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Financing Covid 19 Vaccination in Kenya:

Cost Simulation Analysis

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1.0 Introduction

1.1 Background

Macroeconomic indicators reveal underperformance of the economy which was occasioned by the adverse impact of COVID-19 pandemic and the ensuing containment measures adopted in March 2020. The contraction was spread across all sectors of the economy but was more dismal in accommodation and food services activities, education, and transport sectors. The overall performance of the economy in 2020 was cushioned from a deeper slump by accelerated growths in agricultural production (4.8 percent), mining and quarrying (6.7 percent), construction activities (11.8 percent) and health services (6.7 percent).

It is notable that most of the emerging markets and developing economies such as Kenya are projected to experience a more challenging recovery from the pandemic compared to their counterparts. This is largely on account of uneven access to COVID-19 vaccine which is therefore likely to impact negatively on the full resumption of economic activities in these economies. Additionally, the rapid spread of delta and the threat of new variants have increased uncertainty about how quickly the pandemic can be overcome.

In light of this, the government is implementing the economic recovery strategy and other priority programmes as outlined in the Third Medium Term Plan of Vision 2030, with the objective of returning the economy to the pre COVID-19 growth trajectory by increasing demand for local goods and services, cushioning vulnerable Kenyans, securing household food security for the poor, and creating employment and incomes.

While the government through the Budget Policy Statement (BPS) recognizes the risk of emergence of new variants of COVID-19, the budgetary commitments towards mitigation of these risks are inadequate. The actual allocation in FY 2021/22 to facilitate further roll-out of vaccines to create herd immunity, was proposed to be Ksh 14.3 billion. We anticipate that more resources prioritized for enhanced Covid-19 vaccination roll out will boost economic activities towards attainment of the projected economic growth rate of 6% in 2021 and 5.8% in 2022.

1.2. Why vaccination?

Vaccination will lead to a reduction in community transmission of COVID-19, cases of severe illness and the number of hospitalizations and fatality cases because of COVID-19 infection. Most importantly, successful vaccination program will allow for the full re-opening of the economy.

1.3. Justification for Financing COVID 19 Vaccination

- Vaccination is one of the key measures to contain the spread of COVID-19
- Kenya has been relying on donations which have been insufficient and unsustainable
- Challenges in global vaccine supply chain continue to be experienced
- Public health benefits and other benefits such as growth in economic output outweigh the cost of vaccines in the long term (refer to Annex IV)
- Health being a constitutional right as per article 43(1)(a) which provides that every person has the right to the highest attainable standard of health
- Ensures vaccine equity, that is, guarantee that vaccines are available to all Kenyans including the most vulnerable persons. The risk of re-surgence in the infections still remains high, this is especially following the trends in the waves of infections experienced in Kenya since the onset of the pandemic in March 2020

Figure 1: Trends in the COVID 19 infections in Kenya

Source: IEA-Kenya | COVID Tracker

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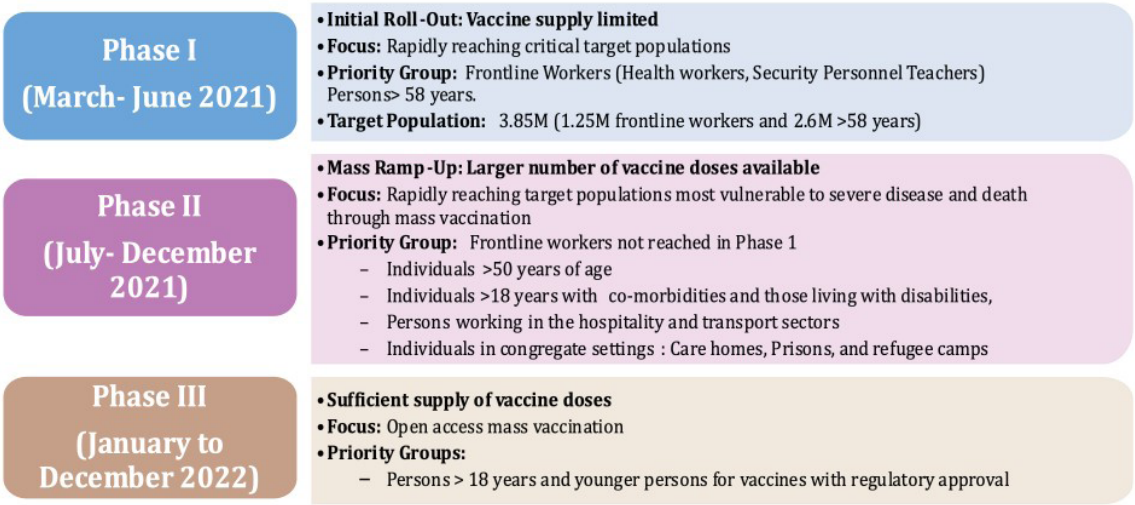
2.0 State of play

2.1. Vaccine Deployment Plan

Kenya COVID-19 vaccination program started in March 2021 with the government prioritizing the population by vulnerability, vaccine availability and health system capacity in order to ensure effective uptake. A phased approach was adopted as represented below.

