteers at temporary sites vs 2 in facility-based sites). Costs across all other resource types were similar for the two delivery strategies.

Figure 10. Average cost per dose, by type of vaccine delivery site

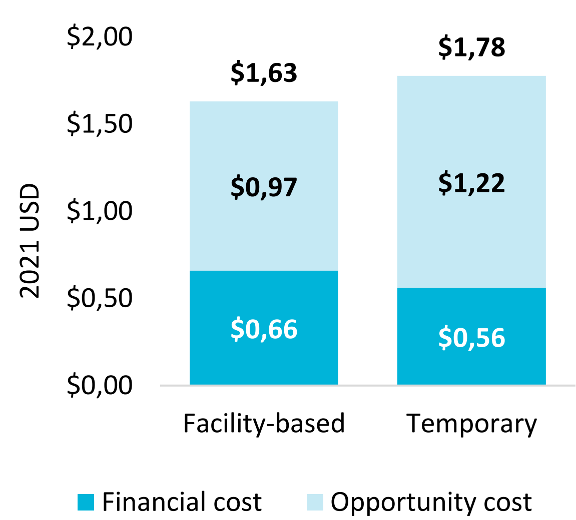
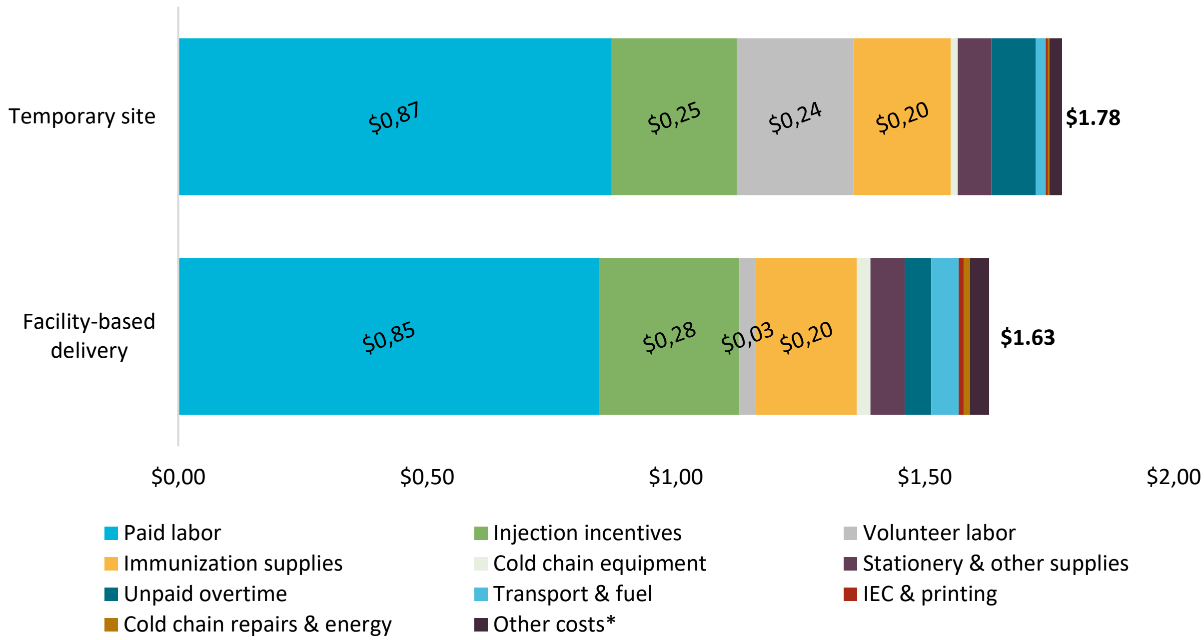


Figure 11. Economic cost per dose across delivery strategies, by resource type

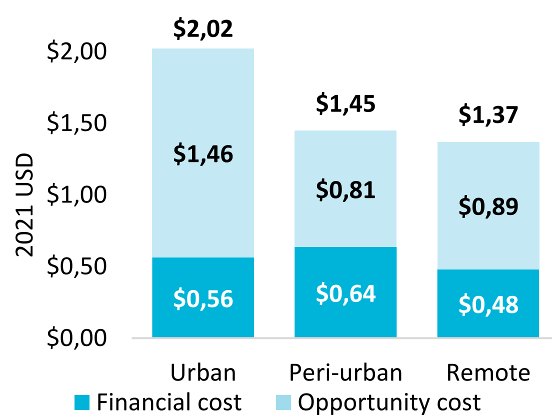


** Other costs include the following resource types (each < $0.005): Workshops and meetings; Per diem and travel allowances; vehicle maintenance; Vehicles; Incinerators*

Delivering vaccines in urban areas was found to be more expensive than in peri-urban and remote areas, due to higher labor costs

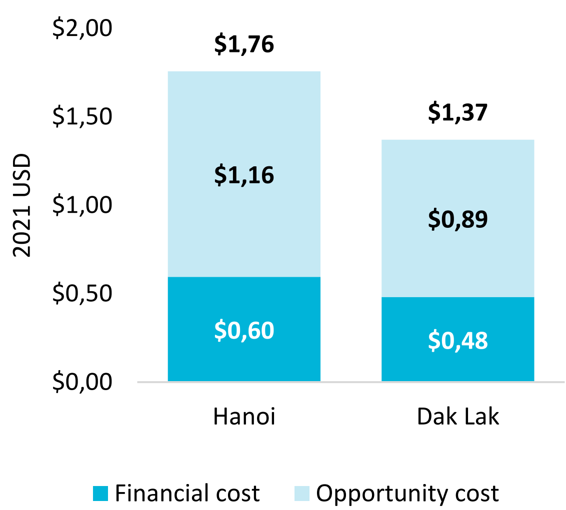
The economic cost per dose for immunization sites located in urban areas was higher ($2.02) than sites in peri-urban areas ($1.45), while sites in remote areas had the lowest delivery cost ($1.37). The difference in cost per dose across geographic areas was driven by higher paid labor in urban areas ($1.09 compared to $0.62 in peri-urban and $0.74 in remote areas) as well as unpaid overtime costs ($0.14 vs. $0.02 vs. $0.04) and higher volunteer costs ($0.21 compared to $0.15 in peri-urban and $0.05 in remote areas). Higher paid labor costs in urban areas are likely driven by the larger number of personnel involved in service delivery (25 staff in urban areas vs 20 in peri-urban and 20 in remote areas). Conversely, higher volunteer labor costs are solely driven by more hours worked by volunteers in urban areas, given that sites in urban areas had the same number of volunteers as rural areas (6 volunteers per site on average), and fewer volunteers than peri-urban areas (9 volunteers per site).

Figure 12. Average cost per dose, by geographic area



While the overall size of the vaccination team—including paid staff and volunteers— was not much larger in urban areas (31 team members vs. 29 in peri-urban areas and 25 in rural areas), staff in urban areas on spent more time in total working on the C19 vaccination program (35 person-minute per dose delivered compared to 22 in both peri-urban and remote areas). Sites located in remote areas also recorded lower injection incentive costs ($0.13, compared to $0.25 in urban areas and $0.29 in per-urban areas), as shown in Table 12 in **Annex 5**.

