Costs of Delivering COVID-19 Vaccines: A Case Study from Botswana

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Outline

- Introduction to study and methods
- Results
- Interpretation of findings
  - How do findings compare with modelled estimates?
  - Why did the expected large expenditures for cold chain expansion, social mobilization and outreach not happen?
  - How were human resources for health gaps filled?
  - How can results be best used in Botswana?
  - How well did this approach to data collection work? What methodological recommendations are there for improving future immunization cost data collection?
- Questions and discussion

Introduction to study

Study aims and objectives

Considerable costs were incurred with COVID-19 vaccine rollout, beyond vaccine procurement; these costs are known as delivery costs (see Box)

Delivery cost estimates are essential for optimal planning and budgeting; however, at the time countries were preparing to roll-out COVID-19 vaccines, actual delivery costs were unknown

Study objectives:

- Estimate total costs of COVID-19 vaccine delivery during first 13 months of delivery
- Estimate total costs of COVID-19 vaccine procurement during first 13 months of delivery
- Estimate costs per dose delivered

Box. Definition of delivery costs

Delivery costs are the costs associated with delivering vaccines to target populations, exclusive of vaccine costs. They are also often referred to as operational costs. For COVID-19 vaccines, key delivery costs are, for example, those for training, human resources, per diems and allowances, syringes, waste management of used syringes, transport, cold chain, and data reporting systems.

Source: ThinkWell general study protocol for COVID-19 vaccine delivery costing. 8 November 2021. Adapted from Vaughan K, Ozaltin A, Mallow M, Moi F, Wilkason C, Stone J, et al. The costs of delivering vaccines in low- and middle-income countries: findings from a systematic review. Vaccine X. 2019;2:100034.

Study methods

Overview

Box. Definition of fiscal and economic costs

Fiscal costs: Financial outlays, i.e., additional expenditures incurred due to COVID-19 vaccine delivery and not including the value of existing health system resources that were used. Health workers recruited as surge were included in fiscal costs.

Economic costs: Financial outlays plus opportunity costs. In the context of this study, opportunity costs only included select health worker time and donated vaccines.

- Perspective:
  - Costs incurred by all Government sectors and donors included
  - Expenditures regardless of funder (government/non-government) and mechanism (on-/off-budget)
  - Costs incurred by people receiving the vaccine, such as transport costs, not included
- Levels of health system:
  - National and District Health Management Teams (DHMTs)
- Types of costs:
  - Fiscal costs only, except for human resources and vaccines, for which economic costs were also included (see Box)
- **Study period:** 1 March 2021 - 31 March 2022

Resource items included and approach to cost estimation

- Originally proposed to include only what we thought were the main cost drivers: HR, social mobilization, cold chain and outreach
- At MoH request, all resource items included
- Used mixed of ingredient approach and top-down estimation

Box. Definition of ingredients approach and top-down estimation

Ingredient approach:
Quantities and unit costs identified and multiplied.

Top-down estimation:
Total amount paid collected and not separated into specific quantities and unit costs.

Table. Approach to each resource item

No.	Resource type	Ingredient approach	Top-down estimation
1	Adverse event monitoring for immunization (AEFI)		X
2	Cold chain	X	X
3	Communications*		X
4	Human resources (HR) for vaccine delivery**		X
5	Monitoring & evaluation		X
6	Planning and coordination		X
7	Personal protective equipment (PPE) and hand hygiene supplies	X	X
8	Refreshments		X
9	Regulatory	X	
10	Social mobilization		X
11	Supervision	X	
12	Syringes & safety boxes	X	
13	Training		X
14	Transport	X	X
15	Ultra-cold chain equipment (UCC)	X	X
16	Vaccine procurement incl. freight and handling	X	
17	Vaccine transport***	X	X
18	Waste management of used syringes	X	X
19	Other****		X

* Includes airtime, internet, cabling and networking, etc.
** "Human resources for vaccine delivery" include vaccinators and other staff on-site at vaccination sites. Other human resources than for vaccine delivery were allocated to the domain they support, for example human resources for social mobilization were listed under "social mobilization." We attempted to include salaries plus benefits, but in some cases only base salary amounts were provided.
*** "Vaccine transport" includes only in-country transport.
**** "Other" includes screening shades for vaccination sites.

