The Costs of Different Vaccine Delivery Strategies to Reach Children Up to 18 Months in Rural and Urban Areas in Tanzania

Final Report

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This study was conducted by Fatuma Manzi, PhD, and Kassimu Tani, MA, from Ifakara Health Institute (IHI), in collaboration with the Ministry of Health, Community Development, Gender, Elderly and Children (MOHCDGEC), Immunization and Vaccine Development (IVD) Program, as part of the Immunization Costing Action Network (ICAN). ICAN was facilitated by ThinkWell and John Snow, Inc. (JSI) and supported by the Bill & Melinda Gates Foundation.

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ACRONYMS

AEFI	Adverse event following immunization
BCG	Bacillus Calmette-Guérin
BMGF	Bill & Melinda Gates Foundation
CCHP	Comprehensive Council Health Plan
cMYP	Comprehensive Multi-Year Plan
DHS	Demographic and Health Survey
DIVO	District Immunization and Vaccine Officer
DTP	Diphtheria, Tetanus and Pertussis
EPI	Expanded Programme on Immunization
EPIC	EPI Costing and Financing Project
FIC	Fully immunized child
FTE	Full-time equivalent
HepB	Hepatitis B
Hib	Haemophilus influenzae type B
HPV	Human Papilloma Virus
HSPH	Harvard T.H. Chan School of Public Health
ICAN	Immunization Costing Action Network
ICC	Inter-Agency Coordinating Committee
IDC	Immunization delivery cost
IEC	Information, education and communication
IHI	Ifakara Health Institute
IPV	Inactivated Polio Vaccine
IRB	Institutional Review Board
IVD	Immunization and Vaccine Development Program
JSI	John Snow, Inc.
LMIC	Low- and middle-income countries
MSD	Medical Stores Department
MOHCDGEC	Ministry of Health, Community Development, Gender, Elderly and Children
MR	Measles/Rubella
NIMR	National Institute for Medical Research
OPV	Oral Polio Vaccine
PCV	Pneumococcal Conjugate Vaccine
PI	Principal Investigator
PO-RALG	President's Office - Regional Administration and Local Government
RCHCO	District Reproductive and Child Health Coordinator
UNICEF	United Nations Children's Fund
USD	US dollar
WHO	World Health Organization

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EXECUTIVE SUMMARY

Background

The United Republic of Tanzania is preparing to enter the Gavi Preparatory Transition Phase in 2020, meaning the Government of Tanzania will need to invest more funds to support the immunization program, both for vaccines and injection supplies as well as immunization delivery costs.[1] Reliable cost information is required to make a case to the Ministry of Finance and Planning to mobilize resources for the delivery of the existing schedule of vaccines and inform new vaccine introduction planning.

At the same time, the budgeting and planning processes and procedures are not always well understood by district-level government planners, some of whom may not be deeply familiar with immunization, leading to lower prioritization of the program. In turn, this may lead to shortages in financing to support the delivery of immunization services. Lack of sufficient funds for immunization delivery costs may force cancellation of outreach and mobile sessions, important in a country where 71% of the population lives in rural and hard to reach areas and 17% of the population is nomadic.

With this background in mind, the 2016-2020 Comprehensive Multi-Year Plan (cMYP) identified the need to conduct a study about the cost per

Box 1. Research Question and Key Findings

Research question: What is the average delivery cost to immunize children up to 18 months in rural and urban areas at current coverage levels and using the current mix of delivery strategies (fixed facility delivery, outreach and mobile)?

Key findings:

- Vaccine delivery costs are estimated to total US$21.8 million/year (exclusive of vaccine, injection supply and labor costs). By level of the health system, delivery costs are incurred at facility (72.4%), district (20.5%), regional (7.0%) and national (0.5%) levels. This equates to a cost per dose of US$0.67 and a cost per capita of US$0.38.
- Looking only at facility-level costs, delivery costs are an estimated US$2,200 per year (facility average), equating to a cost per dose of US$0.45 at rural facilities which include nomads in their catchment population, US$0.48 per dose at urban facilities, and US$0.56 per dose at rural facilities which do not include nomads. The main delivery cost drivers are cold chain equipment & energy, and per diem & travel allowances.
- The cost per fully immunized child (FIC) defined as Measles/Rubella 1st dose is US$7.35 in rural areas without nomads, US$8.33 in rural areas with nomads, and US$8.89 in urban areas.
- Overall, outreach is more than three times as expensive as facility-based delivery (US$1.47 versus US$0.43), but the magnitude of the difference varies immensely by geography. Outreach is more expensive in rural areas than in urban areas, presumably due to the distances covered. None of the 51 sampled facilities conducted mobile sessions, reportedly due to a lack of sufficient funds for delivery. Mobile delivery is likely more expensive than outreach due to greater distances covered.

Use of findings: The timing of the release of these study findings is ideal for their use in both annual budgeting and planning processes as well as multi-year planning. At sub-national level, the development of the Comprehensive Council Health Plans (CCHPs) provides a key opportunity to use the delivery cost findings to better budget for immunization. At national level, guidelines that inform this process should be updated. Additionally, the five-year National Health Plan and comprehensive multi-year plan (cMYP) for 2021-2025 are currently being developed. Study findings can inform cost projections and budget impact analyses for national and/or district level delivery activities and new vaccine introductions.

[1] Delivery costs are sometimes called operational costs, and are defined as those costs associated with delivering immunizations to target populations, exclusive of vaccine costs. In the context of Tanzania, we have also excluded injection supplies (e.g. safety boxes, diluents, reconstitution syringes) and paid human resources (labor) from delivery costs as these items are funded centrally and undergo a different process for resource mobilization. Delivery costs may include any or all of the following recurrent and capital cost items: (1) volunteer human resources, (2) per diem and travel allowances, (3) cold chain equipment and their overheads (e.g. energy, maintenance, repairs), (4) vehicles, transport and fuel, (5) program management, (6) training and capacity building, (7) social mobilization and advocacy, (8) disease surveillance and activities related to adverse events following immunization (AEFI), (9) buildings, utilities, other overheads and shared costs, (10)

fully immunized child in Tanzania. Although several immunization program costing studies have been done in Tanzania, all previous studies were limited to specific antigens especially for new vaccines, such as Rotavirus and Human Papilloma Virus (HPV) vaccines, and also for oral cholera vaccine used to respond to a cholera outbreak. Prior to this work, there was no study on the cost of delivering the full schedule of vaccines offered as part of the national expanded program on immunization.

Our study therefore aimed to estimate the cost to immunize children up to 18 months in rural and urban areas at current coverage levels and using the current mix of delivery strategies (see Box 1 for research question). Our study looked at the three delivery strategies used as part of routine immunization:

- Fixed facility delivery
- Outreach
- Mobile clinics to reach nomadic and hard-to-reach communities

While the majority of immunization sessions occur via fixed facility delivery, outreach sessions are used to reach populations living a short distance from the facility, typically reached by motorcycle and without requiring an overnight stay. Mobile clinics are for further distances, typically requiring a vehicle for transport and an overnight stay.

The vaccines included in our study are those on the immunization schedule up to 18 months, including OPV (4 doses), BCG (1 dose), DTP/HepB/Hib (3 doses), Measles/Rubella (2 doses), PCV13 (3 doses) and Rotavirus (2 doses).

During the period 2016-2019, ThinkWell and JSI provided technical support to the costing study within the context of the Immunization Costing Action Network (ICAN), a research and learning community working to increase the visibility, availability, understanding, and use of immunization delivery cost information. ICAN supported three countries – Indonesia, Tanzania and Vietnam – to build country capacity to generate and use cost evidence to inform planning, budgeting and decision making for the immunization program.

Methods

The study used ingredients-based costing from a government/provider perspective to retrospectively estimate the full, economic and financial immunization-related delivery costs[2] incurred at the facility, district, region and national levels during the period July 2016 to June 2017.

The sample included 4 regions randomly selected from the country's 7 mainland zones (excluding Zanzibar). Within each region, we randomly selected 2 districts (1 urban district and 1 rural district which does not include nomads in the catchment population ('rural without nomads')) and purposively selected 1 rural district which includes nomads in the catchment population ('rural with nomads'). Within each district, we randomly selected

waste management, (11) other supplies and recurrent costs, and (12) other non-vaccine costs. Definition adapted from Vaughan, et. al. (2019).

[2] Economic costs represent the value of all resources used to deliver the immunization program, i.e. financial outlays plus opportunity costs of volunteer time and any donated items such as vaccines. Financial costs are limited to financial outlays, usually with straight-line depreciation of capital assets (i.e., total cost of item divided by the number of years it will be used, without any discounting).

four or five health facilities, for a total sample of 4 regions, 12 districts and 54 facilities. Three facilities were later dropped from the sample due to poor data quality.

Because of small differences in economic and financial costs, we present only economic costs in this summary. We include average total facility costs and unit costs, calculated using inverse probability of sampling weights and volume-weights. Unit costs include cost per dose and per fully immunized child (FIC), defined as a child who has received the second dose of Measles/Rubella at 18 months. For international comparison purposes, we also calculate cost per FIC defined as DTP3. We analyze costs by delivery strategy (facility, outreach, mobile) and by geographic area (urban, rural without nomads, and rural with nomads). We also analyze the main cost-driving activities and line items. Finally, we project the costs of the program nationally based on the calibration technique, using auxiliary information about national delivery volumes.

All results are presented in 2016 US dollars using a conversion rate of 1 USD = 2,177 Tanzania shillings (World Bank official exchange rate, period average for 2016).

Findings and discussion

This study found a very small difference in total delivery costs (facility average) by location, excluding the cost of vaccines, injection supplies and paid human resources (labor). The lowest costs were at facilities in rural areas without nomads (US$2,138/year), followed by rural areas with nomads (US$2,224) and then urban facilities (US$2,427/year). Cold chain equipment & energy is the main cost driving line item at all facility types when excluding the vaccine, injection supply and labor costs.

Cost per dose delivered is lowest at rural facilities which include nomads in their catchment population (US$0.45), followed by urban facilities (US$0.48) and rural facilities without nomads (US$0.56). Dividing total facility delivery costs by the number of fully immunized children (FICs), we estimate the cost per FIC overall to be US$8.04, defining FIC in terms of Measles/Rubella 1st dose. However, the cost per FIC is lower in rural areas with nomads (US$7.35) and higher in both rural areas without nomads (US$8.33) and urban areas (US$8.89).

By delivery strategy, this study confirmed that outreach is more expensive than facility-based delivery, but the magnitude of the difference varies immensely by geography. Overall, outreach is more than three times as expensive as facility-based delivery (US$1.47 versus US$0.43), but this is largely driven by the nearly five-fold difference between the unit cost of outreach and facility delivery in rural areas without nomads (US$1.91 versus US$0.43). In urban areas, outreach is slightly more expensive than facility-based delivery (US$0.62 versus US$0.48), whereas in rural areas with nomads the difference is about three-fold (US$1.16 versus US$0.40). Outreach is more expensive in rural areas than in urban areas, presumably due to the distances covered. Surprisingly, facility-based delivery is more expensive in urban areas as opposed to rural areas.

Planned mobile sessions were cancelled in all of the sampled facilities during the year of our study, an interesting finding in and of itself and reflective of challenges with funding for delivery costs at district level. Our estimation is that mobile would be more expensive than outreach or facility-based delivery due to the greater distances to be covered and use of motor vehicles (as opposed to motorcycles and buses/taxis for outreach). Allocating sufficient funding for delivery costs would help ensure mobile delivery can happen as scheduled, although increasing facility-based delivery at existing sites, particularly those in rural areas, may be preferable in terms of cost implications for the immunization program.

Coverage would need to be monitored to ensure nomads and other populations living in hard-to-reach areas continue to access services.

The total cost of the immunization program, including facility, district, regional and national level costs, is estimated to be US$138.2 million, or US$2.41 per capita based on a population of 57.31 million. These estimates include vaccine, injection supply and labor costs. This equates to a cost per dose of US$3.99. By level of the health system, 87% of these costs are incurred at facility level, 4% at district level, 1% at regional level and 8% at national level. Delivery costs only (total costs minus the vaccine, injection supply and labor costs) totals US$21.8 million, or 15.8% of the total program cost. By level of the health system, the delivery cost portion of total costs is comprised of facility-level costs (72.4%), district-level costs (20.5%), regional costs (7.0%) and national costs (0.5%). The immunization delivery cost per dose and per capita, including costs from all levels of the health system, equate to US$0.67 and US$0.38 respectively.

Overall our analysis found a high level of variability in the data and some surprising findings. These results may reflect the patient mix that came to certain facilities in the sample during the study period, and/or reflect unique characteristics of some of the sampled facilities which cause them to have higher or lower delivery volumes than usual, or higher or lower costs than usual. Examples of unique characteristics of our sampled sites include some sites that receive patients from nearby facilities where vaccination is not offered, leading to a higher than expected number of doses delivered, and sites that collected vaccines daily from the district because of lack of cold chain equipment, leading to higher vaccine collection/transport costs. These results could also be the result of errors in administrative and/or study data collection, or other data challenges. Notably, data related to the number of FICs was confusing. There were also a large number of facilities with missing data, requiring us to drop three facilities from the sample and leading us to impute to fill in some gaps, primarily in the number of doses delivered, for a number of other facilities. However, in a representative sample as large as ours, one would not expect these cases to have a large impact on the average results. Given the size of our sample we remain confident in the results.