Figure 2: Phases for vaccine introduction (as at 31st August 2021)



Source: Ministry of Health

Phase 1 covered the period between 5th March to 30th June 2021. The aim of this first phase was to vaccinate 1.25 million adults with the priority groups being front line workers (health workers, teachers and security personnel) and Kenyans above 58 years of age. In the second and third phases, Kenya anticipated to vaccinate 26 million people over 12 months, up to December 2022. In this accelerated phase, as the global supply chain improves, the country will get 20 million doses of different types of WHO approved quality assured vaccines including 13 million doses of single shot Johnson and Johnson procured through the African Vaccine Acquisition Trust (AVAT) of the African Union mechanism. In tandem, vaccination posts are hoped to increase from the current 800 to 3,000. In addition, the government aims to scale up the communication campaign, conduct out-reach services to targeted populations, increase and capacity build the work force and bring into full utility the IT digital platform (ChanjoKE) to support all aspects of the entire vaccination program.

2.2. Vaccine Supply Chain and Logistics

Table 1: Kenya COVID-19 vaccine supply, 2021-2022

Vaccine	Doses per patient	Storage	Approx allocation by funding and/ or procurement mechanism	Delivery Schedule	PPB approval (date)
AstraZeneca	2	Fridge: 2ºC to 8ºC	4,130,000 doses (Bilateral donations from EU and UK)	Received 1,130,000 doses July -August 2021	February, 2021
AstraZeneca	2	Fridge: 2ºC to 8ºC	765,200 doses (COVAX)	407,000 doses delivered August 2021 358,200 doses to be delivered in September, 2021	
Janssen Pharmaceutical (Johnson &Johnson)	1	Fridge: 2ºC to 8ºC		393,600 doses to be delivered September 500,000 monthly (September-December, 2021) 1-2 million monthly in 2022	
			13,300,000 doses (GOK)		July, 2021
Johnson & Johnson	2	Fridge: 2ºC to 8ºC	1,000,000 Doses for Private Sector (KEPSA)	Sep 2021 – June 2022	
Moderna	2	Freezing -20 ºC	1,760,780 doses (COVAX)		
BioNTech/Pfizer	2	Ultra-low temp freezer : -70ºC to - 80ºC		September 2021	August, 2021
			1,760,850 doses (USG donation)		
			270,000 doses (COVAX)		
Sinopharm	2	Fridge: 2ºC to 8ºC	2,000,000 doses (COVAX)	Sep 2021	August,2021
Total			**24,986,830**		

Source: Ministry of Health

By October 2021, the Pharmacy and Poisons Board had authorized at least 5 types of vaccines to be administered in Kenya: AstraZeneca, Johnson & Johnson, Pfizer, Moderna and SinoPharm.

In terms of dosage, all the vaccines require administration of 2 dosage per patient with exception of Johnson & Johnson which require only one.

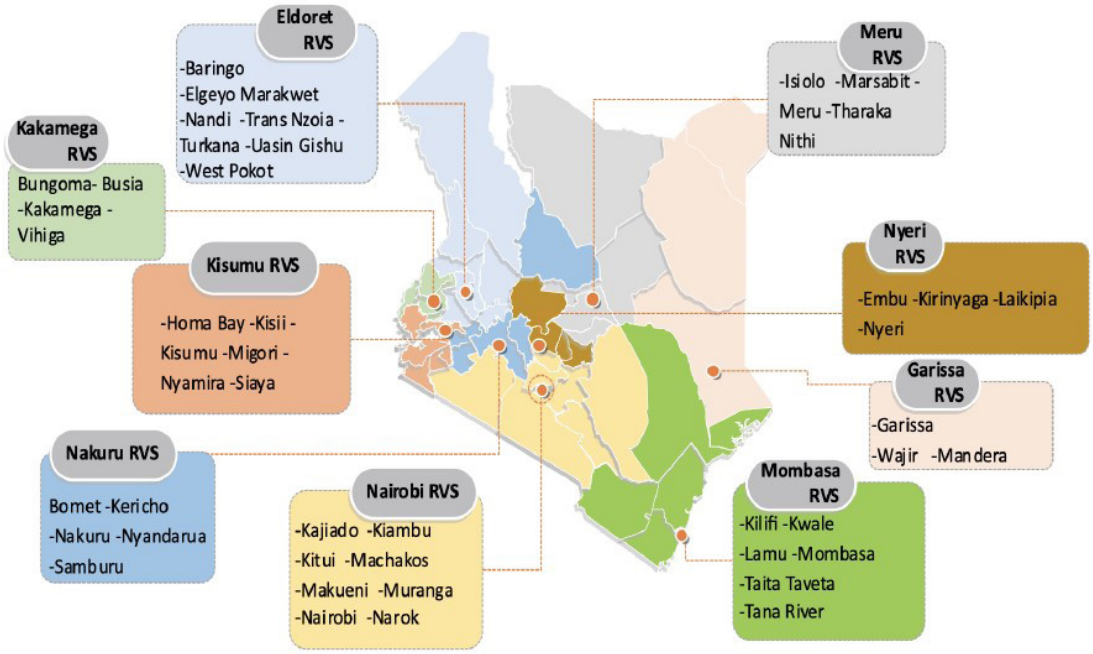
It is noted that the country requires additional storage facilities in order to boost the storage of vaccines to support mass vaccination exercise in Phase 3.