Sampling and extrapolation

- **National-level**: No sampling required, as data from all government/non-governmental funders identified

- **DHMTs:**
  - Originally planned to interview all 18 DHMTs via phone/WhatsApp; challenges with network/internet connectivity.
  - Purposively sampled 6 of the 18 DHMTs.
    - 2 cities (of 2)
    - 1 town (of 3)
    - 3 rural (of 13)
    - 1.1 million doses delivered (of 2.6 million, 43%)
    - Coverage 63-96% (63-97%)
  - Extrapolated results to the non-sampled DHMTs on a per-dose basis according to each DHMT's characteristics.

Figure. Map of sampled DHMTs

Source: Department of Surveys and Mapping, 2022.

Note: DHMTs don't always align with districts. Ghanzi DHMT includes the districts of Charleshill and Ghanzi. Greater Gaborone DHMT includes the districts of Gaborone and South East. Greater Lobatse DHMT includes the districts of GoodHope and Lobatse. Greater Selebi Phikwe DHMT includes the districts of Phikwe and Bobirwa. Kgalagadi North DHMT is noted on the map by its district capital, Hukuntsi. Ngamiland DHMT is also known as North West. Kgalagadi South DHMT is known by its district capital of Tsabong. Kweneng DHMT includes the districts of Kweneng (Letlhakeng) and Kweneng West. Southern DHMT includes the districts of Jwaneng, Kanye, Mabutsane and Moshupa. The remaining DHMTs (Boteti, Chobe, Greater Francistown, Khatleng, Mahalapye, North East, Okavango, Tutume) are comprised of a single district of the same name.

Data sources: national-level (government and non-governmental) and sampled DHMTs

National-level respondents

Governmental respondents

- Botswana Medicines Regulatory Agency (BOMRA)
- Botswana Defense Force (BDF)
- Botswana Police
- Botswana Post
- Central Medical Stores (CMS)
- Ministry of Defense, Justice and Security
- Ministry of Finance
- Ministry of Health*: Procurement, HR & Admin, Corporate Services, Health Services, Health Education, Health Services Monitoring & Evaluation and Quality Assurance (HSMEQA), Health Policy Research and Development (HPRD), Logistics Team
- National Emergency Operations Committee (NEOC)
- Office of the President
- Presidential Task Force

Other respondents

- Botswana Red Cross Society
- DEBSWANA
- FHI 360
- Global Communities
- Global Health Supply Chain Program - Procurement and Supply Management (GHSC-PSM)
- USAID
- UNICEF
- WHO*

DHMT-level respondents

- Boteti
  - Coordinator, EPI Coordinator (Covid-19 Vaccine team leader), Head of Corporate, Chief Pharmacist, Head Procurement, Head Accounts
- Chobe
  - Community Health Nurse (CHN), Chief Medical Officer, M&E Officer
- Greater Francistown
  - Public Health Specialist (PHS), CHN, Procurement officer, Pharmacist, Head of Corporate
- Greater Gaborone
  - Family Physician, Chief Medical Officer, Head Pharmacy, Human Resources (HR) Officer, M&E Officer, CHN
- Kgalagadi North
  - RHMT Coordinator, PHS, M&E Officer, Head of Corporate, Pharmacist, Procurement Officer
- Southern
  - Head of Corporate, PHS, CHN, M&E Officers, Pharmacist, Admin Officer

Data not received: MOH: Waste management, Health Services Management (HSM) - tents, vehicle purchases, etc. WHO: support for social mobilization.

Limitations and research scope

- Some missing or incomplete data
  - National-level: transport costs (fuel and driver per diems), waste management, tents, vehicle purchases, WHO support for social mobilization
- Private sector delivery excluded
- Costs related to vaccine wastage excluded
- Items, such as PPE, procured prior to March 1, 2021, but used during study time period, excluded
- Due to research scope, health effects of vaccination excluded