Findings are largely in line with other Sub-Saharan Africa countries. In four recent studies from Benin[3], Ghana[4], Uganda[5] and Zambia[6], the reported economic cost per dose delivered ranged from US$0.75 to $US3.18, including injection supply costs but excluding vaccine costs. This puts Tanzania's delivery cost per dose of US$1.28 (also including injection supply costs but excluding vaccine costs) at the lower end of this range.

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Opportunities for use of results

Developing sufficient budgets for vaccination activities in Tanzania has been challenging as baseline cost estimates have been unavailable and districts do not know their delivery costs. The amount of funds needed for outreach and other delivery strategies has been estimated primarily relying on historical expenditures. In this context, these findings can provide valuable insights into the cost of different delivery strategies across a range of urban, rural and nomad settings. Interviews carried out with immunization stakeholders in Tanzania identified several key opportunities with potential entry points for the presentation and use of the ICAN study results:

1. Annual budgeting and planning process: The findings can be used for planning at different levels to help determine efficiencies and maximize local resources. Tanzania's decentralized system for budgeting and planning presents a key opportunity to use ICAN findings at the facility and district levels. Funds for operational activities are included in the budget of the Comprehensive Council Health Plan (CCHP) that local governments prepare annually starting in October based on national guidelines that are revised every few years. The release of the study findings is timely for their inclusion in the budgets currently being developed, which will be approved by parliament in June 2020. At the national level, the next revision of the guidelines could be a key entry point for the use of ICAN findings.
2. National Health Plan and cMYP development: The next five-year National Health Plan, as well as the immunization comprehensive multi-year plan (cMYP), will run from 2021-2025. Plans and budgets will be drawn up for the next plan starting from mid-2019 until mid-2020, so the timing is opportune for the use of ICAN evidence for costing national and/or district level delivery activities and new vaccine introductions.
3. Directed Health Facility Funding (DHFF): DHFF is a payment directly to health facility bank accounts which is an output-based payment to facilities to better match payment to priority services and empower facilities to manage funds and procure inputs to deliver health services to their communities. It is used to strengthen basic financial management systems, PlanRep and Facility Financial Accounting and Reporting System (FFARS). The findings can now enable more targeted strategy considerations and potentially better predictability on operational costs.

The ICAN research team is working closely with the MoHCDGC and PO-RALG to ensure that the research findings are shared both at the national and regional/district levels, and with key stakeholders involved in the Health Plan development as well. Given the large sample designed to be nationally representative, these findings present an excellent opportunity for greater accuracy of planning and budgeting and potentially a more effective use of immunization resources in Tanzania.

BACKGROUND

This study was carried out as part of the Immunization Costing Action Network (ICAN), led by ThinkWell and John Snow Inc. (JSI) and supported by the Bill & Melinda Gates Foundation (BMGF). The ICAN is a research and learning community working to increase the visibility, availability, understanding, and use of immunization delivery cost information. During the period 2016-2019, the ICAN aimed to build country capacity to generate cost evidence that is policy relevant and a priority for the immunization program. The ICAN also worked with countries to improve interpretation and translation of cost evidence so that it is used in country decision-making processes and informs routine planning and budgeting.

Designed and implemented by researchers from the Ifakara Health Institute (IHI), with technical support from ThinkWell, the study benefited from strong engagement from the Ministry of Health, Community Development, Gender, Elderly and Children (MOHCDGEC), Immunization and Vaccine Development (IVD) Program, the MOH Directorate of Finance and Planning, and other key stakeholders. The Need for Cost Evidence at the National and Subnational Levels

Over the last two decades, great strides have been made in expanding the coverage of routine and new vaccines, in part through better understanding the cost of delivering immunization services. However, as Tanzania and other low- and middle-income countries (LMICs) continue to drive towards achieving high and equitable coverage of life-saving vaccines and introduce new vaccines, all while transitioning from donor- to self-funded immunization programs, the availability of sustainable, equitable, and predictable financing for vaccine delivery is essential.

Country decision-making processes are increasingly demanding cost evidence to guide fundraising and advocacy efforts and inform routine planning and budgeting. Although more is known about delivery costs (i.e., immunization delivery costs or operational costs, see Box 2) now than twenty years ago, gaps in cost evidence remain, such as the costs of different delivery strategies and the variable cost of delivering the same vaccine across settings (Vaughan, et al., 2019). Historical funding levels and/or cost norms, rather than primary cost evidence, are often used to plan and budget immunization programs which leaves the potential for insufficient and/or inefficient financing to sustain the programs. The performance of the immunization program is determined by how well the programs are managed, using available resources

Box 2. Definition of Immunization Delivery Costs (IDCs)

We define immunization delivery costs (IDCs) (also referred to as operational costs) as the costs associated with delivering immunization services to target populations, exclusive of vaccines. In the context of Tanzania, we have also excluded injection supplies (e.g. safety boxes, diluents, reconstitution syringes) and paid human resources (labor) from delivery costs as these items are funded centrally. Delivery costs may include any or all of the following recurrent and capital cost items: (1) volunteer human resources, (2) per diem and travel allowances, (3) cold chain equipment and their overheads (e.g. energy, maintenance, repairs), (4) vehicles, transport and fuel, (5) program management, (6) training and capacity building, (7) social mobilization and advocacy, (8) disease surveillance and activities related to adverse events following immunization (AEFI), (9) buildings, utilities, other overheads and shared costs, (10) waste management, (11) other supplies and recurrent costs, and (12) other non-vaccine costs.

Source: Adapted from Vaughan et al., 2019.

to achieve national targets. Appropriate estimation is required for the program to be implemented effectively and efficiently.

Objectives of the research study

Tanzania is preparing for an eventual transition from GAVI immunization financing support, which is likely to begin in 2021. The Government of Tanzania will need to invest more in delivery costs, and like other countries transitioning from donor to domestic financing, the government needs reliable immunization delivery cost evidence to inform the country's financial sustainability plan.

Currently, the cost to procure vaccines is almost exclusively covered by GAVI (95%), with the government funding 5% of the total costs. Delivery or operational costs are included in the budget of the Comprehensive Council Health Plan (CCHP) prepared by local governments. However, uncertainty regarding operational costs has typically led to budgeting for them based on historical expenditures plus some top up. Previous costing studies or relevant work that was done were focused only on specific antigens and/or defined geographic areas (see Annex 3), with limited potential to support broader budgeting for the immunization program.

Due to increasing pressure on domestic resources, Tanzania's 2016-2020 comprehensive multi-year plan (cMYP) called for a study to estimate the cost of delivering immunization services and to estimate the cost per fully immunized child (FIC). In response, this study aimed to generate reliable cost information to inform sustainability planning and support equitable and predictable financing for vaccine delivery. The specific objectives were to:

- Determine the use of different immunization delivery strategies (fixed facility delivery, outreach and mobile clinics) at existing coverage levels in urban and rural settings.
- Determine the cost of different immunization delivery strategies (fixed facility delivery, outreach and mobile clinics) at existing coverage levels in urban and rural settings.
- Examine the cost components that contribute to the total unit cost by level of the health system.
- Examine the cost breakdown by level of the health system.

Research question

In early 2017, the research team consulted the MOHCDGEC-IVD to understand what specific cost data the program needed to improve their planning and budgeting and program decision-making processes. The research question was developed following these discussions, when the need for a cost per FIC and per dose delivered through different delivery strategies was identified and validated with a group of stakeholders in March 2017. Therefore, the specific research question was: what is the average delivery cost to immunize children up to 18 months in rural and urban areas at current coverage levels and using the current mix of delivery strategies (fixed facility delivery, outreach and mobile)?

Fixed facility delivery is the predominate delivery strategy used in Tanzania, accounting for over half of the immunization budget. Outreach is used for shorter distances, with transport usually by motorcycle or bus/taxi and without an overnight stay. Mobile clinics

are for further distances, usually with a vehicle and requiring an overnight stay, and are mainly used to reach nomadic and hard-to-reach communities.

Study setting

The United Republic of Tanzania is comprised of the Tanzania mainland and the Islands of Zanzibar. It is the largest country in East Africa covering an area of 947,300 square kilometers. Mainland Tanzania has 26 administrative Regions and 186 districts (Councils).

The country's last census in 2012 estimated the country's mainland population to be 43.6 million (21.2 million men and 22.4 million women) with an average annual growth rate of 2.7% (The United Republic of Tanzania, 2013). Of the population, about 71% is estimated to be living in rural areas and among them 17% are living as nomads or in hard to reach areas. The crude birth rate is 41.6 per 1,000 population, and life expectancy at birth is 63 years for women and 60 years for men, respectively.

Expanded Programme on Immunization

The Tanzania IVD program is responsible for all immunization activities from the national to the community level. The IVD is tasked with ensuring that vaccines are delivered, that vaccine coverage rates are monitored and coverage targets are achieved. The IVD is also responsible for the introduction of new vaccines into the national schedule.

Our study is focused on the antigens provided to children up to 18 months as of 2016 (Table 1). The country's current immunization schedule (as of 2019) includes the below vaccines plus IPV and HPV, which were not included in the study.

Table 1. Overview of the Tanzania immunization schedule (up to 18 months)

Antigens	Age	Type of Fully Immunized Child (FIC)
OPV0	At birth up to 14 days	DTP3
BCG	At birth or first contact	
OPV1, DTP-HepB-Hib1, PCV13 1, Rota 1	6 weeks	
OPV2, DTP-HepB-Hib2, PCV13 2, Rota 2	10 weeks	
OPV3, DTP-HepB-Hib3, PCV13 3	14 weeks	
Measles/Rubella – 1st dose	9 months	Measles/Rubella 1
Measles/Rubella – 2nd dose	18 months	Measles/Rubella 2

The key vaccines are presented in the table below, with detail on the vaccine characteristics, including the packaging (doses/vial and size), formulation (liquid or reconstituted), type of syringes used for administration, and an indication of vaccine coverage (

Table 2).

Table 2. Characteristics of vaccines included in the study

Vaccine	Number of required doses	Packaging (doses per vial)	Formulation	Vaccine coverage (2017)
OPV	4	20 doses	Liquid	96%
BCG	1	20 doses	Reconstituted	131%
DTP-HepB-Hib	3	10 doses	Liquid	99%
PCV13	3	1 dose	Liquid	99%
Rotavirus	2	1 dose	Liquid	101%
Measles/Rubella (MR)	2	10 doses	Reconstituted	79%

Source for coverage data: WHO/UNICEF, 2017.

All vaccines are procured through UNICEF procurement processes and delivered through the Medical Stores Department (MSD), which is responsible for delivering vaccines to the regional level.

There were an estimated 23.8 million doses delivered as part of the EPI in 2017. Nationwide, coverage of DTP3 is estimated to be 99%, while Measles-Rubella 2nd dose (MR2) is 79% (WHO/UNICEF, 2017).

METHODOLOGY

Overview

This study estimates the health system's costs of delivering immunization services during the financial year July 2016 to June 2017. The study estimated both economic and financial costs from a government perspective. Costs from all levels of the health system, including facility, district, region and national, are included. We focused on routine immunization, defined as services provided regularly as part of the government program at facilities and through outreach and mobile clinics. Immunization services provided by private providers and any supplementary immunization activities taking place during the study period were excluded. We used ingredients-based costing, where the full costs and quantities of inputs used for immunization were valued.

Definitions

Although the focus of the research is on immunization delivery costs (IDCs; see Box 2), we also collected information on vaccines and consumables costs to provide a comprehensive overview of immunization program costs. Some other important definitions used throughout this report include:

Cost line items and cost activities: in this research, we differentiated between cost line items and cost of activities, similar to the Expanded Program on Immunization (EPIC) project studies (Brenzel, 2014). The separate categories are essentially two sides of the same coin; the sum of cost line items should equal the sum of cost activities. Line items are inputs used (e.g., human resources, vaccines, buildings) whereas cost activities reflect the implementation of the EPI resulting from the combination of different inputs (e.g.,

school-based delivery, supervision). The cost line items and cost activities are detailed in Annex 1.

Delivery strategies: mechanisms employed to reach target populations for immunization, according to the Tanzania health system structure. The delivery strategies used in Tanzania include fixed facility delivery (greater than 50% of immunization budget), outreach and mobile clinics. Outreach is used for shorter distances, with transport usually by motorcycle or bus/taxi and without an overnight stay. Mobile clinics are for further distances, usually with a vehicle and requiring an overnight stay, and are mainly used to reach nomadic and hard-to-reach communities.

Economic costs: Financial outlays plus opportunity costs of volunteer time and any donated items such as vaccines.

Financial costs: Financial outlays, usually with straight-line depreciation of capital items (i.e., total cost of item / number of years it will be used, without any discounting).

Fully immunized child (FIC): a child who has completed all doses in the schedule up to the second dose of measles (i.e., up to 18 months).