Figure 13. Average cost per dose, by province



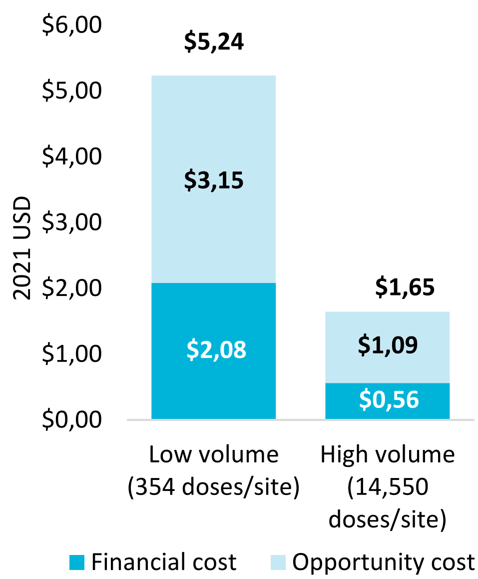
Delivering vaccines in Hanoi was found to be more expensive than in Dak Lak, driven by higher labor costs and injection incentives in urban areas. All urban sites in our sample were located in Hanoi and all remote sites were located in Dak Lak, which explains the higher cost per dose for sites located in Hanoi province compared to the sites in Dak Lak. The economic cost per dose of delivering C19 vaccines in Hanoi province was estimated at $1.76, compared to $1.37 in Dak Lak province, as shown in Figure 13. Descriptive statistics on our sample showed that Hanoi sites had more regular staff (9 vs. 8), more mobilized staff (22 vs. 17) and more volunteers (7 vs. 6) as well as more person-minutes needed to deliver one dose, when compared to sites in Dak Lak. This explains the higher paid labor costs, $0.87 in Hanoi, and $0.74 in Dak Lak, as well as higher volunteer costs, $0.18 in Hanoi and $0.05 in Dak Lak.

Financial costs were also found to be higher in Hanoi—$0.60 compared to $0.48 in Dak Lak—due to higher injection incentives per dose ($0.27 vs $0.13). Nevertheless, several other costs, such as for workshops and meetings, per diem and travel allowances, vehicle maintenance, depreciation costs, and incinerator energy costs, were slightly higher in Dak Lak province ($0.08 vs $0.03 in Hanoi), as shown in Table 12 in **Annex 5**.

Delivery costs per dose dropped significantly when delivery volume scaled up

Both the financial and economic costs per dose for doses delivered during the low-volume period (March to June 2021) were significantly higher than the cost per dose for the high-volume period (July to December 2021), as shown in Figure 14. The economic cost per dose for the low-volume period —during which 354 doses were delivered on average in our sampled immunization sites—was $5.24, while the cost per dose for the high-volume period—when sites in our sample delivered an average of 14,550 doses—was $1.65. Higher costs in the low-volume period were driven by a much higher labor cost per dose ($2.69, compared to $0.82 during the high-volume period), higher transport and fuel costs ($0.60 vs. $0.02 in the high-volume period), and higher cold chain equipment costs ($0.30, compared to $0.01 in the high-volume period). Similar quantities of certain inputs were needed during both periods—such as number of vaccination team members or the number of vaccine transport trips—while the expanded target population meant that each vaccination team member delivered more doses during the high-volume period, and more vials were transported per trip.

Figure 14. Average cost per dose, by delivery volume period

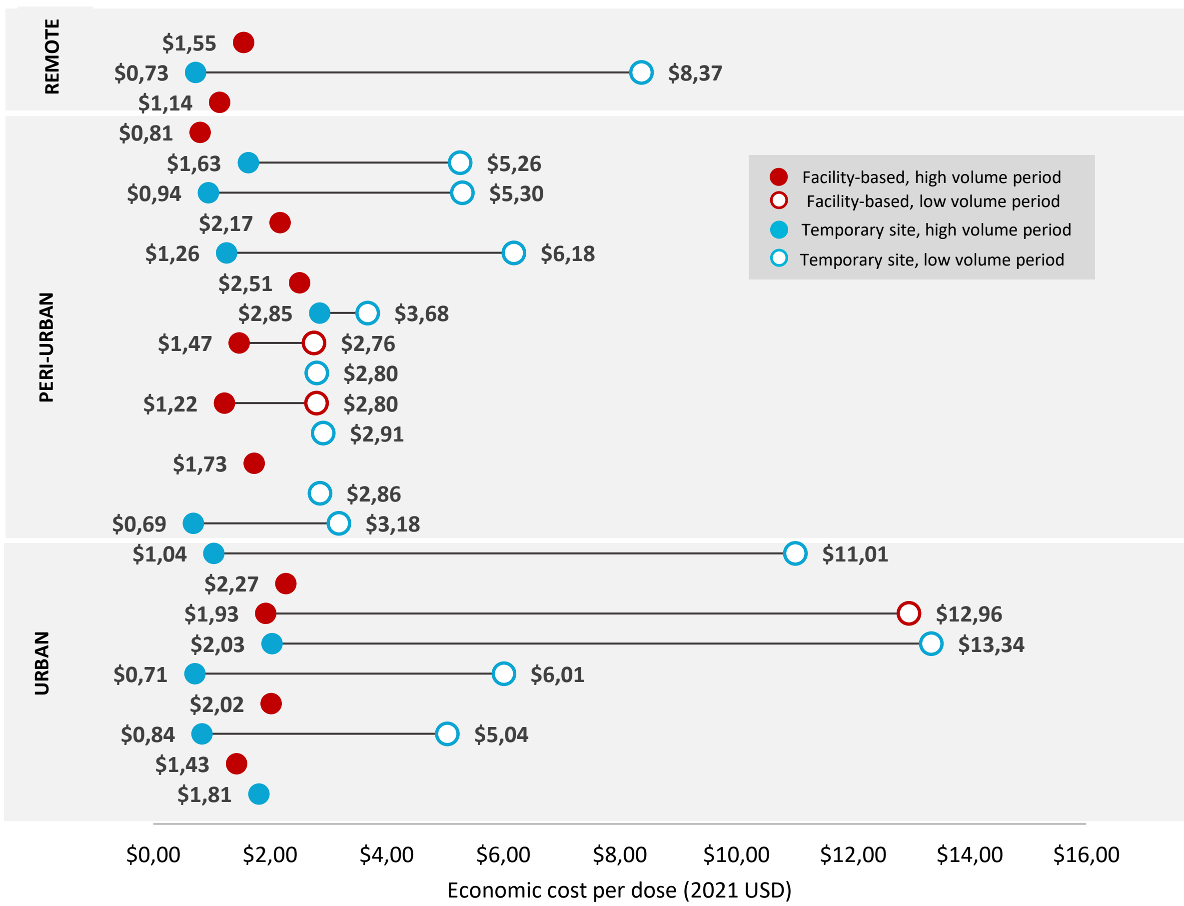


The high-volume period also recorded lower injection incentive costs (dropping from $0.75 to $0.26 per dose). This is explained by the design of the incentive scheme, which capped the incentive per dose at a maximum amount of 20 doses per person per day. In both periods, the vaccination members generally delivered more doses than that, and during the high-volume period, they delivered up to 5-7 times more than the number of doses they could receive incentives for.

The unit cost dropped at each of the immunization sites when the target population expanded, especially in urban areas. Of the 26 immunization delivery sites in our sample, 16 were operational both in the initial low-volume delivery period and in the higher-volume period which started with the expansion of the target population to everyone 18 or older. For each of the 16 sites that were active during both periods, the cost per dose dropped significantly as the volume delivered increased, as shown in Figure 15.

While immunization costing studies usually find a relationship between volume delivered and cost per dose across sites, this study did not find this (Figure 18 in Annex 5)**.** Immunization costing studies usually analyze a period with relatively stable delivery volumes and find that economies of scale drive down the delivery cost. For example, a study on delivering TT/Td vaccines in Vietnam found an inverse relationship between the cost per dose and the volume delivered.[18] However, because of the dramatic changes in delivery volume over the period March-December 2021 and associated changes in the cost structure, the relationship between the average cost per dose for the entire period is dependent on many more factors than overall delivery volume. For example, the unit cost of delivery would be lower for sites that were only briefly active during the high-delivery period, than for sites that also had a long active period at lower delivery volumes.