Results

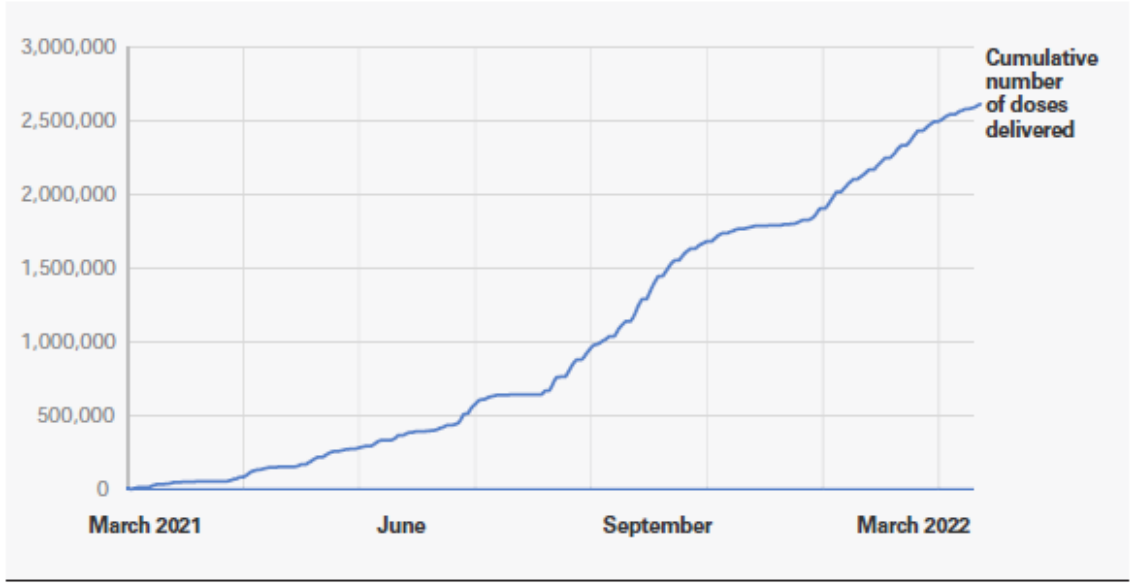
Total and cumulative number of COVID-19 vaccine doses delivered 1 March 2021 - 31 March 2022

DHMT	1st Dose	2nd Dose	Johnson & Johnson (single dose)	1st Booster	2nd Booster	Total no. doses delivered
Boteti	34,384	29,333	22,273	9,319	0	95,309
Chobe	13,101	10,048	7,942	7,753	0	38,844
Ghanzi	19,608	15,821	13,094	7,351	0	55,874
Greater Francistown*	89,422	79,782	38,551	18,697	0	218,796
Greater Gaborone*	193,310	173,029	111,380	60,819	0	537,813
Greater Lobatse	44,017	35,366	22,970	13,950	0	116,303
Greater Selebi Phikwe	58,632	50,559	21,284	16,471	0	146,946
Kgalagadi North	10,311	8,346	5,925	4,583	0	29,165
Kgalagadi South	15,303	13,123	8,324	6,823	1	43,574
Kgatleng	43,849	41,915	18,870	11,743	0	116,377
Kweneng	104,186	77,693	39,999	23,642	0	245,520
Mahalapye	51,094	45,754	26,774	15,797	0	139,419
Ngamiland	42,080	30,803	25,640	8,739	0	107,262
North East	26,255	23,296	4,979	13,377	0	67,907
Okavango	28,372	24,375	15,433	11,920	0	80,100
Serowe/Palapye	91,224	75,286	45,167	23,252	0	234,929
Southern	78,741	68,167	34,670	23,214	0	204,792
Tutume	52,140	45,174	13,641	17,117	0	128,072
TOTAL	**996,029**	**847,870**	**476,916**	**294,567**	**1**	**2,607,002**

Source: Ministry of Health, February 2023.

*Doses delivered in private facilities with private HR have been removed (n=8,381).

Cumulative number of doses delivered



Source: MoH, March 2023.