Sampling strategy

The sampling strategy was developed in consultation with the MOHCDGEC-IVD and following the principles used in the EPIC studies to oversample rural areas. The study was designed to be nationally representative, and the sample reflects that. Both random and purposive selection were used at different stages to arrive at the sampled sites.

First, the study categorized the country into seven geographically-defined zones, namely northern, eastern, southern, western, central, southern highland and lake zones. These zones were further recategorized into four regions based on coverage levels as reported in the Demographic and Health Survey (DHS) 2015-16: high, high-medium, medium and low[7]. Zanzibar was excluded from the study as it has its own IVD Program and modus operandi.

Within each region, we randomly selected two districts: 1 urban district and 1 rural district which does not include nomads in the catchment population. Purposive selection was used to select 1 rural district which includes nomads in the catchment population. Within each district, we randomly selected four health facilities (five in rural districts with nomads).

The resulting sample includes four regions, 12 districts and 54 facilities (

[7] The average vaccine coverage results of DHS 2015/16 and the recategorization into 4 zones is as follows: 1) high coverage (83%; central, southern highland and eastern); 2) high to medium coverage (80%; southern zone; 3) medium coverage (70%; lake zone); 4) lowest coverage (66-67%; western and south western). The northern zone was excluded owing to highest vaccination coverage and a different ongoing costing study by PATH through the Better Immunization Data (BID) initiative (http://bidinitiative.org).

Table 3). A full list of sampled facilities can be found in Annex 2.

Table 3. Overview of the sample

Regions	Districts	Health Facilities	Total Facilities
Random selection from the 8 zones, categorized into 4 groups based on coverage*	Random selection of 2 districts and purposive selection of 1 district**	Random selection of 4-5 health facilities per district***	
Region 1	3	5	15
Region 2	3	4	12
Region 3	3	5	15
Region 4	3	4	12
Total	**12 districts**	**54 facilities****	

* Northern zone omitted due to another ongoing study; Zanzibar excluded as it has its own IVD Program and modus operandi.
** Random selection of 1 urban district and 1 rural district which does not include nomads in the catchment population. Purposive selection of 1 rural district which includes nomads in the catchment population.
*** Five health facilities selected in rural districts with nomads.
**** Three facilities were later dropped from the sample due to data problems.

Data collection, cleaning and analysis

Two research officers from IHI experienced in costing studies participated in data collection and cleaning, supported by the Principal Investigator (PI), Fatuma Manzi. Data collection primarily took place from February to June 2018; during data cleaning (August-September 2018) some additional information was needed, which was obtained primarily via telephone from the facility In-Charge.

The team adopted two questionnaires and data analysis tools (one for facility-level, one for all other levels) developed and used by the EPIC studies in Benin, Ghana, Honduras, Moldova, Uganda and Zambia.[8] The study team worked with ThinkWell to tailor these recommendations and instruments to the Tanzania context. After some initial adjustments, the tools were pretested with the District Immunization and Vaccine Officer (DIVO) as well as the District Reproductive and Child Health Coordinator (RCHCO) at a health facility in Kisarawe district. They were then further modified. Before data collection began, both questionnaires were piloted in Kilosa district and further changes were made.

The facility-level questionnaire was used to obtain resource use and output information (doses delivered and children vaccinated) for all delivery strategies, as well as associated administrative and managerial activities. The cost of activities that were done in parallel with immunization were excluded from the analysis, for example growth monitoring, vitamin A supplementation, family planning and deworming. The questionnaire used at district, regional and national level collected similar administrative and managerial information. Data were captured from the facility and district registers, interviews with

[8] The EPIC studies used a common approach on facility sampling, data collection and analysis (Brenzel, 2014).

health workers, lists of inventory found in the immunization section at facility, district, regional and national levels, and national records. Since facilities did not routinely record the number of doses delivered through different delivery strategies, making it impossible to reliably deduce this information from existing registers, we asked facilities to provide records for the last three months for the number of doses delivered through each delivery strategy, up to the second dose of Measles/Rubella.

Two facilities from the originally chosen sample (1 hospital and 1 dispensary) were replaced by other facilities during actual data collection, as they were found not to be providing immunization services.

Immediately following data collection, data were entered in a Microsoft Excel-database tool previously used for the EPIC studies, which was modified to mimic our questionnaires. We performed validation checks to ensure data were entered properly and that answers were within a plausible range. A number of other steps were taken to ensure that the data collected were of high quality, including reviewing data collected periodically after a number of facilities were visited to identify trends with respect to missing information or poor quality data and trends with respect to data collectors' understanding and use of survey instruments. These reviews allowed the team to develop and implement strategies to collect better data at subsequent facilities and retrain data collectors as needed.

Data from each facility was entered into a separate workbook, and then summary total cost data from each workbook was combined into a single master file. The same was done for districts and regions, creating a second master file. We used Excel to check the data from these two master files for outliers using various simple analytic techniques, such as summary pivot tables and graphs with trendlines. We investigated any findings that appeared on visual inspection to be problematic to identify possible data entry errors. In cases of missing data, we imputed from similar facilities, mainly with regards to the number of doses delivered. Three facilities were ultimately dropped from the sample during data analysis due to the large amounts of missing data.

Shared inputs – including labor time and equipment and vehicles usage – were allocated to routine immunization and specific immunization activities on the basis of responses from staff on usage. We considered observation as a better way of assessing staff time usage, but were unable to coordinate data collection to coincide with all of the immunization activities we wanted to capture, some of which were quite infrequent (namely outreach and mobile clinics). Rather than asking salary information directly, which can be sensitive, the questionnaires captured health worker/staff cadre and seniority level. This information was then matched with the Ministry of Health salary scale to estimate monthly and annual salary.

Building space was allocated based on the share of facility area used for routine immunization activities including vaccine administration and vaccine storage. Capital costs such as equipment, training and vehicles were annualized based on useful lifetimes provided by ThinkWell, adapted from recently validated estimates for immunization, other costing studies and WHO CHOICE, and annualized using a discount rate of 3% (Brenzel, 2014; Brenzel L. , 2017; World Health Organization, 2017). Vaccine prices were extracted from UNICEF's website (UNICEF Supply Division, 2017).

We used both Microsoft Excel and the analysis package R. We include average total costs and unit costs, calculated using inverse probability of sampling weights and volume-weights, as opposed to calculating simple averages based on facility values. For ease of

communication, in the findings section we refer to these results simply as “averages”. Total costs sum the costs from all levels (facility, district, regional and national levels). Unit costs are presented as cost per dose and cost per FIC, defined as a child who has received the second dose of Measles/Rubella (MR2) at 18 months. For international comparison purposes, we also calculated the cost per FIC, defined firstly as completion of all doses up to DTP3 and secondly as completion of all doses up to first dose of Measles/Rubella (MR1). We project the costs of the program nationally based on the calibration technique, using auxiliary information about national delivery volumes. Two variables were used for calibration: total volume of DTP3 doses and total volume of MR2 doses delivered.

We analyze costs by delivery strategy (facility, outreach, mobile) and by geographic area (urban, rural without nomads, and rural with nomads). We also analyze the main cost-driving activities and line items. We did not remove any outliers or otherwise adjust the results; explanations for outlier findings are presented in the findings section. We used statistical methods to establish differences in unit costs by sub-group (delivery strategy and geographic area).

All results are presented in 2016 US dollars using a conversion rate of 1 USD = 2,177 Tanzania shillings (World Bank official exchange rate, period average for 2016).

Sensitivity analysis

Planned mobile sessions were cancelled in all 18 of the sampled facilities which planned mobile clinics during the year of our study, an interesting finding in and of itself and reflective of challenges with funding for delivery costs at district level. We performed a one-way sensitivity analysis to estimate what unit costs and delivery volumes would have been if this planned mobile delivery had been carried out. We assumed that mobile cost per dose delivered would be 20% higher than the total cost per dose of outreach-based service delivery (including vaccines, injection supplies and delivery-specific paid labor costs, but excluding costs shared across delivery strategies), given further distances. We divided costs shared across the three delivery strategies (facility, outreach, and mobile) and assumed the number of doses delivered via mobile would be 5% of current delivery volume.

Ethical clearance

Ethical approval was granted on 19 February 2018 by the National Institute for Medical Research (NIMR) with reference number NIMR/HQ/R.8a/Vol.IX/2702.

Stakeholder engagement

The research team engaged with a diverse group of stakeholders, including MOHCDGEC-IVD and the MOH Directorate of Finance and Planning, to develop and refine the research question and determine the study’s sample size. The team conducted stakeholder meetings with key partners (e.g., WHO, UNICEF, CHAI, PATH) to fine tune the proposed study. The team engaged the President’s Office - Regional Administration and Local Government (PO-RALG) to give clearance for data collection at regional, district and facility levels.

The team presented research progress at an ICC meeting mid-way through the research. JSI interviewed 20+ stakeholders to request input on using cost information from this study for planning and budgeting and program decision making. The team periodically engaged IVD staff for updates and review of study progress and interpretation of results.

Limitations

This study's main limitation relates to the quality of data available. The data collection team encountered poor record keeping at many facilities, which may have resulted in errors in administrative and/or study data collected. Notably, data related to the number of FICs was confusing. There were also a large number of facilities with missing data, requiring us to drop three facilities from the sample and leading us to impute to fill in some gaps, primarily in the number of doses delivered, for a number of other facilities. However, in a representative sample as large as ours, one would not expect these cases to have a large impact on the average results. Given the size of our sample we remain confident in the results.

The other, related challenge is that some immunization-related transport, for example for vaccine collection or outreach, is done by ambulances or vehicles provided by other government offices. Due to how records were kept, the costs of these forms of transport could not be collected, and therefore are excluded from our analysis.

FINDINGS

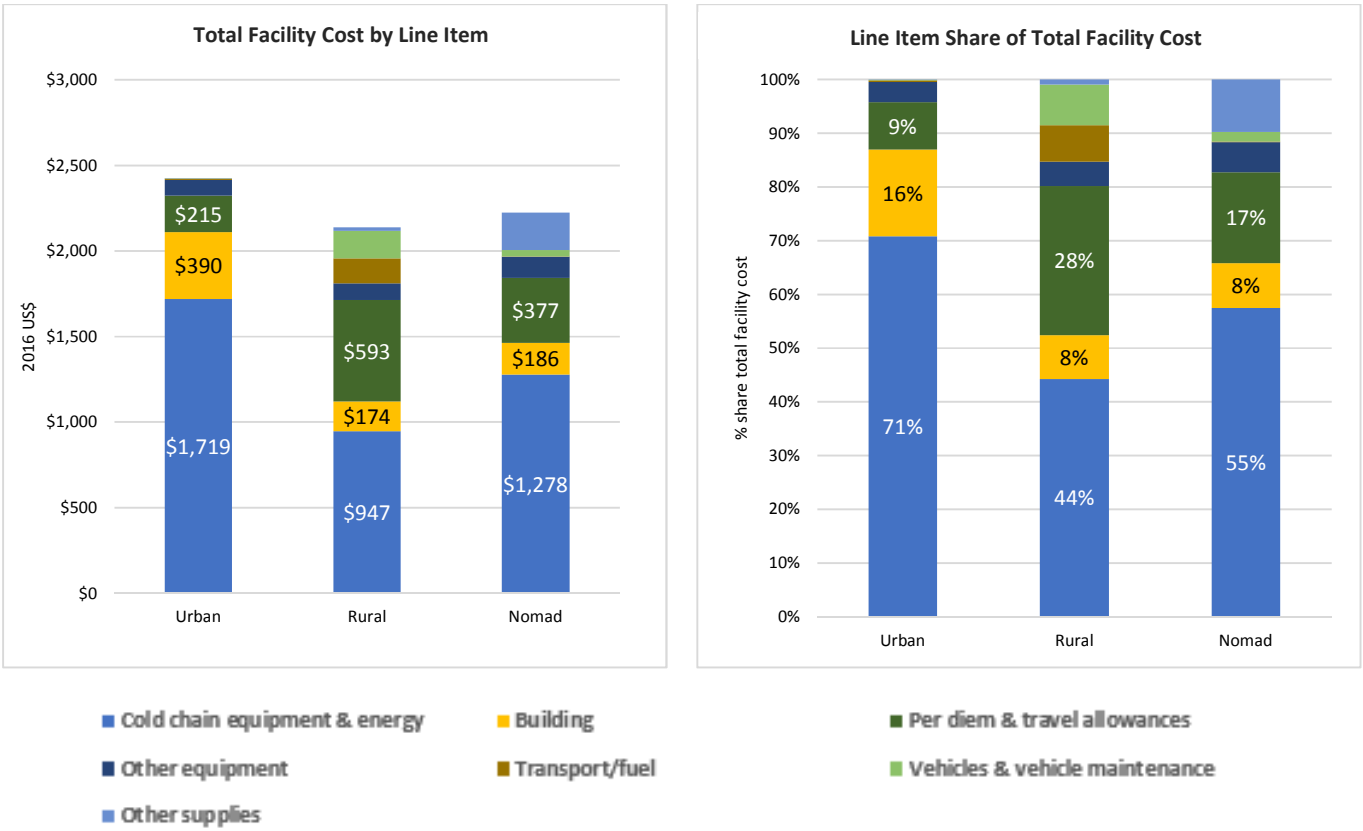
We present economic costs in the main body of the report; financial costs can be found in Annex 4. We found a small difference between economic and financial costs, meaning there is a financial outlay for most of the resources being used to deliver the immunization program. While Tanzania does use some volunteers in the health sector, the ones at our sampled facilities tended to do growth monitoring, vitamin A supplementation, and other activities, but were not involved in immunization. Other additional, more detailed findings can be found in Annex 5.