Figure 15. Economic cost per dose at facility-based and temporary sites, by residence area and period



SCENARIO ANALYSIS: ALTERNATIVE FINANCIAL INCENTIVES

Although injection incentives were the biggest financial cost driver, amounting to $0.26 per dose delivered, staff largely considered them to be insufficient. The compensation scheme was described as inadequate by implementation staff, both in scope and magnitude. According to the incentive scheme, each vaccination team member was meant to receive $0.32 per dose delivered. However, there was a daily cap of $6.48, which corresponds to a maximum of 20 doses per day per staff, far less than what staff delivered on average, especially during the high-volume period. Therefore, each member ended up receiving significantly less than $0.32 per dose. For example, in our sample we observed an average vaccination team size of 4 members, and an average of 240 doses delivered per team per day. This means that each vaccination team member on average received an incentive of $0.03 per dose. In addition, the scheme excluded staff working on microplanning, record-keeping, monitoring and reporting.

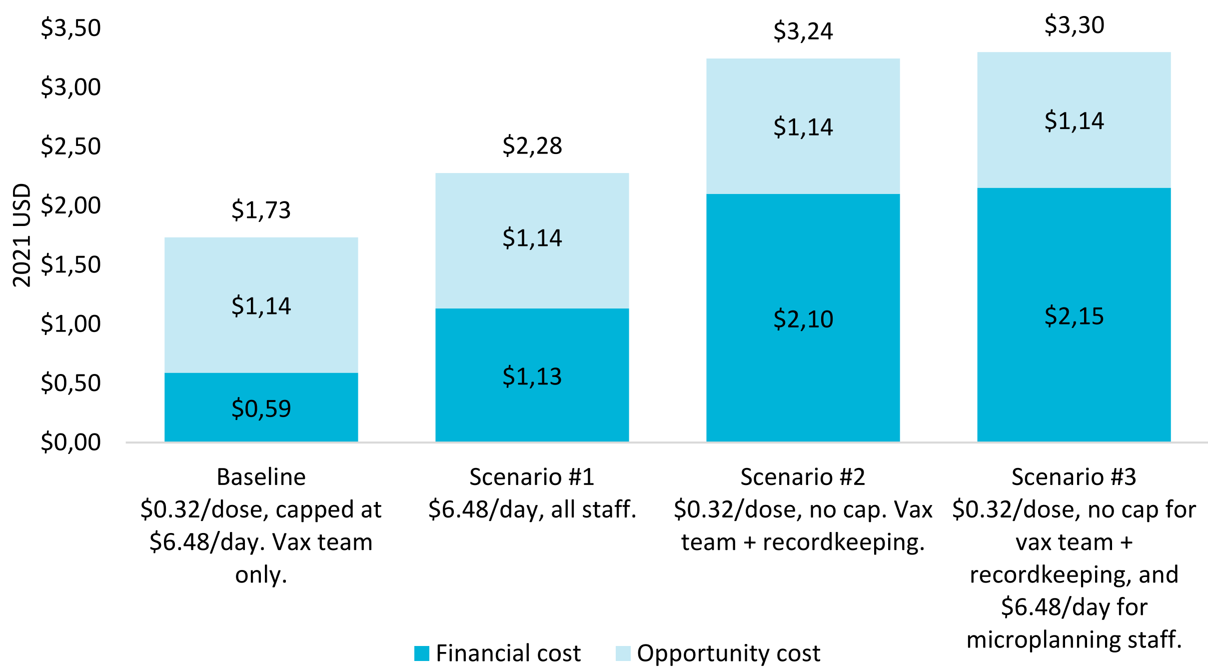
This scenario analysis estimates delivery costs associated with three alternative financial incentive schemes. Immunization program experts at the NIHE and TIHE noted that lack of funds prevented dedicating more resources to further compensating health workers. Therefore, based on the feedback from NIHE and TIHE expert as well as based on findings from the qualitative interviews, we designed three scenarios that outline alternative compensations schemes that could have been implemented if additional funding was available to compensate staff. Details for each scenario and for the financial incentive scheme actually implemented (baseline) are outlined in Table 5.

Table 5. Description of scenarios

Scenario	Vaccination team members	Microplanning and social mobilization staff
Baseline	$0.32 per dose per member, capped at $6.48 per member per day (excluding record-keeping staff)	No financial incentive
Scenario 1	$6.48 per member per vaccination day (<u>including</u> record-keeping staff)	$6.48 per member per day of microplanning and social mobilization (1 day/round)
Scenario 2	$0.32 per dose per member, no cap (<u>including</u> record-keeping staff)	No financial incentive
Scenario 3	$0.32 per dose per member, no cap (<u>including</u> record-keeping staff)	$6.48 per member per day of micro planning and social mobilization (1 day/round)

The scenarios tested lead to an increase in the economic cost per dose of 32% to 91% (Figure 16). Expanding the existing financial incentive scheme to include microplanning and record-keeping staff would bring the economic cost per dose to $2.28 (+32% compared to the baseline), while only adding record-keeping staff and removing the daily cap would bring the cost per dose to $3.24 (+87%). Finally, expanding the scheme to microplanning and record-keeping staff while also removing the daily cap for vaccination team members and record-keeping staff would bring the cost per dose to $3.30 (+91%). Findings from this scenario analysis can be used to model the impact on costs of different incentive schemes both for future phases of the C19 vaccination program as well as for other vaccination efforts.

Figure 16. Economic cost per dose across different financial incentives scenarios



Screening and registration at a C19 vaccine temporary vaccination site in Vietnam.

ENABLING FACTORS AND CHALLENGES

ENABLING FACTORS FOR THE SUCCESS OF THE C19 VACCINATION PROGRAM

Effective collaboration and staff commitment were essential for the program's success

An effective multisectoral collaboration and health workers' commitment to reach the vaccination targets proved essential for the successful implementation of the C19 vaccination program. The C19 vaccination program was an unprecedented program in terms of geographic scale and volume delivered, and its successful implementation required effective collaboration across several entities both within and outside of the health sector. Within the health sector, public and private clinics collaborated to pool available human resources, and volunteers were mobilized among retired health workers as well as medical students. Outside of the health sectors, several entities filled resources gaps as needed, with private airline companies supporting vaccine shipments on an ad hoc basis, several ministries and some private companies collaborating to standardize and merge different vaccine certificate apps,[iv] the Ministry of National Defense stepping in to support vaccine storage and distribution at regional and provincial level, youth and women's unions mobilizing to provide volunteers to support vaccinations at temporary sites, and People's Committees at district and commune level supporting coordination efforts across all the actors involved. Moreover, health staff and volunteers' commitment to consistently work overtime for extended periods of time also proved essential in allowing Vietnam to meet and exceed all its vaccination targets.

Communication technologies were leveraged for trainings and social mobilization

Vietnam leveraged technology to reduce the training-related burden on health workers and existing community structures to generate demand of the vaccines. To comply with the country's social distancing regulations, Vietnam leveraged virtual trainings, reducing training costs and decreasing the time commitment required of health workers to participate in trainings. While

[iv] Multiple C19 vaccination related apps/features were initially developed: PC-COVID (developed by BKAV, Viettel – Ministry of National Defense and VNPT – Ministry of Information and Communication), VNEID (developed by the Ministry of Public Security), Digital Health Records (MOH). Later, in October 2021, Ministries came to mutual agreement to merge data and features from these applications and only use PC-COVID to avoid any confusion among users and duplications of efforts. This app currently houses the C19 vaccination certificate, as well as the C19 tracing function, a risk transmission map and more features.

the pressure on health staff related to participation in multiple trainings remained significant, it would have been much greater had the trainings been conducted in person. Moreover, technologies such as instant messaging software (e.g., Zalo, a communication app similar to WhatsApp) were employed to identify and mobilize the target population. These technologies were used in combination with existing neighborhood-level community structures: neighborhood officers actively supported C19 vaccination teams by setting up a neighborhood Zalo group to keep the population informed of changes in target populations and on upcoming vaccination rounds, and to encourage them to get vaccinated.