A total of 2.6 million doses were delivered during 1 March 2021 - 31 March 2022

Fiscal costs (US$)
1 March 2021 – 31 March 2022

Resource item	National level	DHMTs	Total	National level as % total	DHMT level as % total
AEFI	156,676	-	156,676	<1%	-
Cold chain	1,528,749	105,040	1,633,789	4%	1%
Communications**	3,285	95,396	98,681	<1%	1%
Delivery HR***	15,829,572	5,773,375	21,602,946	43%	45%
M&E	1,093,389	2,577,100	3,670,489	3%	20%
Planning and coordination	892,901	624,716	1,517,617	2%	5%
PPE and hand hygiene supplies	9,130,475	202,467	9,332,942	25%	2%
Refreshments	-	93,277	93,277	-	1%
Regulatory	58,733	-	58,733	<1%	-
Social mobilization	4,990,684	482,975	5,473,659	13%	4%
Supervision	1,719,331	-	1,719,331	5%	-
Syringes and safety boxes	169,748	23,548	193,296	<1%	<1%
Training	111,517	87,669	199,186	<1%	1%
Transport	306,579	1,317,297	1,623,876	1%	10%
UCC	400,239	-	400,239	1%	-
Vaccine transport****	490,295	1,132,778	1,623,073	1%	9%
Waste management	58,107	221,900	280,007	<1%	2%
Other*****	161,818	9,568	171,386	<1%	<1%
Total	**37,102,098**	**12,747,105**	**49,849,203**	**100%**	**100%**
% Total	**74%**	**26%**	**100%**	**100%**	**100%**

* "Communications" includes airtime, internet, cabling and networking, etc.

** Delivery HR = vaccinators and other staff on-site at vaccination sites. Other human resources are allocated to the domain they support, for example human resources for social mobilization are listed under "social mobilization."

*** Vaccine transport includes only in-country transport.

**** "Other" includes screening shades for vaccination sites.

Note: National-level costs exclude expenditures from the MoH about waste management costs and the purchase of tents, vehicles and other capital items, as well as social mobilization expenditures from WHO.

Delivery fiscal cost per dose delivered

	BWP			US$		
	National-level	DHMTs	Total	National-level	DHMTs	Total
Total delivery fiscal cost	**417,843,827**	**143,557,897**	**561,401,724**	**37,102,098**	**12,747,105**	**49,849,203**
Number of doses delivered						**2,607,002**
Delivery fiscal cost	160	55	**215**	14.23	4.89	**19.12**

Note: National-level costs exclude expenditures from the MoH about waste management costs and the purchase of tents, vehicles and other capital items, as well as social mobilization expenditures from WHO.

- **Total fiscal costs: US$ 49.8 million**
  - **74% incurred at national level**
  - **26% incurred in DHMTs**
- **Fiscal cost per dose delivered: US$19.12**

Economic costs (US$)
1 March 2021 – 31 March 2022

Resource item	National-level	DHMTs	Total	National level as % total	DHMT level as % total
AEFI	156,676	-	156,676	<1%	-
Cold chain	1,528,749	105,040	1,633,789	3%	<1%
Communications**	3,285	95,396	98,681	<1%	<1%
Delivery HR***	23,331,585	30,049,239	53,380,824	47%	81%
M&E	1,093,389	2,577,100	3,670,489	2%	7%
Planning and coordination	892,901	624,716	1,517,617	2%	2%
PPE and hand hygiene supplies	9,130,475	202,467	9,332,942	18%	1%
Refreshments	-	93,277	93,277	-	<1%
Regulatory	58,733	-	58,733	<1%	-
Social mobilization	4,990,684	482,975	5,473,659	10%	1%
Supervision	6,583,877	-	6,583,877	13%	-
Syringes and safety boxes	169,748	23,548	193,296	<1%	<1%
Training	111,517	87,669	199,186	<1%	<1%
Transport	306,579	1,317,297	1,623,876	1%	4%
UCC	400,239	-	400,239	1%	-
Vaccine transport****	490,295	1,132,778	1,623,073	1%	3%
Waste management	58,107	221,900	280,007	<1%	1%
Other*****	161,818	9,568	171,386	<1%	<1%
Total	**49,468,657**	**37,022,969**	**86,491,626**	**100%**	**100%**
% Total	**57%**	**43%**	**100%**	**100%**	**100%**

* "Communications" includes airtime, internet, cabling and networking, etc.

** Delivery HR = vaccinators and other staff on-site at vaccination sites. Other human resources are allocated to the domain they support, for example human resources for social mobilization are listed under "social mobilization."

*** Vaccine transport includes only in-country transport.

**** "Other" includes screening shades for vaccination sites.

Note: National-level costs exclude expenditures from the MoH about waste management costs and the purchase of tents, vehicles and other capital items, as well as social mobilization expenditures from WHO.