Findings are presented in 2016 US$. "Delivery costs" in the Tanzania context refers to costs exclusive of vaccines, injection supplies and paid human resources (labor) costs.

Delivery costs

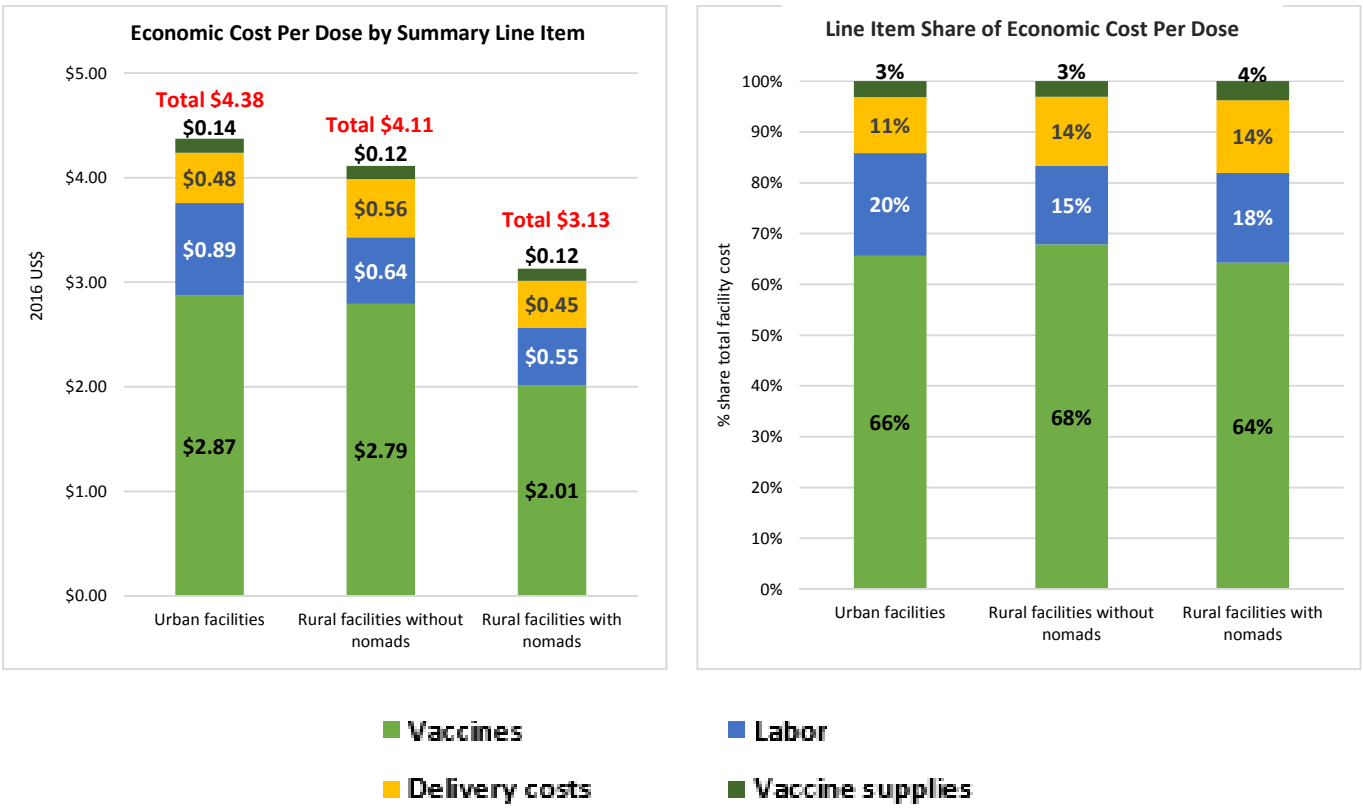
This study found a very small difference in total delivery costs (facility average, without the vaccine and injection supplies and paid labor costs) by location, with the lowest costs at facilities in rural areas without nomads (US$2,138/year), followed by rural areas with nomads (US$2,224) and then urban facilities (US$2,427/year) as shown in Figure 1. Excluding the vaccine and injection supply costs as well as paid labor, cold chain equipment & energy is the main cost driving line item at all facility types, accounting for up to 71% of costs at urban facilities as can be seen in Figure 1.

Figure 1. Immunization delivery economic costs by line item (facility average) (2016 US$)



As labor cost is centrally funded, our analysis separated this cost out from delivery costs. When labor is excluded from the definition of delivery costs, delivery costs amount to US$0.45 to US$0.56 (Figure 2, left), or 11% to 14% of the cost per dose delivered (Figure 2, right). When labor cost is included in the definition of delivery costs, this proportion increases to 29-32% of the cost per dose delivered (Figure 2, right).

Figure 2. Immunization delivery economic unit costs by line item (facility average) (2016 US$)



Although facilities in urban areas have the lowest delivery cost per dose, the costs per dose for paid human resources, vaccines and injection supplies are all higher. The higher vaccine and injection supplies costs in urban areas could be reflective of both more vaccines being delivered and/or delivery of more expensive vaccines, for example PCV and Rota. Further research could provide more insight on this issue. In terms of paid human resources, the higher labor costs in urban areas reflect a greater number of staff working on immunization in these facilities. In the sampled facilities there were an average of 1.29 full-time equivalent (FTE) staff for immunization in urban areas, in contrast to 1.05 in rural areas without nomads and 1.22 in rural areas with nomads (

Table 4). This extra staffing in urban facilities may be justified given the higher volumes of doses delivered. It may also indicate a possible opportunity to improve staff efficiency in rural areas with and without nomads where the average doses/FTE is much lower than in urban facilities.

Table 4. FTE analysis

Area	n	Total FTE for immunization	Hours/week for immunization	Total doses delivered	Average doses/FTE	FTE/ facility
Urban facilities	17	22.0	879.6	199,973	9,093	1.29
Rural facilities without nomads	20	21.1	843.9	113,495	5,379	1.05
Rural facilities with nomads	14	17.1	685.2	99,278	5,796	1.22

Delivery unit costs

The economic cost per dose delivered is lowest at rural facilities which include nomads in their catchment population (US$0.45 per dose), followed by urban facilities (US$0.48) and rural facilities without nomads (US$0.56 per dose), as detailed in Table 5.

By delivery strategy, this study confirmed that outreach is more expensive than facility-based delivery, but the magnitude of the difference varies immensely by geography. Overall, outreach is more than three times as expensive as facility-based delivery (US$1.47 versus US$0.43), but this is largely driven by the nearly five-fold difference between the unit cost of outreach and facility delivery in rural areas without nomads (US$1.91 versus US$0.43). In urban areas, outreach is slightly more expensive than facility-based delivery (US$0.62 versus US$0.48), whereas in rural areas with nomads the difference is about three-fold (US$1.16 versus US$0.40). Outreach is more expensive in rural areas than in urban areas, presumably due to the distances covered. Surprisingly, facility-based delivery is more expensive in urban areas as opposed to rural areas.

Table 5. Delivery economic unit costs per dose (excluding vaccines, injection supplies and labor costs) (facility average) (2016 US$)

Type of cost	All delivery strategies	Facility-based delivery	Outreach-based delivery*
All health facilities (n=51)	0.49	0.43	1.47
Urban areas (n=17)*	0.48	0.48	0.62
Rural areas without nomads (n=20)*	0.56	0.43	1.91
Rural areas with nomads (n=14)*	0.45	0.40	1.16

* Outreach-based delivery was not used in all areas. In the 17 urban areas, 6 used outreach. In the 20 rural areas without nomads, 13 used outreach. In the 14 rural areas with nomads, 8 used outreach.

Dividing total facility delivery costs by the number of fully immunized children (FICs), we estimate the cost per FIC overall to be US$8.04 (Table 6), defining FIC in terms of Measles/Rubella 1st dose (MR1). However, the cost per FIC is lower in rural areas with nomads (US$7.35) and higher in both rural areas without nomads (US$8.33) and urban areas (US$8.89). Measles/Rubella 2nd dose (MR2) FIC is highest in rural areas without nomads and lowest in urban areas. In contrast, the cost per DTP3 FIC is highest in rural areas without nomads and lowest in rural areas with nomads.

These results may be unusual, because normally the cost per DTP3 FIC is lower than the cost per MR1 or MR2 FIC, due to more children reaching DTP3 than MR1 and MR2. These results may reflect the patient mix that came to certain facilities in the sample during the study period and/or may be the result of errors in administrative and/or study data collected.

Table 6. Delivery economic unit costs per FIC (excluding vaccines, injection supplies and labor costs) (facility average) (2016 US$)

Type of cost	Measles/ Rubella 1st dose	Measles/ Rubella 2nd dose	DTP3
All health facilities (n=51)	8.04	10.42	8.27
Urban areas (n=17)*	8.89	8.09	8.28
Rural areas without nomads (n=20)*	8.33	11.38	8.86
Rural areas with nomads (n=14)*	7.35	11.30	7.70

* Outreach-based delivery was not used in all areas. In the 17 urban areas, 6 used outreach. In the 20 rural areas without nomads, 13 used outreach. In the 14 rural areas with nomads, 8 used outreach.

Doses delivered

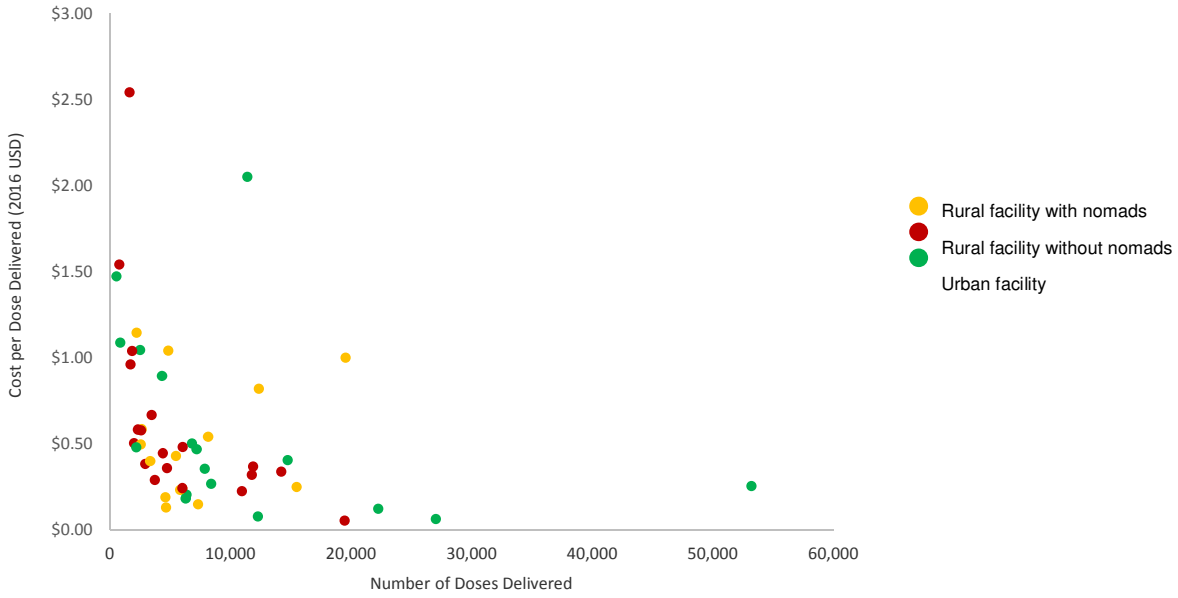
The average number of doses delivered at urban facilities was more than double those delivered at rural facilities either with or without nomads, as could be expected due to a higher population density in urban areas. The lowest volumes are in rural facilities without nomads. The average number of FIC per facility follows a similar pattern, as detailed in Table 7.

Table 7. Average number of doses delivered and FICs per facility

Area	Average doses delivered per facility	Average number of FICs per facility		
		Measles/ Rubella 1st dose	Measles/ Rubella 2nd dose	DTP3
Urban facilities	25,027	1,219	1,028	1,544
Rural facilities without nomads	9,646	527	381	547
Rural facilities with nomads	10,662	637	396	576

As can be seen in Figure 3, there is a negative association between economic cost per dose delivered and the number of doses delivered in that as the number of doses delivered increases, the cost per dose decreases. However, there is still high variability in the cost per dose at similar delivery volumes.

Figure 3. Delivery cost per dose (2016 US$) vs number of doses delivered



Mobile delivery

The estimated economic cost per dose of mobile delivery is US$5.76 as shown in Table 8. This estimate includes vaccines, injection supplies and labor costs as we could not separate out the delivery portion of the modelled mobile delivery cost due to lack of data and too much uncertainty around assumptions that would have to be made. We did not estimate the impact of mobile delivery on total costs since we don't know how many mobile doses were or should have been delivered nationwide.