Lockdowns facilitated social mobilization and microplanning, and increased the pool of volunteers

Lockdowns implemented to slow the spread of the disease helped the vaccination program by facilitating social mobilization and microplanning efforts and increasing the pool of available volunteers. As residents were forced to stay home by the lockdowns imposed by the government as part of Vietnam's C19 containment strategy, health workers could more effectively conduct door-to-door microplanning and social mobilization activities. Moreover, as entire categories of workers that could not work remotely were forced to stay home (e.g., teachers), there were more people available to be mobilized as volunteers to support the vaccination program, often filling in for critical shortages in support staff.

Rapid and effective response to initial vaccine hesitancy

Initial vaccine hesitancy was quickly and effectively addressed through strengthened social mobilization and advocacy. Health workers reported that in the very first weeks of the program's implementation, many in the target population had reservations about getting the vaccines due to doubts related to its safety, its efficacy, and the need of getting vaccinated. This led to a heightened focus on social mobilization through the production and distribution of tailored advocacy material at implementation level, which effectively addressed the issue and contributed to the very high coverage achieved in Vietnam.

CHALLENGES IN IMPLEMENTING THE C19 VACCINATION PROGRAM

Overburdened health workers due to high workload, high pressure, and shortages

Long working hours with high pressure to perform, little to no time off, and for an extended period of time was identified as the key challenge faced by health workers in the implementation of the C19 vaccination program in Vietnam. The C19 vaccination program was unprecedented in scale and complexity, while funding limitations meant that additional hiring was not possible. The staff shortage was further exacerbated by health workers getting infected with C19. Furthermore, when lockdowns ended in September 2021, volunteers returned to their primary occupations, and the reduced the availability of volunteers further increased the burden on health workers. This ultimately increased the burden on the staff contributing to the program. As a consequence, health workers at all levels of the health system reported consistently working overtime for several months, under significant stress, and often on weekends, to ensure the successful implementation of the C19 vaccination program. Many health workers reported working 10 to 12 hours per day, with peaks of up to 16 hours, with nearly no time off on weekends during the highest-volume period of the program, approximately between August and November 2021. The long working hours are also reflected in the cost analysis, which showed that costs related to health staff salaries were the key cost driver of the economic cost per dose, and all labor costs—also including unpaid overtime labor and volunteer labor—represented 64% of the economic costs.

Excessive number of trainings put additional pressure on the workforce

During the first year of implementation, health workers participated to 10-15 formal trainings related to the introduction of new vaccine products, updates to vaccination guidelines or expansions in target populations. The various C19 vaccines had different presentations, and different requirements in terms storage, and compatibility between first and second doses. Therefore, trainings were held every time a new vaccine product was approved for use in the C19 vaccination program, and whenever guidelines were introduced or changed, around topics such as vaccine storage, organization of the vaccination site, data entry protocols, production of daily reports, adverse effect management and reporting and more. This contributed to long working hours for vaccination team members, as trainings were often conducted late in the evenings to avoid interfering with vaccination activities. While health workers reported trainings to be a significant contributor to the additional workload, our cost analysis shows that training costs were quite low on a per dose basis, due to cost saving strategies, such as the use of virtual technologies, that reduced financial costs and due to the high volume delivered which spread labor costs related to training over a very high number of doses.

Unpredictability and high frequency of vaccination rounds led to inefficiencies in planning and vaccine distribution

Unpredictable and frequent vaccination rounds caused significant overtime for staff across roles and administrative levels. The arrival of a vaccine lot in the country would trigger a series of preparation activities that had to be completed within just a few days. However, the exact timing of vaccine lot arrivals was mostly unknown due to variability in the duration of shipping and importing procedures. This meant that workers across all administrative levels had very little notice to prepare vaccination plans, coordinate with all entities involved in vaccine delivery, and ensure that vaccines reached immunization sites in time for the start of the vaccination round. At the national level, this entailed collecting vaccines from airports and ports, inspecting them, and transporting them to the national cold store. National level vaccine logistics staff involved in these activities reported that during the highest volume period of the program they worked all day every day, resting and conducting personal business while on the road. Similarly, at implementation level in remote areas staff reported spending long periods of time travelling to and from vaccine collection sites at district level, due to long travel times and back-to-back vaccination rounds implemented during the high-volume period. While the additional labor related to the unpredictability of the vaccination rounds was flagged as a key challenge by program implementers, these activities were not identified as key cost drivers in the cost analysis and program management and vaccine distribution only made up respectively 3% and 4% of the economic cost per dose.

Multi-entity collaboration required additional effort for smooth implementation

At implementation level, coordination across all entities involved in the program required constant communication and prompt responses to avoid delaying activities, which in turn required health workers to work late into the night. This was especially true in the lead up to a vaccination round, for which planning was usually to be completed within 1-2 days since the announcement of the vaccine allocation decision. Vaccination plans were drafted by health centers in coordination with the district department of disease control, the local people's committee, the police force, and all entities that mobilized health workers or volunteers to support that vaccination round (such as other health facilities, the youth union, and the women's union). Ahead of every vaccination round, a health center managing an immunization site had to coordinate communication with each entity to obtain an official sign off on the plan from every organization involved. This process was seen as essential in facilitating the successful implementation of the program because it provided additional human resources, but required long working hours by health workers.

Across administrative levels, the complexity of the program translated into a greater supervision burden. To manage the unprecedented scale of this vaccination program, the work was distributed across several sub-unit within each administrative level, all the way down to neighborhoods (National level -> Regional level -> Provincial level -> District level -> Commune level -> Neighborhood level). This meant that supervisors at each level spent a significant amount of time each day checking in with all the sub-units they oversaw, answering questions about the organization of the vaccination site and verifying data from the daily vaccination performance reports before submitting them to higher administrative levels. According to our cost analysis, costs related to supervision amounted to $0.10 per dose (or 6% of the economic cost per dose), and almost all supervision costs were for labor.

Social distancing regulations increased the workload at temporary sites

Social distancing regulations meant that workers at temporary sites could spend hours setting up and cleaning up the space every day. At the beginning of each new round, and in many sites at the beginning of each vaccination day, vaccination team members had to set up the site in compliance with social distancing regulations, measuring the space within tables and chairs to ensure a distance of at least 2 meters at all times. This took significantly more time than setting up temporary vaccination posts for a regular immunization program. In many sites, this process had to be done every day, as the space used for vaccinations was outdoors or because it was needed for other purposes after the vaccination activities.

Laborious reporting and verification process and issues during the introduction of a new software

New record-keeping software and a daily data reporting and verification process contributed to additional overtime at all administrative levels. At implementation level, a new vaccination data management software was rolled out specifically for the C19 vaccination program. Staff reported that this software, which was web-based, crashed frequently during the initial phase of the program, slowing down the record-keeping process. On a daily basis, staff at implementation level would compile data on doses delivered after the end of the vaccination activities (around 5 to 7pm), and share them with district level officials, who would validate the data, compile them with data received from other immunization sites and in turn share with higher levels. National level staff reported receiving vaccination data around 11pm-12am and often worked until 2am to generate a daily report on doses delivered nationally. While cost related to record-keeping represent only 8% of the economic cost per dose, they are the second largest cost activity, following service delivery which made up the largest share of the cost by far (70%).

Initial supply shortages were followed by a drop in demand

Inconsistent, and at times insufficient, vaccine supply put vaccinators in the difficult position of selecting who would get the vaccine and who would not. During the initial period, demand for vaccines was greater than the supply received by vaccination sites. This put health workers in the difficult position of having to prioritize among eligible recipients when drafting the list of those who were to be vaccinated within each round. Health workers reported that this sometimes led to perceived unfairness and repeated requests for vaccines by people seeking to be vaccinated.