Delivery economic cost per dose delivered

	BWP			US$		
	National-level	DHMTs	Total	National-level	DHMTs	Total
Total delivery economic cost	**557,116,012**	**415,952,679**	**974,068,691**	**49,468,657**	**37,022,969**	**86,491,626**
Number of doses delivered						**2,607,002**
Delivery economic cost per dose delivered	214	160	**374**	18.98	14.2	**33.18**

Note: National-level costs exclude expenditures from the MoH about waste management costs and the purchase of tents, vehicles and other capital items, as well as social mobilization expenditures from WHO.

- Inclusion of existing HR increases the cost of delivery HR and supervision
- Total economic costs: US$86.5 million
  - 57% incurred at national level
  - 43% incurred in DHMTs
- Economic cost per dose delivered: US$33.18

Variation by DHMT: number of doses delivered, total cost and cost per dose (US$)
1 March 2021 – 31 March 2022

	Fiscal cost			Economic cost		
DHMT	Total	Per dose	Per person in target pop.	Total	Per dose	Per person in target pop.
Boteti	319,660	3.30	5.50	1,653,186	17.09	28.46
Chobe	455,663	13.52	24.70	1,089,111	32.33	59.04
Ghanzi	*323,298*	*5.79*	*9.74*	*1,192,551*	*21.34*	*35.92*
Greater Francistown	1,160,118	7.53	6.80	1,551,226	10.07	9.10
Greater Gaborone	*3,016,709*	*6.22*	*10.16*	*5,144,874*	*10.61*	*17.33*
Greater Lobatse	*146,985*	*1.26*	*1.93*	*230,440*	*1.98*	*3.03*
Greater Selebi Phikwe	185,712	1.26	1.70	291,155	1.98	2.67
Kgalagadi North	134,861	5.02	5.91	615,113	22.89	26.95
Kgalagadi South	*252,127*	*5.79*	*9.85*	*930,025*	*21.34*	*36.33*
Kgatleng	*673,379*	*5.79*	*8.29*	*2,483,902*	*21.34*	*30.59*
Kweneng	*1,420,625*	*5.79*	*8.37*	*5,240,277*	*21.34*	*30.86*
Mahalapye	*806,705*	*5.79*	*7.63*	*2,975,701*	*21.34*	*28.16*
Ngamiland	*620,638*	*5.79*	*8.43*	*2,289,356*	*21.34*	*31.10*
North East	*392,923*	*5.79*	*11.22*	*1,449,379*	*21.34*	*41.38*
Okavango	*463,474*	*5.79*	*9.44*	*1,709,621*	*21.34*	*34.80*
Serowe/Palapye	*1,359,344*	*5.79*	*8.70*	*5,014,227*	*21.34*	*32.11*
Southern	273,833	1.26	1.96	429,309	1.98	3.07
Tutume	*741,049*	*5.79*	*10.14*	*2,733,516*	*21.34*	*37.40*
Total	12,747,105	4.89	7.52	37,022,969	14.20	21.85

- Unit costs varied significantly by region
  - Fiscal costs: US$1.26-13.52
  - Economic costs: US$1.98-32.33
- Findings driven by:
  - Differences in total costs
  - Differences in number of doses delivered
  - Programmatic and financial decisions at both national and sub-national levels
  - Geographic characteristics such as vast areas => higher transport costs
- Costs incurred at national level on behalf of DHMTs not included here

* "Communications" includes airtime, internet, cabling and networking, etc.

** Delivery HR = vaccinators and other staff on-site at vaccination sites. Other human resources are allocated to the domain they support, for example human resources for social mobilization are listed under "social mobilization."

*** Vaccine transport includes only in-country transport.

**** "Other" includes screening shades for vaccination sites.

Interpretation of findings

How do findings compare with modelled estimates?

Total cost of delivering 1.2 billion doses in 92 Advanced Market Commitment countries

	Total (US$ millions)	US$ per dose supplied	US$ per person vaccinated with 2 doses	Percent of total
Gavi eligible (n= 57)	951	1.39	3.11	55%
India	283	1.07	2.39	16%
Gavi transitioned (n=12)	250	1.66	3.70	13%
Non-Gavi (n=22)	238	1.97	4.39	14%
Technical Assistance	198	0.16	0.36	10%
Global and regional	98	0.08	0.18	5%
Total	**2,018**	**1.66**	**3.70**	**100%**

Notes on V2:

- No HRH for delivery included
- No country-specific coverage targets
- Scenario focused on original COVAX plan for about 1.2billion doses
- allocated to countries in proportion to population size.
- Starting from zero coverage.