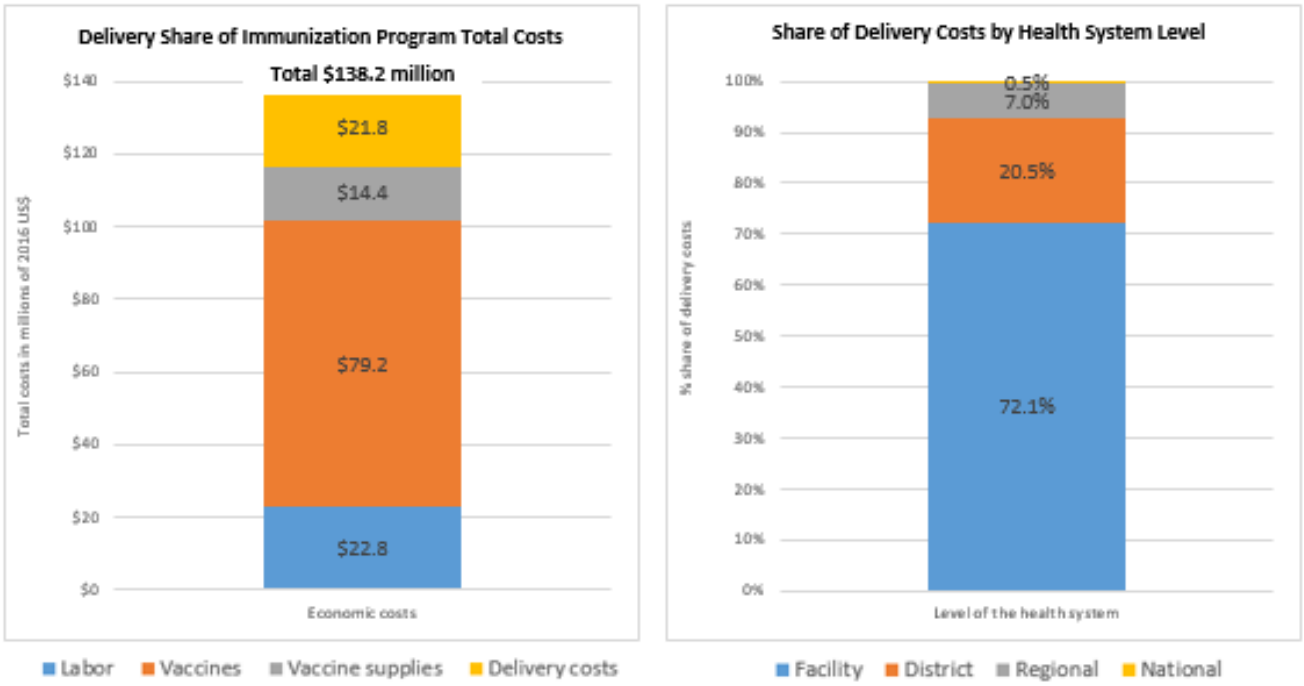
Table 8. Mobile delivery sensitivity analysis findings (including vaccines, injection supplies and labor costs) (2016 US$)

Type of cost	Existing delivery (2016 US$) (including vaccines, injection supplies and labor)			With mobile delivery (2016 US$) (including vaccines, injection supplies and labor)		
	Facility-based delivery	Outreach-based delivery	Mobile delivery (n=18)	Facility-based delivery	Outreach-based delivery	Mobile delivery (n=18)
Economic cost per dose delivered	3.62	5.88	N/A	2.92	5.15	5.76

Delivery cost share of total costs

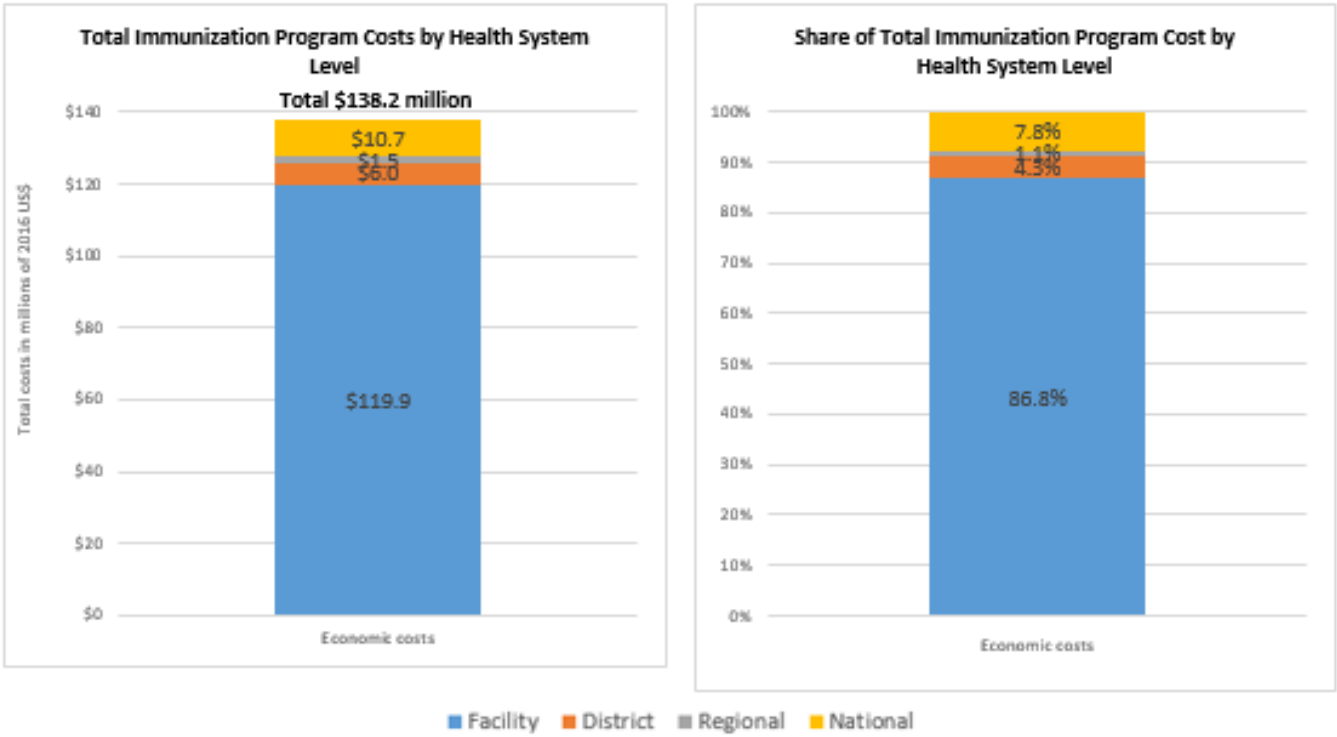
Delivery costs make up 21.8% of the total economic cost of the immunization program, as shown in Figure 4 (left). By level of the health system, the *delivery* portion of total costs is comprised of facility-level costs (72.1%), district-level costs (20.5%), regional costs (7.0%) and national level costs (0.5%) (Figure 4, right). Including costs from all levels of the health system equates to an economic cost per dose of US$0.67 and an economic cost per capita of US$0.38.

Figure 4. Delivery economic costs as share of total immunization program costs and by health system level (2016 US$)



The total economic cost of the immunization program, including facility, district, regional, and national level costs is estimated to be US$138.2 million or US$2.41 per capita, based on a population of 57.31 million (The World Bank, 2019). In addition to delivery costs, this estimate includes vaccine and injection supply costs as well as paid labor. This total cost equates to an estimated cost per dose of US$3.99. By level of the health system, 87% of economic costs are incurred at facility level, 4% at district level, 1% at regional level and 8% at national level, as shown in Figure 5. The economic cost per dose at all levels is US$4.32, and the economic cost per capita at all levels is US$2.41.

Figure 5. Total immunization program economic costs by health system level (millions of 2016 US$)



DISCUSSION

This study found a very small difference in total delivery costs (facility average) by location, excluding the cost of vaccines, injection supplies and paid human resources (labor). The lowest costs were at facilities in rural areas without nomads (US$2,138/year), followed by rural areas with nomads (US$2,224) and then urban facilities (US$2,427/year). Cold chain equipment & energy is the main cost driving line item at all facility types when excluding the vaccine, injection supply and labor costs.

Cost per dose delivered is lowest at rural facilities which include nomads in their catchment population (US$0.45), followed by urban facilities (US$0.48) and rural facilities without nomads (US$0.56). Across all geographies, the cost per FIC is estimated to be US$8.04, defining FIC in terms of Measles/Rubella 1st dose. However, the cost per FIC is lower in rural areas with nomads (US$7.35) and higher in both rural areas without nomads (US$8.33) and urban areas (US$8.89).

This study confirmed that delivery strategy is an important determinant of costs. Outreach is more expensive than facility-based delivery, but the magnitude of the difference varies immensely by geography. Overall, outreach is more than three times as expensive as facility-based delivery (US$1.47 versus US$0.43), but this is largely driven by the nearly five-fold difference between the unit cost of outreach and facility delivery in rural areas without nomads (US$1.91 versus US$0.43). In urban areas, outreach is slightly more expensive than facility-based delivery (US$0.62 versus US$0.48), whereas in rural areas with nomads the difference is about three-fold (US$1.16 versus US$0.40). Outreach is more expensive in rural areas than in urban areas, presumably due to the distances

covered. Surprisingly, facility-based delivery is more expensive in urban areas as opposed to rural areas. However, the difference is small. It may be due to sampling error and not reflect a true difference in costs.

Planned mobile sessions were cancelled in all of the sampled facilities during the year of our study, an interesting finding in and of itself and reflective of challenges with funding for delivery costs at district level. Our estimation is that mobile would be more expensive than outreach or facility-based delivery due to the greater distances to be covered and use of motor vehicles (as opposed to motorcycles and buses/taxis for outreach). Allocating sufficient funding for delivery costs would help ensure mobile delivery can happen as scheduled, although increasing facility-based delivery at existing sites, particularly those in rural areas, may be preferable in terms of cost implications for the immunization program. Coverage would need to be monitored to ensure nomads and other populations living in hard-to-reach areas continue to access services.

The total cost of the immunization program, including facility, district, regional and national level costs, is estimated to be US$138.2 million, or US$2.41 per capita based on a population of 57.31 million. These estimates include vaccine, injection supply and labor costs. This equates to a cost per dose of US$3.99. By level of the health system, 87% of these costs are incurred at facility level, 4% at district level, 1% at regional level and 8% at national level. Delivery costs only (total costs minus the vaccine, injection supply and labor costs) total US$21.8 million, or 15.8% of the total program cost. By level of the health system, the delivery cost portion of total costs is comprised of facility-level costs (72.4%), district-level costs (20.5%), regional costs (7.0%) and national costs (0.5%). The immunization delivery cost per dose and per capita, including costs from all levels of the health system, equate to US$0.67 and US$0.38 respectively.

Overall our analysis found a high level of variability in the data and some surprising findings. These results may reflect the patient mix that came to certain facilities in the sample during the study period, and/or may reflect unique characteristics of some of the sampled facilities which cause them to have higher or lower delivery volumes than usual, or higher or lower costs than usual. Examples of unique characteristics of our sampled sites include some sites that receive patients from nearby facilities where vaccination is not offered, leading to a higher than expected number of doses delivered, and sites that collected vaccines daily from the district because of lack of cold chain equipment, leading to higher vaccine collection/transport costs. These results could also be the result of errors in administrative and/or study data collection, or other data challenges. Notably, data related to the number of FICs was confusing and does not mirror the nationwide coverage (Table 10

Table 9). For example, coverage of MR1 was estimated to be higher than DTP3 nationwide (101% vs. 99%), while in our study we found a higher number of DTP3 doses delivered compared to MR1 in urban facilities and rural facilities without nomads; only in rural facilities with nomads were more doses of MR1 delivered than DTP3. On the other hand, nationwide coverage of MR2 shows a significant dropoff from MR1 (79% vs. 101%), which is also reflected in the number of each type of FIC found by our study (WHO/UNICEF, 2017).

Table 9. Comparison of immunization coverage: number of FICs at sampled facilities versus national coverage averages

Vaccine	Number of FICs at sampled facilities			Coverage - national averages		
	Measles/ Rubella 1st dose	Measles/ Rubella 2nd dose	DTP3	Measles/ Rubella 1st dose	Measles/ Rubella 2nd dose	DTP3
Urban facilities	1,219	1,028	1,544			
Rural facilities without nomads	527	381	547	101%	79%	99%
Rural facilities with nomads	637	396	576			

Source: Joint Reporting Form, 2017.

There were also a large number of facilities with missing data, requiring us to drop three facilities from the sample and leading us to impute to fill in some data gaps, primarily in the number of doses delivered, for a number of other facilities. However, in a representative sample as large as ours, one would not expect these cases to have a large impact on the average results. Given the size of our sample we remain confident in the results.