Once lockdowns were lifted, health workers reported increased challenges in planning due to the sudden mobility of residents. When lockdowns ended, large numbers of residents moved to other areas, which complicated microplanning and doses allocation decisions as sites had inaccurate information on the target population in their area. Additionally, this initially caused no-shows at vaccination sessions, prompting health workers to call every beneficiary ahead of the vaccination day to ensure they would be able to deliver all available doses, as well as causing them to do additional social mobilization activities to replace beneficiaries in the list of those to be vaccinated during that round.

Insufficient cold chain equipment contributed to the burden of overloaded health workers

Limited cold chain capacity and lack of ultra-cold chain equipment at lower levels put more pressure on health workers to delivery vaccines quickly. Across all levels, the cold chain capacity was limited. This meant that vaccines had to be delivered quickly to make space for incoming lots of vaccines, particularly during the high-volume period. Additionally, UCC was not present at lower administrative levels: vaccines requiring UCC were defrosted when leaving higher-level storage facilities and after defrosting they had to be delivered within a very short timeframe. These constraints in cold chain capacity put additional pressure on health workers to deliver vaccines quickly, prompting more frequent vaccine collection trips and causing longer working hours to make sure no doses would be wasted.

Shortage of adequate vehicles and cold boxes also contributed to additional workload for health workers. Study sites reported that due to only having access to motorbikes—rather than vans—to transport vaccines and due to a shortage of cold boxes, the carrying capacity of each vaccine collection trips was limited. This meant that health staff had to do multiple vaccine collection trips for the same shipment of vaccines, sometimes even causing them to conduct several trips in the same day, particularly when larger volume vaccines (e.g., Sinopharm) were delivered.

KEY TAKEAWAYS

Findings from this study can provide valuable evidence for policymakers in Vietnam and globally. This is the first study on the cost of delivering C19 vaccines in Vietnam, and one of the first studies on this topic globally. Our results can help inform planning and budgeting for the future of the C19 vaccination program in Vietnam, as well as in countries for which there is no domestic data. Given the limited literature on immunization delivery costs in Vietnam, these findings could also inform resource allocation decisions for other vaccination programs.

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

While development partners donated over $12.6 million for the C19 vaccination program in 2021, funding still fell short.

Most of the funding for the C19 vaccination program was not 'felt' at facility level, where they reported having received little to no additional funding to implement the C19 vaccination program. This inhibited the recruitment of additional health workers to support the vaccination effort, there was also no funding to hire additional vehicles for vaccine transportation, and not enough investment in cold chain capacity was made.

Limited investments to expand capacity ahead of the roll-out resulted in inefficient vaccine distribution practices, and greater recurrent costs.

While some investments in cold chain equipment from development partners were recorded, health staff at immunization sites and the district level suggested that cold chain and vehicle capacity remained inadequate. Limited refrigerator capacity at higher administrative levels meant that there was pressure to pass vaccines down to lower levels and to deliver them to the population quickly, while inadequate cold storage capacity at vaccination sites meant that health staff had to travel sometimes multiple times a day to pick up vaccines at district level. Moreover, at some sites, staff reported only having motorcycles available to pick up vaccines, which meant they could only transport a very limited number of vials per trip, thus increasing the number of trips required.

The low financial cost reported in this study masks shortages in funding, staffing, and other resources that the C19 vaccination program had to work around.

Our study shows that the large majority of delivery costs were for the use of existing resources. As little additional funding was mobilized, Vietnam made things happen with the resources that were available. This meant that health workers had to consistently work late in the evenings and on weekends, for several months at the time. The limited additional funding also translated into a performance-based incentive scheme that was perceived by staff as insufficient, contributing to low morale during a period that staff described as incredibly stressful and demanding. Therefore, policymakers should recognize that the low financial cost found by our study reflect practices that would not be sustainable in the long run.

Heavily relying on existing resources placed a significant burden on health workers and caused disruptions to the delivery of other health services, the cost of which is not quantified in our study.

Our study found relatively low economic delivery costs, but these should not be interpreted as the 'true cost' of the program to the health system. Most models that estimated the cost of delivering C19 vaccines have focused only on the financial cost of delivery, without taking into account the cost to the health system. Policymakers should recognize that although the program was very successful in the short term—when C19 vaccination were a key national priority—this came at the expense of the delivery of other health services.

Delivery through temporary sites was very labor-intensive and costly, even during high-volume periods, drawing into question the sustainability of this delivery modality.

Although temporary sites were effective at delivering large volumes of C19 vaccines, and the financial cost of delivery were slightly lower, our findings showed that this delivery strategy required considerably more labor. The larger crowds vaccinated at temporary sites required longer vaccination sessions, larger vaccination teams and the support of more volunteers. This suggests that facility-based delivery is a better suited strategy for the current phase of the C19 vaccination program in Vietnam, as delivery volumes are now much smaller.

Effective collaboration across sectors and administrative levels was essential in facilitating a successful rollout of the C19 vaccination program.

Interviews with key informants across all levels of the health system highlighted how pooling and coordinating resources across sectors was essential for the implementation of such high-volume vaccination program. Effective leveraging of communication technologies for trainings and for social mobilization were also identified as enabling factors for the implementation of this large-scale vaccination program.

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ANNEXES

ANNEX 1: PROGRAM ACTIVITIES AND RESOURCE TYPES DEFINITIONS

Table 6. Program activities definitions

Program activity	Definition
Program management	C19 vaccination program management, including: development of guidelines, program meetings, development of vaccination implementation plan for each round, budgeting for the program.
Vaccine collection, distribution and storage	Vaccine acquisition procedures; Vaccine collection at the airports or other distribution points, storing vaccines in national or subnational cold stores, distributing vaccines down to the facility, and to outreach or program sites where relevant.
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	Mainly advocacy activities, such as: developing and distributing advocating materials, via mass media, social media and leaflets.
Supervision	Supervising subordinate or peer health or community workers.
Service delivery: facility-based delivery	Including the administration of the vaccine to people within the district general clinics and commune health centres, preparation and cleaning up before and after the vaccination event.
Service delivery: temporary sites	Including traveling to and from temporary sites outside of the facility, the act of administering the vaccine and supporting vaccine administration (crowd control, screening, setting up and cleaning up the vaccination site before and after).
Waste management	Time and resources spent on disposing sharps and infectious non-sharp waste.
AEFI management	Managing and following up on post-vaccination events following C19 vaccine administration; Developing reports on AEFI events occurred.
Record-keeping, HMIS, monitoring and evaluation	Data entry and analysis, reporting, monitoring.
Microplanning and social mobilization	Referring to the development of eligible participants lists for each round and inviting eligible participants coming in vaccination sites in the area.