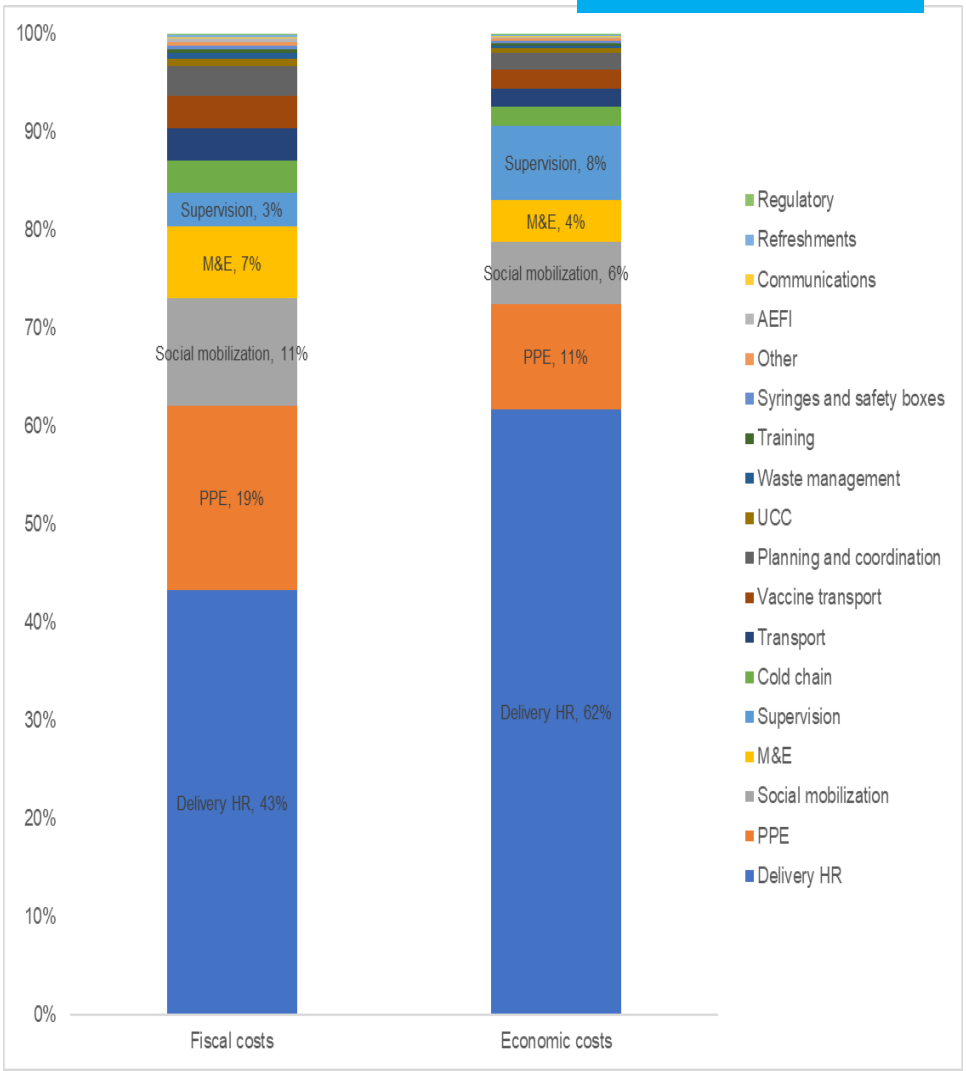
- The costs of delivering COVID-19 vaccines in Botswana were much higher than the global model estimated.
- The global model was based largely on routine childhood immunization, meaning the costs of COVID-19 vaccination in Botswana are much higher than the costs of childhood vaccination
- Due to lack of previous immunization costing studies in Botswana, we cannot conclude if findings are in line with costs of vaccine delivery in Botswana or represent an escalation on normal delivery costs

Griffiths *et al*, Costs of delivering COVID-19 vaccine in 92 AMC countrie2, 2021
https://www.corecommitments.unicef.org/kp/costs-of-delivering-covid19-vaccine-in-92-amc-countries.url

Why did the expected large expenditures for cold chain expansion, social mobilization and transport not happen?