Findings are largely in line with other Sub-Saharan Africa countries based on our review of all grey and published literature from 2005-2018 reporting economic cost per dose delivered (Immunization Costing Action Network (ICAN), 2019). In four recent studies from Benin (AMP, 2014; Suharlim, 2018), Ghana (Le Gargasson, 2015; Suharlim, 2018), Uganda (Guthrie, 2014; Suharlim, 2018) and Zambia (Schütte, 2015; Suharlim, 2018), they reported economic cost per dose delivered ranged from US$0.75 to U$S3.18, including injection supply and labor costs but excluding vaccine costs (Table 10). This puts Tanzania's delivery cost per dose of US$1.28 (adjusted to also include injection supply and labor costs but exclude vaccine costs) at the lower end of this range.

Table 10. Comparison of study findings with other countries

Country	Vaccines costed*	Delivery strategy	Cost per dose (2016 US$)
Benin	BCG, Measles, DTP-HepB-Hib, OPV, YF	Health facility	0.75
Tanzania	**BCG, Measles/Rubella, DTP-HepB-Hib, OPV, PCV, Rotavirus**	**Multiple strategies****	**1.28*****
Uganda	BCG, Measles, DTP-HepB-Hib, OPV	Health facility	1.67
Zambia	BCG, Measles, DTP-HepB-Hib, OPV	Multiple strategies**	2.11
Ghana	BCG, Measles, DTP-HepB-Hib, OPV, YF	Multiple strategies**	3.18

* For comparator countries, vaccines costed are included on the schedule for children under the age of 1.
** This is the estimate from our current study. Multiple strategies refers to a combination of two or more delivery strategies – in this case, health facility and outreach delivery.
*** For comparability with other countries in this table, the estimate includes delivery cost, labor and injection supplies.
For a complete comparison of these unit costs, please see https://immunizationeconomics.org/ican-idcc.

OPPORTUNITIES FOR USE OF RESULTS

Developing sufficient budgets for vaccination activities in Tanzania has been challenging as baseline cost estimates have been unavailable and districts do not know their delivery costs. The amount of funds needed for outreach and other delivery strategies has been estimated primarily relying on historical expenditures. In this context, these findings can provide valuable insights into the cost of different delivery strategies across a range of urban, rural and nomad settings. Interviews carried out with immunization stakeholders in Tanzania identified several key opportunities with potential entry points for the presentation and use of the ICAN study results:

1. Annual budgeting and planning process: The findings can be used for planning at different levels to help determine efficiencies and maximize local resources. Tanzania's decentralized system for budgeting and planning presents a key opportunity to use ICAN findings at the facility and district levels. Funds for operational activities are included in the budget of the Comprehensive Council Health Plan (CCHP) that local governments prepare annually starting in October based on national guidelines that are revised every few years. The release of the study findings is timely for their inclusion in the budgets currently being developed, which will be approved by parliament in June 2020. At the national level, the next revision of the guidelines could be a key entry point for the use of ICAN findings.
2. National Health Plan and cMYP development: The next five-year National Health Plan, as well as the immunization comprehensive multi-year plan (cMYP), will run from 2021-2025. Plans and budgets will be drawn up for the next plan starting from mid-2019 until mid-2020, so the timing is opportune for the use of ICAN evidence for costing national and/or district level delivery activities and new vaccine introductions.
3. Directed Health Facility Funding (DHFF): DHFF is a payment directly to health facility bank accounts which is an output-based payment to facilities to better match payment to priority services and empower facilities to manage funds and procure inputs to deliver health services to their communities. It is used to strengthen basic financial management systems, PlanRep and Facility Financial Accounting and Reporting System (FFARS). The findings can now enable more targeted strategy considerations and potentially better predictability on operational costs.

The ICAN research team is working closely with the MoHCDGC and PO-RALG to ensure that the research findings are shared both at the national and provincial/district levels, and with key stakeholders involved in the Health Plan development as well. Given the large sample designed to be representative nationally, these findings present an excellent opportunity for greater accuracy of planning and budgeting and potentially a more effective use of immunization resources in Tanzania.

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ANNEXES

Annex 1: Cost line items and cost activities

Table 11 and Table 12 provide an overview of cost line items, activities and their definitions.

Table 11. Cost line items and their definitions

Type of Cost	Cost Line Item	Definition
Recurrent	Paid labor*	Allocation of labor salaries and benefits for immunization-related activities.
	Per diem and travel allowances	Any allowances paid to paid or volunteer workers (including private midwives) for immunization-related activities.
	Vaccines*	Cost of traditional and new vaccines, including wastage.
	Vaccine injection and safety supplies*	Cost of auto-disabled syringes, diluent, reconstituting syringes, safety boxes and other supplies used for administration of vaccines.
	Other supplies	Cost of stationery and other supplies for the immunization program.
	Transport and fuel	Cost of bus fare, plane ticket, and the cost of fuel for immunization-related transports.
	Vehicle maintenance	Cost of maintaining vehicles (of all types) used for immunization-related activities. Note: in our sampled areas most staff use their own vehicles; the vehicle cost is not included but any reimbursements staff receive for personal vehicle use are.
	Cold chain energy costs	The cost of running the cold chain (gas, electricity, etc.), and the cost of ice.
	Printing costs	The cost of printing immunization cards, training and IEC materials, and other materials that are immunization-related.
	Utilities and communication	Costs related to building overheads, including maintenance, utilities, telephone, internet connections with some portion of these costs allocated to immunization.

	Other recurrent	Other recurrent costs for immunization-related activities that are not included in the above line items (this category should be very small).
Capital	Cold chain equipment	Value of all cold chain equipment used to store and transport vaccines.
	Vehicles	Value of all vehicles and other modes of transport (boats, etc.).
	Lab equipment	Value of all equipment used for laboratory testing and diagnosis related to surveillance principally.
	Other equipment	Value of other equipment, such as computers, printers, peripherals, furniture, other medical equipment used for immunization-related activities.
	Other capital	Any other capital investments.
	Buildings	Value of building space used to delivery and store vaccines.

* Data on these cost items was collected to give an overview of immunization costs, but they are not included in the delivery costs presented in this report.

Table 12. Cost activities and their definitions

Cost activity	Definition
Routine facility-based service delivery*	Time and resources spent on the act of administering vaccines to children within the facility/compound.
Record keeping, HMIS, monitoring and evaluation	Time and resources spent on data entry and analysis, including maintaining stock registers, maintaining records of children vaccinated, completing reports and analyzing, monitoring, and evaluating immunization program data.
Supervision	Time and resources spent by a facility (or district/city level) staff to supervise subordinate or peer health or community workers.
Outreach service delivery*	Time and resources to reach populations living a short distance from the facility, typically reached by motorcycle and without requiring an overnight stay.
Mobile service delivery*	Time and resources spent to reach populations living further from the facility, typically requiring a vehicle for transport and an overnight stay.

Training	Time and resources spent for attending and/or providing immunization-related training.
Social mobilization and advocacy	Time and resources spent mobilizing the community and households, and advocating for vaccination. This could include the cost of television and radio time, as well as the cost of hiring actors, etc.
Surveillance	Time and resources spent following-up post-vaccination events and active cases of diseases that are prevented by vaccination.
Vaccine, collection, distribution and storage	Time and resources spent collecting vaccines at the airport or other distribution points, storing vaccines in national or subnational cold stores, maintaining stock records of vaccines, and distributing vaccines down to the facility.
Program management	Time and resources spent on planning, budgeting, managing the immunization program at various levels. This would include the cost of time and resources spent on forecasting vaccine needs and procuring vaccines. Costs may include time spent preparing GAVI applications and other applications for funding and technical support. Costs may include attendance at immunization-related meetings. General management of the health system would not be allocated here.
Cold chain maintenance	Time and resources spent maintaining the cold chain at the respective level of analysis.
Other	Time and other resources spent on any other immunization-related activity not covered in the above categories. This category should be very small or not represented at all in the analysis.

* The cost of vaccines and supplies are included in the service delivery activities.

Annex 2: Full list of sampled regions, districts and facilities

Table 13 provides a full list of the sampled regions, districts and facilities.

Table 13 List of sampled regions, districts and facilities

Region	District	Sampled facilities
Morogoro	Kilombero	Mangula HC, Mngeta HC, Kisegese Dispensary Signal Dispensary and Msolwa Station Dispensary
	Kilosa	Kilosa Hospital, Dumila Dispensary, Msimba dispensary, Dakawa Dispensary
	Morogoro MC	Kihonda HC, Kilakala Dispensary, Kingolwira HC, Towero Dispensary and Mji mpya Dispensary
Mbeya	Mbeya CC	Itegano Dispensary, Itensa Dispensary, Mbeya regional referral Hospital and Ruanda HC
	Rungwe DC	Bujela Dispensary, Kyobo Dispensary, Masukulu Dispensary and Makandana Hospital
	Mbarali DC	Imalilo Songwe Dispensary, Madundasi Dispensary, Mapogoro HC, Mbarali Hospital and Nyamakuyu Dispensary
Mtwara	Mtwara MC	Luhula Hospital, Chino Dispensary, Mikindani HC and Ufukoni Dispensary
	Masasi DC	Chikunja Dispensary, Chiwale HC, Nambaya Dispensary, Nanganga Dispensary and Nasindi Dispensary
	Nanyumbu DC	Chipuputa Dispensary , Mangaka Hospital, Michiga HC, Masuguru Dispensary and Mandete Dispensary
Simiyu	Bariadi TC	Muungano HC, Ngulyati HC, Ditima Dispensary and Isanga Dispensary
	Itilima DC	Bumera Dispensary, Kashishi Dispensary, Mahembe Dispensary, Mwalusu HC and Kabale HC4
	Meatu DC	Butuli Dispensary, Makao Dispensary, Meatu Hospital, Mwabagimu Dispensary and Sungu Dispensary

Annex 3: Recent costing studies conducted in Tanzania

Table 14. Recent immunization costing studies conducted in Tanzania

Study and reference	Cost results
Cost-effectiveness of live oral attenuated human rotavirus vaccine (Ruhago, 2015)	• US$ 8.4 per dose • US$ 5.2 per dose in urban health facilities • US$ 9.8 in rural facilities
Incremental costs to add HPV vaccine (Hutubessy, 2012; Levin, 2014)	• US$5.77 per fully immunized girl (FIG) and US$1.66 per dose, excluding the vaccine cost [financial costs] • US$4.78 per FIG at schools compared with US$3.51 per FIG at health facilities [financial costs]
Incremental costs of a school-based HPV vaccination project (Quentin, 2012)	• US$5.48 per FIG and US$1.73 per dose, excluding costs of the vaccine and salaries of existing staff [financial costs] • Total costs per FIG at urban schools were US$66 for class-based delivery and US$100 for age-based delivery [US$78 and US$107 at rural schools]
Cost to deliver Oral Cholera Vaccine through Zanzibar campaign (Schaetti, 2012)	• 68% of mass vaccination campaign costs were spent on vaccine purchase and 32% on delivery • Average costs per vaccine course of US$21 and average costs for delivery of US$9.7 [vaccine price of US$10/course]
Incremental costs of adding a hypothetical malaria vaccine (Hutton, 2006)	• Average cost per fully immunized child (FIC) of US$4.2 at a vaccine price of US$1 per dose • Average cost per FIC of US$31.2 at vaccine price of US$10 per dose

Annex 4: Financial cost findings

Figure 6. Immunization delivery financial costs by line item (facility average) (2016 US$)

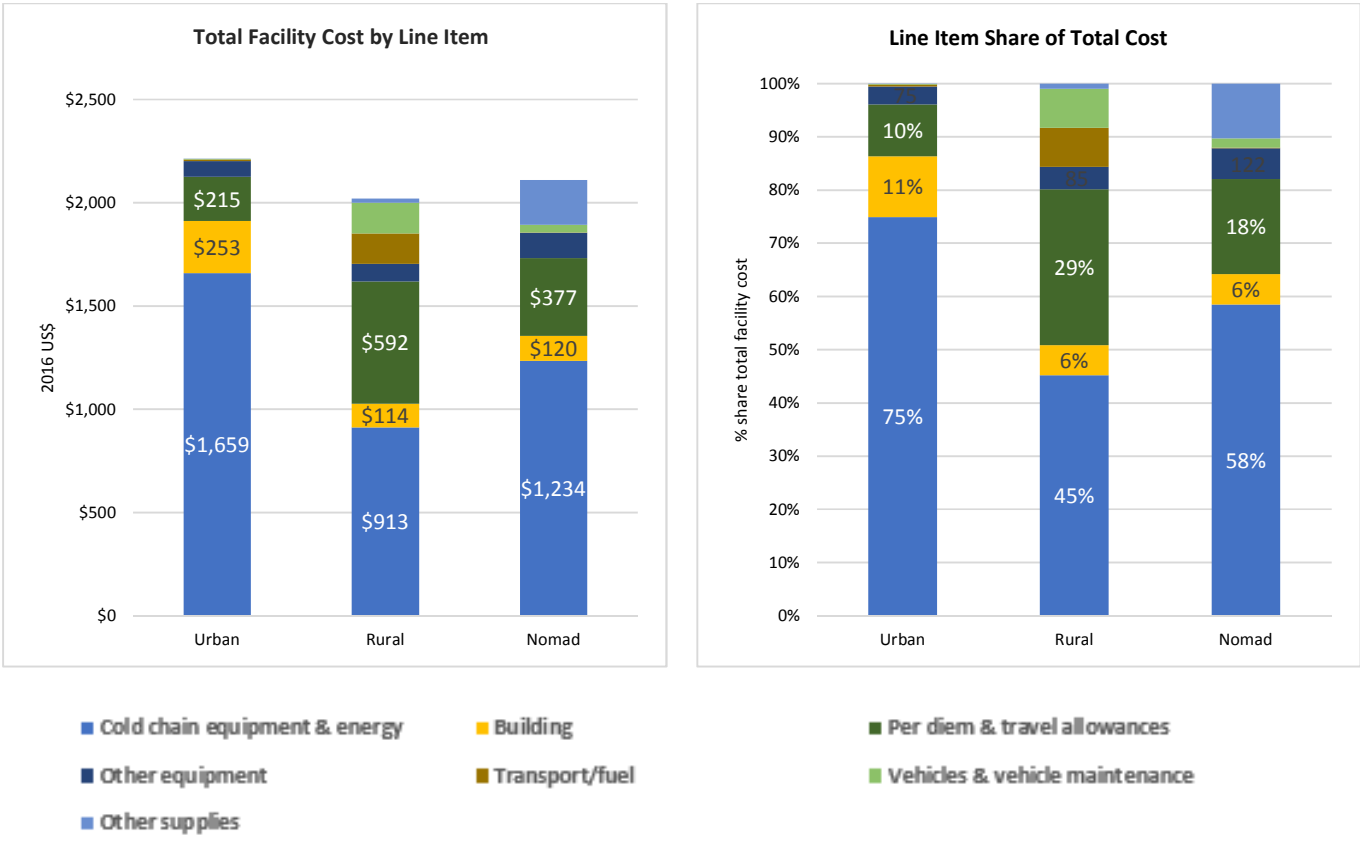


Figure 7. Immunization delivery financial unit costs by line item (facility average) (2016 US$)