Table 7. Resource types definitions

Resource types	Description	Financial vs. opportunity cost	Start-up vs. operating
Recurrent costs			
Paid labor	Paid salary for health staff and government officers. The paid personnel costs were derived from the total working time of each staff and their annual salary in 2021.	Opportunity cost	Operating, unless related to start-up activities
	Paid salary for new staff that were hired specifically for C19 vaccination program. Based on the financial records of the study site(s).	Financial cost	Operating, unless related to start-up activities
Unpaid labor	Unpaid overtime of health staff related to C19 vaccination activities. Defined as any time worked in excess of the regular working time during the study period (calculated based on a 6-day work week, an 8-hour workday and 11 days of holiday in 2021).	Opportunity cost	Operating, unless related to start-up activities
Volunteer labor	Value of volunteer labor (medical students, local youth members, etc.) for those staff who are not receiving salary from the government/MOH. This cost was calculated based on each volunteer's working time and valued at minimum wage (specific for the region of each study site).	Opportunity cost	Operating, unless related to start-up activities
Per diem and travel allowances	Per diem and travel allowances paid to regular staff as well as volunteers for participation to activities related to the C19 vaccination program.	Financial cost	Operating
Injection incentives	Performance-based injection incentives, of the value of 7,500 VND per delivered dose and per each vaccination team member, capped at 150,000VND per member, per day (which corresponds to 20 doses per member per day). The average injection incentive per dose may vary from site to site due to the capped amount paid per day to each vaccination team member.	Financial cost	Operating
Vaccine injections and safety supplies	Cost for immunization supplies and personal protective equipment.	Financial cost	Operating
Stationery and other supplies	Cost for stationery and IEC materials required for the program.	Financial cost	Operating

Resource types	Description	Financial vs. opportunity cost	Start-up vs. operating
Transport and fuel	Fuel costs specifically for C19 vaccination program activities that required travelling (supervision, trainings, vaccine collection, distribution, etc.)	Financial cost	Operating
	A proportion of total cost for gasoline at the study site which was used for C19 vaccination program activities.	Opportunity cost	Operating
Vehicle maintenance	Cost for vehicles maintenance specifically done for C19 vaccination program in 2021.	Financial cost	Start-up
	Routine and non-routine vehicle maintenance done in 2021.	Opportunity cost	Operating
Cold chain equipment repairs and energy costs	Cost for CCE maintenance specifically done for C19 vaccination program in 2021.	Financial cost	Start-up
	Routine and non-routine cold chain maintenance/repairs done in 2021 The energy cost for the CCE is the energy bill of the storage room (if available)	Opportunity cost	Operating
Printing cost	Share of the site's printing for 2021 spent in relation to C19 vaccination activities	Opportunity cost	Operating, unless related to start-up activities
	Cost incurred specifically for C19 vaccination program as reported in financial reports (if available), or estimations based on number of pages printed per each participant (per dose delivered) at implementation sites.	Financial cost	Operating
Workshops and meetings	Cost incurred specifically for C19 vaccination workshops and meetings (line of budget, if available)	Financial cost	Start-up
	Cost incurred for general workshops and meetings which was also used for C19 vaccination program	Opportunity cost	Start-up
Waste disposal fuel	Costs for fuel used in incinerators for C19 vaccination program specifically.	Financial cost	Operating
	Share of routine waste disposal incinerator fuel costs that was used in relation to C19 vaccine waste management.	Opportunity cost	Operating
Other recurrent cost	Other financial outlays that are not included in the categories above, including direct financial support for development of guidelines and policies and vaccine acquisition costs at National level, waste disposal (for a	Financial cost	Operating, unless related

Resource types	Description	Financial vs. opportunity cost	Start-up vs. operating
	third party) at district level, sugar drinks for vaccine recipients, etc.		to start-up activities
Capital costs			
Cold chain equipment	Depreciation costs of existing cold chain equipment used for C19 vaccine storage at study sites	Opportunity cost	Operating
	New cold chain equipment acquired in 2021 and used for C19 vaccination program.	Financial cost	Start-up
Vehicles	Depreciation costs of existing vehicle(s) used for C19 vaccination activities (trainings, supervision, vaccine collection/distribution) at study sites	Opportunity cost	Operating
	New vehicle(s) acquired in 2021 and used for C19 vaccination program.	Financial cost	Start-up
Incinerators	Depreciation costs of existing incinerator(s) used for C19 vaccination waste disposal at study sites	Opportunity cost	Operating
	New incinerator(s) acquired in 2021 and used for C19 vaccination program.	Financial cost	Start-up

ANNEX 2: IMPUTATION METHODS AND COST ALLOCATION RULES

Missing data imputation methods

If after following up with the respondent some data still could not be obtained, assumptions were made to impute the data from the same site or other sites, as detailed in Table 5 below:

Table 8. Imputation methods used for missing data

Missing data	Methods
Acquisition cost of cold chain equipment or vehicle	Used the acquisition cost for same cold chain equipment item or vehicle (same brand and model) recorded from other study sites.
Acquisition year of cold chain equipment or vehicle	If there was no written record of the acquisition, we asked the health staff to estimate the year the equipment/vehicle was put to use. If health staff could not estimate, we used the same acquisition year of the most recent cold chain equipment/vehicle at that study site.
Salary for health staff	Imputed based on the average salary for staff of the same cadre of at the same study site.
Quantities used for immunization supplies	Used the average supply used per dose delivered reported at the sites that were able to provide these data.
Time spent administering vaccines per day during low volume period	For three vaccinations sites, we only had data on health workers' daily time spent administering vaccines during the high-volume period. In these cases, we imputed their time spent administering vaccines in the low-volume period using the average from other sites in our sample.
Vaccination team size (only for scenario analysis)	The vaccination team size at each site was estimated assuming that each team would have 1 vaccinator, thus dividing the total number of vaccination team members at a site by the number of vaccinators present at that site. For the sites that did not report the number of vaccinators, we imputed this based on the average doses delivered per vaccinator at similar delivery sites, matching sites by province, geographic area and where possible by delivery strategy.

Allocation of shared resources

Resources that were shared between the C19 vaccination program and the health system were allocated based on indicators that best reflected how the resource was used (see Table 9).

- Costs shared across delivery strategies (facility-based delivery and temporary site delivery) were allocated based on the % of doses were delivered via each strategy over the total number of doses delivered.
- At implementation level, cost data were collected at commune health centers, which in some cases managed more than one immunization site. In such cases, costs that were shared across vaccination sites were allocated to each site based on the proportion of doses delivered by each site.

Allocation rules were also used to distribute the costs shared across the low- and high-volume period for each implementation site:

- Shared operating costs, including electricity, shared printing, and fuel costs, were allocated based on the duration of each period as a percentage of a year;
- One-off costs related to training and program management were allocated based on the duration of each period as a percentage of a year and assuming a 1-year useful life for the activity;
- One-off costs related to managing AEFI cases and to cold chain equipment maintenance and repair were allocated based on the number of doses delivered in each period.

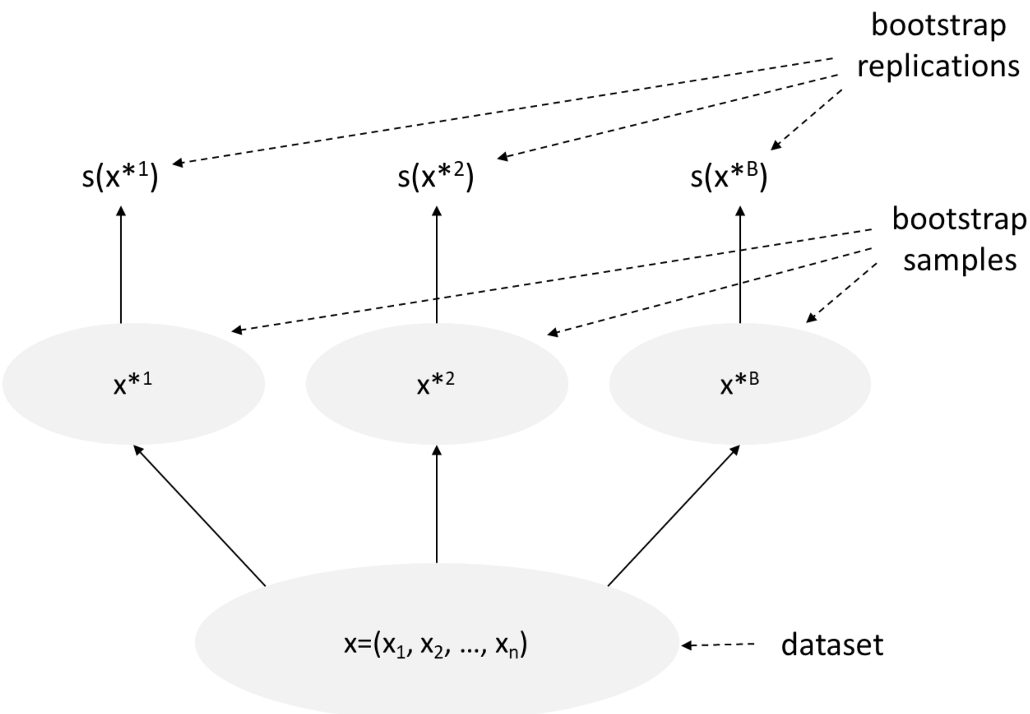
Table 9. Methods for allocation shared resources