- Regular cold chain
  - 2019 cold chain assessment used to predict gap
  - Planned alternative storage sites:
    - Botswana Vaccine Institute (BVI), Botswana Meat Commission (BMC) and private sector partners
  - BVI and Sir Ketumile Masire Teaching Hospital (SKMTH) ultimately used
    - Some new cold chain equipment purchased and distributed to DHMTs
- Ultra-Cold Chain (UCC)
  - Originally thought that there would be insufficient UCC capacity and did not chose Pfizer in initial procurement plan
  - Ended up borrowing existing UCC capacity from laboratories and other ministries, such as Ministry of Agriculture. Some equipment relocated to Central Medical Stores (CMS), some used at its original location
  - GoB and UNICEF ultimately supported purchase of UCC equipment
- Social mobilization
  - Mix of government and partners; some costs not captured
- Outreach
  - Some MoH-level transport costs not captured
  - Funds ran out for refreshments

Key cost drivers of fiscal and economic costs



How were human resource needs filled?

- Delivery HR:
  - Botswana hired large numbers of retired and unemployed nurses (more than anticipated by the global model), both at national and sub-national level.
  - Some vaccinators came from other ministries and agencies, i.e., Botswana Defense Force.

- Other tasks:
  - Large number of M&E clerks and social mobilizers also hired – some borrowed from HIV/AIDS programs through existing partners.

Overview of existing and newly hired staff at national level

			BWP
Type of human resources	Resource type	Number of staff*	Total economic cost
Existing staff	Delivery HR	133	84,487,673
	Supervision	16	54,784,512
Existing staff sub-total		*149*	*139,272,185*
New staff	Delivery HR	83	178,272,635
	Planning and coordination (Presidential Task Force)	16	9,559,067
	Social mobilization	3,253	49,270,942
New staff sub-total		*3,352*	*237,102,644*
Total both existing and newly hired staff*		**3,501**	**376,374,829**

* Due to data availability the number of existing and newly hired staff used by the following organizations is unknown, though the costs of these staff are included in the table: FHI360 (Delivery HR, newly hired staff); FHI360 (Social mobilization, newly hired staff); Debswana (Delivery HR, newly hired staff); WHO (Planning and coordination, newly hired staff); Global Communities (Delivery HR, newly hired staff); Global Communities (Planning and coordination, newly hired staff); UNICEF (Planning and coordination, newly hired staff).

Overview of existing and newly hired staff at RHMT level

- In our sample of six DHMTs, a total of 266 existing staff were used to deliver vaccines and an additional 692 staff hired to support:
  - Cold chain delivery (19)
  - Delivery of vaccines (480)
  - M&E (146)
  - Planning and coordination (16)
  - Social mobilization (24)
  - Transport (7)

Recommendations for Botswana

1. **Standardized guidance** for responding to public health emergencies
2. Possible **decentralization** of roles and responsibilities to DHMTs?
3. **Resource allocation formula** to guide resource deployment from national to sub-national levels to ensure equity.
4. **Partnership strategy**.
5. **Further research** about the COVID-19 response, for example a cost-effectiveness analysis, or costs of routine vaccination.
6. **Incorporation of the COVID-19 response plan into the routine health system.**
7. **More robust data and financial capturing systems** to aid planning, monitoring and evaluation of interventions.
8. **Digitization** of the Health Procurement and Human Resources systems and **linking** to Financial Management System.
9. Consider **local manufacturing** of key commodities and **pre-negotiated agreements** with select partners.

How well did our approach to data collection work? What methodological recommendations are there for improving future immunization cost data collection?

- Limiting resource items to major cost drivers
  - MoH preferred more standard methods to those originally proposed by research team, which focused on capturing costs related to expected major cost categories only.
- Using telephone/WhatsApp for data collection
  - To capture costs in all 18 DHMTs ultimately did not work due to network/internet challenges.
- Limiting economic costs to existing HR directly involved in administering vaccine
  - Worked well in the context of this study.
- No facility-based data collection
  - Worked well because of how districts organized vaccination.

Questions and discussion