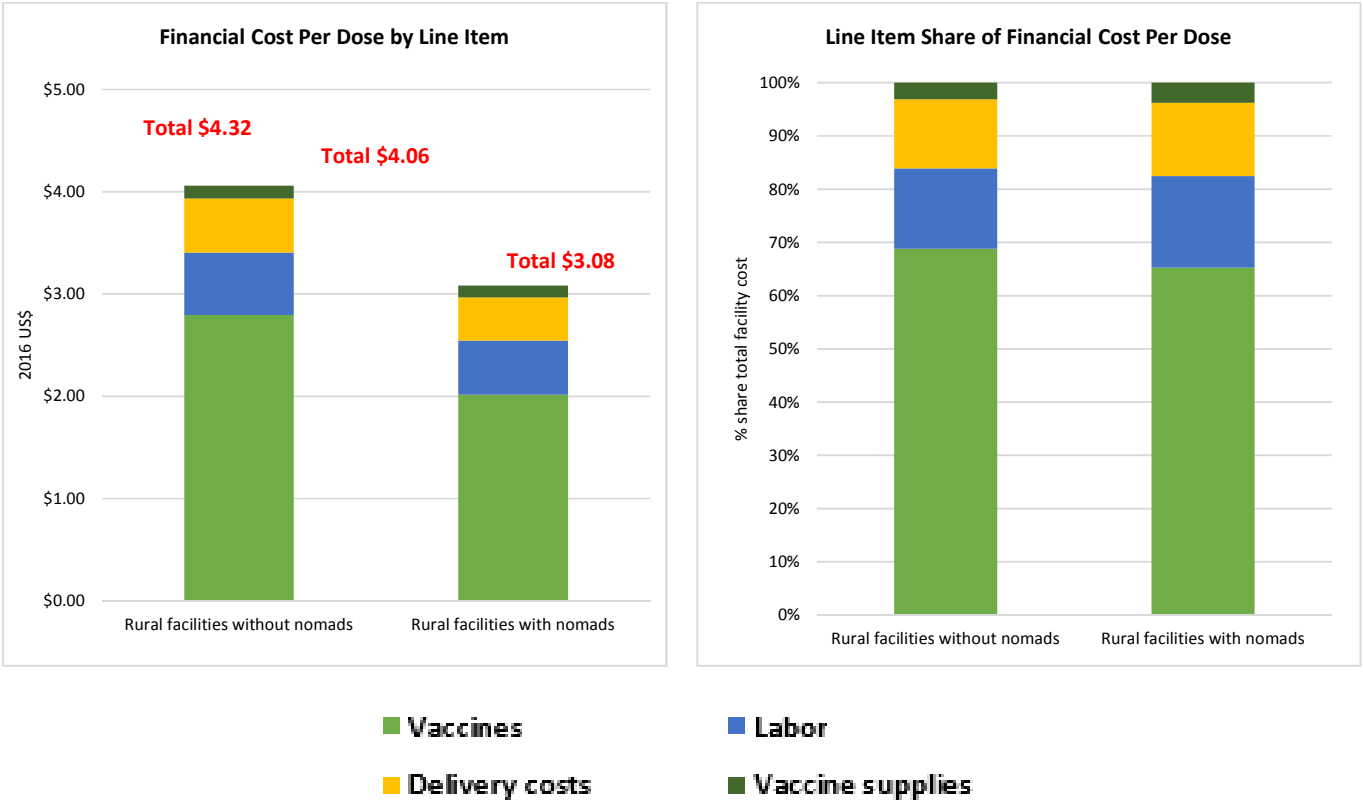


Table 15. Delivery financial unit costs per dose (excluding vaccines, injection supplies and labor costs) (facility average) (2016 US$)

Type of cost	All delivery strategies	Facility-based delivery	Outreach-based delivery*
All health facilities (n=51)	0.46	0.40	1.46
Urban areas (n=17)*	0.44	0.43	0.59
Rural areas without nomads (n=20)*	0.53	0.40	1.89
Rural areas with nomads (n=14)*	0.42	0.38	1.15

* Outreach-based delivery was not used in all areas. In the 17 urban areas, 6 used outreach. In the 20 rural areas without nomads, 13 used outreach. In the 14 rural areas with nomads, 8 used outreach.

Table 16. Delivery financial unit costs per FIC (excluding vaccines, injection supplies and labor costs) (facility average) (2016 US$)

Type of cost	Measles/ Rubella 1st dose	Measles/ Rubella 2nd dose	DTP3
All health facilities (n=51)	7.55	9.78	7.76
Urban areas (n=17)*	8.11	7.38	7.55
Rural areas without nomads (n=20)*	7.87	10.75	8.37
Rural areas with nomads (n=14)*	6.98	10.73	7.32

* Outreach-based delivery was not used in all areas. In the 17 urban areas, 6 used outreach. In the 20 rural areas without nomads, 13 used outreach. In the 14 rural areas with nomads, 8 used outreach.

Figure 8. Delivery financial cost per dose (2016 US$) vs number of doses delivered

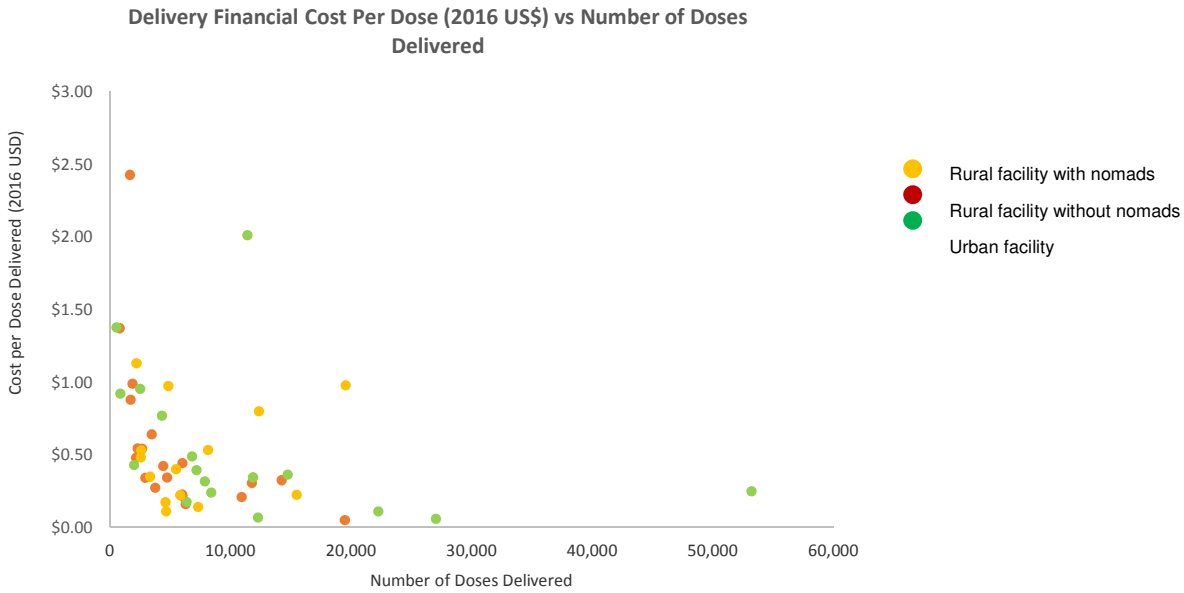


Table 17. Mobile delivery sensitivity analysis findings (including vaccines, injection supplies and labor costs) (2016 US$)

Type of cost	Existing delivery (2016 US$) (including vaccines, injection supplies and labor)	With mobile delivery (2016 US$) (including vaccines, injection supplies and labor)

	Facility-based delivery	Outreach-based delivery	Mobile delivery (n=18)	Facility-based delivery	Outreach-based delivery	Mobile delivery (n=18)
Financial cost per dose delivered	3.57	5.85	N/A	2.90	5.15	5.76

Figure 9. Delivery financial costs as share of total immunization program costs and by health system level (2016 US$)

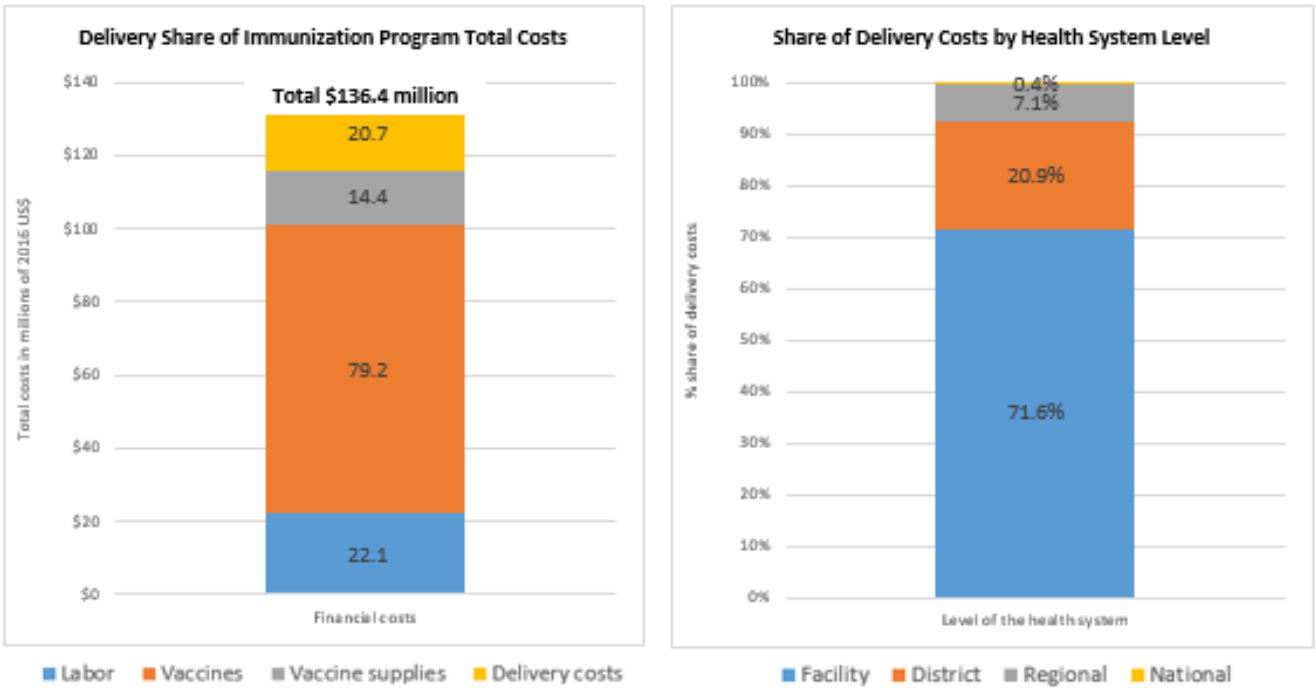
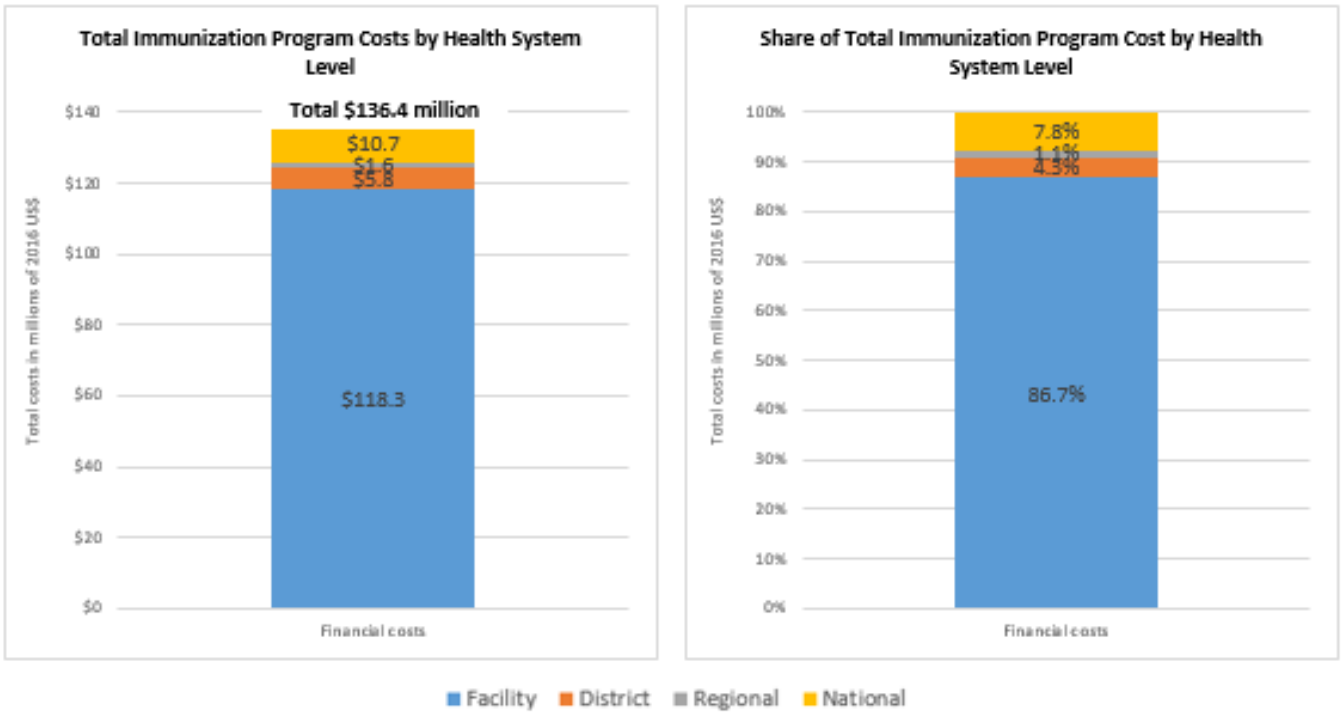