Resources	Allocation methods
Paid labor	Time allocation based on self-reporting by interviewed staff
Fuel	The proportion was taken from the % working time related to C19 vaccination program at the study site, and then this cost was allocated only to C19 activities that required transportation (supervision, trainings, vaccine collection, distribution, etc.)
Vehicle maintenance	Apportioned to C19 vaccination program activities based on number of vehicles used for C19 vaccination activities + % working time related to those C19 vaccination program activities in 2021
Cold chain maintenance	Apportioned to the C19 vaccination program based on the number of CCE used to store C19 vaccines out of the total number of CCE at the site, and the duration of the C19 vaccination program in 2021
Cold chain energy costs	The estimated energy used for CCE based on the area of the vaccine storage room as % of the total (office) area of the study site and the total cost for electricity in 2021 at that site
Printing	Partially allocated to C19 vaccination based on working time for each of C19 vaccination activities
Waste disposal fuel	Partially allocated to the C19 vaccination program based on the estimated vaccination waste weight

ANNEX 3: BOOTSTRAP METHODS

Bootstrap is a statistical method where the original dataset is resampled randomly multiple times (each resampling is called a "run") with replacement, and each run generates a "bootstrap sample."[18] Bootstrap is recommended and allows estimating meaningful confidence intervals when dealing with a sample that is small and not random.[19]

Figure 17. Demonstration of a bootstrap process



The figure above shows a schematic of the bootstrap process for estimating the standard error of a statistic s(x). B bootstrap samples are generated from the original data set. Each bootstrap sample has n elements, generated by sampling with replacement n times from the original data set. Bootstrap replicates $s(x^{*1})$, $s(x^{*2})$… $s(x^{*B})$, are obtained by calculating the value of a statistic s(x) on each bootstrap sample. Finally, the standard deviations of the values $s(x^{*1})$, $s(x^{*2})$… $s(x^{*B})$ is our estimate of the standard error of s(x).

Source: An introduction to the bootstrap[20]

ANNEX 4. STUDY SAMPLE CHARACTERISTICS

Table 10. Detailed findings of sampling characteristics

	Volume weighted average, rounded														
	All	Facility -based	Temp. sites	Hanoi									Dak Lak		
				All			Urban			Peri-Urban			Remote		
				All	FB	TS	All	FB	TS	All	FB	TS	All	FB	TS
Number of sites	26	14	12	23	13	10	9	5	4	14	8	6	3	1	2
Vaccination team members	30	17	43	30	17	44	31	19	44	29	15	44	25	24	26
Vaccinators	7	2	13	8	3	13	7	3	11	9	2	16	2	1	2
Regular staff	9	10	7	9	11	7	11	15	6	6	6	7	8	8	8
Mobilized staff	21	7	36	22	6	37	20	4	37	23	9	37	17	16	18
Mobilized paid staff	14	4	24	14	4	25	14	2	27	14	7	22	12	12	11
Mobilized volunteers	7	2	12	7	2	13	6	2	10	9	2	16	6	4	7
Doses delivered per vaccinator/day	53	57	49	49	56	41	52	52	51	45	60	30	119	76	140
Doses delivered per vacc. team member/day	18	26	9	18	27	9	16	21	10	21	33	9	11	11	12
Person-minute spent to deliver one dose	28	15	42	29	15	43	35	21	50	22	8	35	22	7	29

ANNEX 5: DETAILED COST FINDINGS

Table 11. Financial, opportunity and economic cost per dose, by delivery strategy and time period, for program activities and resource types

		Overall			Delivery strategy						Time period					
					Facility-based			Temporary sites			Low volume			High-volume		
	***Note: True zero values in grey**	Fin	Opp	Eco	Fin	Opp	Eco	Fin	Opp	Eco	Fin	Opp	Eco	Fin	Opp	Eco
Program activities	Program management	0.00	0.06	0.06	0.00	0.05	0.05	0.00	0.06	0.06	0.02	0.31	0.33	0.00	0.05	0.05
	Vaccine collection, distribution and storage	0.04	0.03	0.07	0.07	0.04	0.11	0.02	0.03	0.05	0.77	0.43	1.20	0.02	0.02	0.04
	Cold chain maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00
	Training	0.01	0.03	0.03	0.01	0.05	0.06	0.01	0.01	0.02	0.06	0.24	0.31	0.00	0.02	0.03
	Social mobilization and advocacy	0.00	0.05	0.05	0.00	0.07	0.07	0.00	0.03	0.04	0.00	0.68	0.68	0.00	0.03	0.03
	Supervision	0.00	0.10	0.10	0.00	0.11	0.11	0.00	0.09	0.09	0.01	0.40	0.41	0.00	0.09	0.09
	Service delivery	0.53	0.68	1.21	0.55	0.58	1.13	0.52	0.72	1.24	1.02	0.88	1.90	0.52	0.67	1.20
	Record-keeping, monitoring and evaluation	0.00	0.12	0.13	0.01	0.04	0.05	0.00	0.16	0.16	0.07	0.12	0.19	0.00	0.12	0.12
	Waste management	0.01	0.01	0.02	0.01	0.01	0.03	0.01	0.00	0.01	0.11	0.03	0.14	0.01	0.01	0.01
	AEFI management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Microplanning and social mobilization	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.09	0.10	0.00	0.03	0.03	0.00	0.07	0.07
Resource types	Paid labor	0.00	0.86	0.86	0.00	0.84	0.85	0.00	0.87	0.87	0.01	2.68	2.69	0.00	0.81	0.81
	Unpaid overtime	0.00	0.08	0.08	0.00	0.05	0.05	0.00	0.09	0.09	0.00	0.06	0.06	0.00	0.08	0.08
	Volunteer labor	0.00	0.18	0.18	0.00	0.03	0.03	0.00	0.24	0.24	0.00	0.00	0.00	0.00	0.17	0.17
	Per diems & travel allowances	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00
	Injection incentives	0.26	0.00	0.26	0.28	0.00	0.28	0.25	0.00	0.25	0.75	0.00	0.75	0.25	0.00	0.25
	Immunization supplies	0.20	0.00	0.20	0.20	0.00	0.20	0.20	0.00	0.20	0.20	0.00	0.20	0.20	0.00	0.20
	Stationery & other supplies	0.07	0.00	0.07	0.07	0.00	0.07	0.07	0.00	0.07	0.07	0.00	0.07	0.07	0.00	0.07
	Transport & fuel	0.03	0.00	0.03	0.06	0.00	0.06	0.02	0.00	0.02	0.60	0.00	0.60	0.02	0.00	0.02
	Vehicle maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cold chain repairs & energy	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.13	0.13	0.00	0.00	0.00
	IEC & printing	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.09	0.09	0.00	0.00	0.00
	Workshops & meetings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00

	Other recurrent costs	0.02	0.00	0.02	0.03	0.00	0.03	0.02	0.00	0.02	0.26	0.00	0.26	0.01	0.00	0.01
	Cold chain equipment	0.01	0.01	0.02	0.01	0.01	0.03	0.00	0.01	0.01	0.12	0.16	0.28	0.00	0.01	0.01
	Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00
	Incinerators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OVERALL		**0.59**	**1.14**	**1.73**	**0.66**	**0.97**	**1.63**	**0.56**	**1.22**	**1.78**	**2.06**	**3.15**	**5.22**	**0.56**	**1.09**	**1.65**

Table 12. Financial, opportunity and economic cost per dose, across provinces and geographic areas, for program activities and resource types

		Province						Geographic area								
		Hanoi			Dak Lak			Urban			Peri-urban			Remote		
	***Note: True zero values in grey**	**Fin**	**Opp**	**Eco**	**Fin**	**Opp**	**Eco**	**Fin**	**Opp**	**Eco**	**Fin**	**Opp**	**Eco**	**Fin**	**Opp**	**Eco**
Program activities	Program management	0.00	0.06	0.06	0.00	0.03	0.03	0.00	0.05	0.06	0.00	0.07	0.07	0.00	0.03	0.03
	Vaccine collection, distribution and storage	0.04	0.03	0.07	0.02	0.04	0.06	0.03	0.03	0.06	0.05	0.03	0.08	0.02	0.04	0.06
	Cold chain maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Training	0.01	0.03	0.03	0.00	0.02	0.02	0.01	0.02	0.03	0.00	0.03	0.03	0.00	0.02	0.02
	Social mobilization and advocacy	0.00	0.05	0.05	0.00	0.00	0.01	0.00	0.08	0.08	0.00	0.02	0.02	0.00	0.00	0.01
	Supervision	0.00	0.10	0.10	0.01	0.03	0.04	0.00	0.17	0.17	0.00	0.02	0.02	0.01	0.03	0.04
	Service delivery	0.53	0.70	1.23	0.42	0.44	0.86	0.51	0.95	1.45	0.57	0.40	0.97	0.42	0.44	0.86
	Record-keeping, monitoring and evaluation	0.00	0.13	0.13	0.01	0.07	0.07	0.00	0.14	0.14	0.01	0.12	0.12	0.01	0.07	0.07
	Waste management	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.00	0.01	0.01
	AEFI management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Microplanning and social mobilization	0.00	0.06	0.06	0.01	0.25	0.26	0.00	0.01	0.01	0.00	0.11	0.11	0.01	0.25	0.26
Resource types	Paid labor	0.00	0.87	0.87	0.00	0.74	0.74	0.00	1.08	1.09	0.62	0.62	0.62	0.00	0.74	0.74
	Unpaid overtime	0.00	0.08	0.08	0.00	0.04	0.04	0.00	0.14	0.14	0.00	0.02	0.02	0.00	0.04	0.04
	Volunteer labor	0.00	0.18	0.18	0.00	0.05	0.05	0.00	0.21	0.21	0.00	0.15	0.15	0.00	0.05	0.05
	Per diems & travel allowances	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02
	Injection incentives	0.27	0.00	0.27	0.13	0.00	0.13	0.25	0.00	0.25	0.29	0.00	0.29	0.13	0.00	0.13
	Immunization supplies	0.20	0.00	0.20	0.19	0.00	0.19	0.19	0.00	0.19	0.00	0.00	0.21	0.19	0.00	0.19
	Stationery & other supplies	0.07	0.00	0.07	0.07	0.00	0.07	0.07	0.00	0.07	0.00	0.00	0.07	0.07	0.00	0.07

	Transport & fuel	0.03	0.00	0.03	0.02	0.00	0.02	0.03	0.00	0.03	0.04	0.00	0.04	0.02	0.00	0.02
	Vehicle maintenance	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
	Cold chain repair & energy	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01
	IEC & printing	0.00	0.01	0.01	0.01	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.02
	Workshop & meetings	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Others recurrent costs	0.02	0.00	0.02	0.03	0.00	0.03	0.02	0.00	0.02	0.02	0.00	0.02	0.03	0.00	0.03
	Cold chain equipment	0.01	0.01	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.03	0.02	0.03	0.00	0.01	0.01
	Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Incinerators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OVERALL		**0.60**	**1.16**	**1.76**	**0.48**	**0.89**	**1.37**	**0.56**	**1.46**	**2.02**	**0.64**	**0.81**	**1.45**	**0.48**	**0.89**	**1.37**

Table 13. Financial, opportunity and economic cost per dose, across time periods and delivery strategies, for program activities and resource types

		Low-volume period						High-volume period					
		Facility-based			Temporary			Facility-based			Temporary		
	***Note: True zero values in grey**	**Fin**	**Opp**	**Eco**	**Fin**	**Opp**	**Eco**	**Fin**	**Opp**	**Eco**	**Fin**	**Opp**	**Eco**
Program activities	Program management	0.02	0.31	0.33	0.02	0.32	0.34	0.00	0.03	0.03	0.00	0.06	0.06
	Vaccine collection, distribution and storage	0.79	0.40	1.19	0.68	0.55	1.23	0.02	0.01	0.03	0.02	0.03	0.05
	Cold chain maintenance	0.00	0.02	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Training	0.06	0.28	0.33	0.09	0.09	0.18	0.00	0.04	0.04	0.01	0.01	0.02
	Social mobilization and advocacy	0.00	0.73	0.73	0.00	0.42	0.42	0.00	0.02	0.03	0.00	0.03	0.03
	Supervision	0.01	0.38	0.39	0.01	0.49	0.50	0.00	0.09	0.09	0.00	0.09	0.09
	Service delivery	1.01	0.90	1.91	1.10	0.78	1.88	0.52	0.58	1.10	0.52	0.71	1.23
	Record-keeping, monitoring and evaluation	0.08	0.13	0.21	0.00	0.09	0.09	0.00	0.03	0.04	0.00	0.15	0.15
	Waste management	0.09	0.04	0.13	0.19	0.00	0.19	0.01	0.01	0.02	0.01	0.00	0.01
	AEFI management	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Microplanning and social mobilization	0.00	0.03	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.10	0.10
Reso	Paid labor	0.01	2.74	2.75	0.01	2.40	2.41	0.00	0.73	0.73	0.00	0.85	0.85
	Unpaid overtime	0.00	0.06	0.06	0.00	0.05	0.05	0.00	0.05	0.05	0.00	0.09	0.09

	Volunteer labor	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.23	0.23
	Per diems & travel allowances	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Injection incentives	0.73	0.00	0.73	0.84	0.00	0.84	0.25	0.00	0.25	0.25	0.00	0.25
	Immunization supplies	0.20	0.00	0.20	0.19	0.00	0.19	0.20	0.00	0.20	0.20	0.00	0.20
	Stationery & other supplies	0.07	0.00	0.07	0.07	0.00	0.07	0.07	0.00	0.07	0.07	0.00	0.07
	Transport & fuel	0.60	0.00	0.60	0.59	0.00	0.59	0.02	0.00	0.02	0.02	0.00	0.02
	Vehicle maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cold chain repair & energy	0.00	0.15	0.15	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00
	IEC & printing	0.00	0.10	0.10	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Workshops & meetings	0.03	0.00	0.03	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
	Others recurrent costs	0.26	0.00	0.26	0.28	0.00	0.28	0.01	0.00	0.01	0.01	0.00	0.02
	Cold chain equipment	0.14	0.14	0.28	0.04	0.25	0.29	0.00	0.00	0.01	0.00	0.01	0.01
	Vehicles	0.00	0.03	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	Incinerators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OVERALL		**2.07**	**3.22**	**5.29**	**2.03**	**2.83**	**4.85**	**0.56**	**0.83**	**1.39**	**0.56**	**1.19**	**1.75**

Figure 18. Relationship between volume and cost per dose, for all immunization sites