Figure 10. Total immunization program financial costs by health system level (millions of 2016 US$)



Annex 5: Detailed findings

Table 18. Description of the sample

		Doses delivered				Economic cost per dose* (2016 US$)				Financial cost per dose* (2016 US$)			
Level	**N**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**
Facility-level													
Total	51	566	53,235	8,093	8,738	0.83	7.11	3.54	1.51	0.83	6.98	3.50	1.47
Facility-based delivery	51	566	52,603	7,664	8,718	0.83	7.11	3.45	1.47	0.83	6.98	3.41	1.43
Outreach delivery**	27	43	3,300	811	970	2.57	26.75	5.39	6.27	2.51	26.35	5.36	6.16
District level	12	67,002	259,786	180,654	54,170	0.11	0.49	0.19	0.10	0.11	0.48	0.19	0.10
Regional level	4	723,402	1,146,887	945,900	173,362	0.02	0.03	0.03	0.00	0.02	0.03	0.03	0.00

* Includes vaccines and vaccine injection supplies (facility-level) and paid labor (all levels).
** If non-zero
SD = Standard deviation
Note: because there was no sample at national level, it is excluded from this table.

Table 19. Cost per dose by geographic setting, delivery strategy and cost category (2016 US$)

		Cost per dose delivered (overall)					Cost per facility-based dose delivered					Cost per outreach dose delivered				
Level	n*	Labor	Vaccines	Injection supplies	Delivery costs	Total	Labor	Vaccines	Injection supplies	Delivery costs	Total	Labor	Vaccines	Injection supplies	Delivery costs	Total
All geographic settings																
Economic	51	0.66	2.49	0.12	0.49	3.76	0.59	2.47	0.12	0.43	3.62	1.60	2.69	0.11	1.47	5.88
Financial	51	0.64	2.49	0.12	0.46	3.71	0.57	2.47	0.12	0.40	3.57	1.59	2.69	0.11	1.46	5.85
Urban facilities																
Economic	17	0.89	2.87	0.14	0.48	4.38	0.90	2.89	0.14	0.48	4.41	0.35	2.22	0.11	0.62	3.31
Financial	17	0.88	2.87	0.14	0.44	4.32	0.90	2.89	0.14	0.43	4.36	0.31	2.22	0.11	0.59	3.24
Rural facilities without nomads																
Economic	20	0.64	2.79	0.12	0.56	4.11	0.58	2.79	0.13	0.43	3.92	1.24	2.85	0.11	1.91	6.11
Financial	20	0.61	2.79	0.12	0.53	4.06	0.55	2.79	0.13	0.40	3.86	1.23	2.85	0.11	1.89	6.08
Rural facilities with nomads																
Economic	14	0.55	2.01	0.12	0.45	3.13	0.44	1.97	0.12	0.40	2.93	2.44	2.63	0.12	1.16	6.35
Financial	14	0.53	2.01	0.12	0.42	3.08	0.41	1.97	0.12	0.38	2.88	2.44	2.63	0.12	1.15	6.34

* For outreach, n=27 for all facilities, n=6 for urban facilities, n=13 for rural facilities without nomads and n=8 for rural facilities with nomads.

Table 20. Cost per FIC by geographic setting, delivery strategy and cost category (2016 US$)

		Cost per FIC (MR1)					Cost per FIC (MR2)					Cost per FIC (DTP3)				
Level	n*	Labor	Vaccines	Injection supplies	Delivery costs	Total	Labor	Vaccines	Injection supplies	Delivery costs	Total	Labor	Vaccines	Injection supplies	Delivery costs	Total
All geographic settings																
Economic	51	10.70	40.42	2.02	8.04	61.18	13.87	52.36	2.61	10.42	79.25	11.00	41.55	2.07	8.27	62.90
Financial	51	10.38	40.42	2.02	7.55	60.36	13.44	52.36	2.61	9.78	78.19	10.67	41.55	2.07	7.76	62.06
Urban facilities																
Economic	17	16.36	53.08	2.53	8.89	80.86	14.88	48.28	2.30	8.09	73.55	15.22	49.41	2.36	8.28	75.27
Financial	17	16.20	53.08	2.53	8.11	79.92	14.74	48.28	2.30	7.38	72.70	15.08	49.41	2.36	7.55	74.39
Rural facilities without nomads																
Economic	20	9.47	41.64	1.86	8.33	61.30	12.94	56.88	2.55	11.38	83.74	10.08	44.31	1.98	8.86	65.23
Financial	20	9.13	41.64	1.86	7.87	60.51	12.48	56.88	2.55	10.75	82.66	9.72	44.31	1.98	8.37	64.38
Rural facilities with nomads																
Economic	14	9.12	33.11	1.91	7.35	51.49	14.02	50.89	2.93	11.30	79.15	9.56	34.69	2.00	7.70	53.96
Financial	14	8.73	33.11	1.91	6.98	50.73	13.41	50.89	2.93	10.73	77.96	9.15	34.70	2.00	7.32	53.16

* For outreach, n=27 for all facilities, n=6 for urban facilities, n=13 for rural facilities without nomads and n=8 for rural facilities with nomads.

Table 21. Estimated facility, district, regional and national-level unit costs (2016 US$)

	Economic cost per dose					Financial cost per dose				
Level	Labor (95% CI)	Vaccines (95% CI)	Injection supplies (95% CI)	Delivery costs (95% CI)	Total (95% CI)	Labor (95% CI)	Vaccines (95% CI)	Injection supplies (95% CI)	Delivery costs (95% CI)	Total (95% CI)
Facility	0.66 (0.43-0.88)	2.49 (2.14-2.83)	0.12 (0.12-0.13)	0.49 (0.38-0.61)	3.76 (3.16-4.37)	0.64 (0.41-0.87)	2.49 (2.14-2.83)	0.12 (0.12-0.13)	0.46 (0.35-0.58)	3.71 (3.11-4.32)
District	0.05 (0.04-0.06)	---	---	0.14 (0.12-0.16)	0.19 (0.17-0.21)	0.05 (0.04-0.06)	---	---	0.05 (0.04-0.06)	0.10 (0.16-0.21)
Regional	0.00 (-0.01-0.01)	---	---	0.03 (0.03-0.04)	0.03 (0.03-0.04)	0.00 (-0.01-0.01)	---	---	0.03 (0.03-0.04)	0.03 (0.03-0.04)
National*	0.01	---	0.33	0.00	0.34	0.01	---	0.33	0.00	0.34
Total	0.71 (0.69-0.72)	2.49 (2.14-2.83)	0.45 (0.45-0.46)	0.67 (0.66-0.68)	4.32 (4.30-4.35)	0.69 (0.68-0.71)	2.49 (2.14-2.83)	0.45 (0.45-0.46)	0.64 (0.63-0.65)	4.27 (4.25-4.29)

CI = confidence interval

Table 22. Unit costs per dose delivered, by geography (facility-based delivery) (2016 US$)

Geographic setting	Economic cost per dose					Financial cost per dose				
	Labor (95% CI)	Vaccines (95% CI)	Injection supplies (95% CI)	Delivery costs (95% CI)	Total (95% CI)	Labor (95% CI)	Vaccines (95% CI)	Injection supplies (95% CI)	Delivery costs (95% CI)	Total (95% CI)
All geographic settings	0.66 (0.40-0.79)	2.49 (2.13-2.82)	0.12 (0.12-0.13)	0.49 (0.32-0.54)	3.76 (3.02-4.22)	0.64 (0.37-0.78)	2.49 (2.13-2.82)	0.12 (0.12-0.13)	0.46 (0.29-0.51)	3.71 (2.97-4.17)
Urban facilities	0.89 (0.24-1.56)	2.87 (2.82-2.97)	0.14 (0.13-0.15)	0.48 (0.11-0.84)	4.38 (3.35-5.47)	0.88 (0.25-1.55)	2.87 (2.82-2.97)	0.14 (0.13-0.15)	0.44 (0.10-0.77)	4.32 (3.34-5.38)
Rural facilities without nomads	0.64 (0.41-0.74)	2.79 (2.27-3.31)	0.12 (0.12-0.14)	0.56 (0.30-0.55)	4.11 (3.44-4.40)	0.61 (0.39-0.72)	2.79 (2.27-3.31)	0.12 (0.12-0.14)	0.53 (0.28-0.51)	4.06 (3.36-4.37)
Rural facilities with nomads	0.55 (0.28-0.59)	2.01 (1.61-2.34)	0.12 (0.11-0.12)	0.45 (0.24-0.57)	3.13 (2.47-3.39)	0.53 (0.26-0.57)	2.01 (1.61-2.34)	0.12 (0.11-0.12)	0.42 (0.21-0.55)	3.08 (2.44-3.32)

CI = confidence interval

Table 23. Unit costs per dose delivered, by geography (outreach delivery) (2016 US$)

Level	Economic cost per dose					Financial cost per dose				
	Labor (95% CI)	Vaccines (95% CI)	Injection supplies (95% CI)	Delivery costs (95% CI)	Total (95% CI)	Labor (95% CI)	Vaccines (95% CI)	Injection supplies (95% CI)	Delivery costs (95% CI)	Total (95% CI)
All geographic settings	1.60 (0.88-2.33)	2.69 (2.11-3.27)	0.11 (0.10-0.12)	1.47 (0.37-2.58)	5.88 (4.25-7.51)	1.59 (0.87-2.31)	2.69 (2.11-3.27)	0.11 (0.10-0.12)	1.46 (0.36-2.55)	5.85 (4.23-7.47)
Urban facilities	0.35 (0.09-0.63)	2.22 (1.64-2.80)	0.11 (0.11-0.12)	0.62 (0.13-1.11)	3.31 (2.11-4.51)	0.31 (0.00-0.62)	2.22 (1.64-2.80)	0.11 (0.11-0.12)	0.59 (0.10-1.08)	3.24 (1.98-4.50)
Rural facilities without nomads	1.24 (0.63-1.85)	2.85 (2.19-3.50)	0.11 (0.09-0.13)	1.91 (-0.21-4.04)	6.11 (3.31-8.91)	1.23 (0.64-1.83)	2.85 (2.19-3.50)	0.11 (0.09-0.13)	1.89 (-0.21-3.99)	6.08 (3.32-8.83)
Rural facilities with nomads	2.44 (1.70-3.18)	2.63 (1.94-3.32)	0.12 (0.11-0.12)	1.16 (0.87-1.46)	6.35 (5.62-7.08)	2.44 (1.70-3.17)	2.63 (1.94-3.32	0.12 (0.11-0.12)	1.15 (0.86-1.44)	6.34 (5.59-7.08)

CI = confidence interval