The storage requirements for these different vaccines can be grouped into three:

- Refrigerated (2°C to 8°C) Johnson & Johnson, AstraZeneca and SinoPharm
- Frozen (-15°C to -25°C) Moderna
- Ultra-cold (-70°C to -80°C) Pfizer

Currently, the National Vaccine Store has a total of eight (8) cold rooms with a refrigerated capacity of 130M^3 and 2 freezer rooms with a capacity of 14 M^3. Specialized Ultra Cold Chain (UCC) freezers with a storage capacity of 3 million doses are being procured to store the Pfizer/ BioNTech vaccines until they are ready to be distributed to various vaccination posts. In addition, the UPS foundation has donated 15 portable UCC freezers with a capacity of 6,000 doses which will be used to transport the vaccines to Pfizer designated vaccination posts. The Ministry of Health aims to leverage on UNICEF mechanisms under the Vaccine Independence Initiative Agreement to expedite logistics from the port of entry to the Central Vaccine store and onwards to the regional stores.

Figure 3: Regional stores and counties served



Source: Ministry of Health

The distribution of the regional stores are mainly centred in former provincial headquarters. These include: Nairobi, Mombasa, Kisumu, Nyeri, Nakuru, Kakamega and Garissa. Other towns include, Eldoret and Meru.

Notably, the 'Chanjo' electronic logistics management information system (eLMIS) is being used to manage vaccine stocks, vaccine cold chain management and provide an immunization data dashboard that presents the vaccine coverage, stock levels and integrated indicators for immunization performance including a weekly county logistics report outlining doses received, doses used, dose balances and number of persons vaccinated.

2.3. Vaccine Deployment and Safety

The National COVID-19 Vaccine Deployment and Vaccination Task Force was created with the mandate to provide overall technical leadership for the vaccine deployment planning and implementation. The Taskforce is working closely with the National Vaccines and Immunization program (NVIP) and the 47 County Vaccines Deployment task forces. The National task force reports to the National Emergency Response Committee on COVID-19 (NERCC) chaired by the Cabinet Secretary for Health. Kenya National Immunization Technical Advisory Committee (KENITAG) advises NERCC with regards to vaccine deployment

COVID-19 vaccines (including donations) must receive Pharmacy and Poisons Board (PBB) authorization before use in Kenya. The PPB in conjunction with NVIP monitor the safety of deployed

vaccines through the routine surveillance system using both the paper based and online platforms as outlined in the National Adverse Events Following Immunization (AEFI) guidelines. In addition to routine surveillance, PPB in collaboration with NVIP conduct targeted training for health care workers and others as may be necessary.

2.4. Vaccination Status in Kenya

MINISTRY OF HEALTH

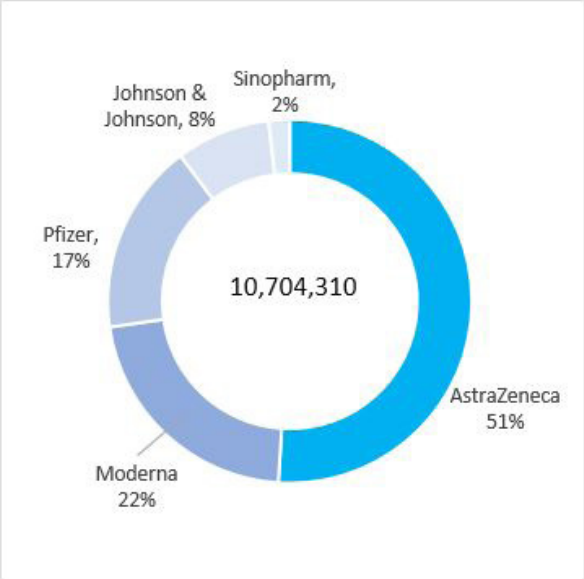
UPDATES ON COVID-19 VACCINATION EXERCISE

Background

- Total Covid-19 Vaccines Received to date- 10,704,690
- 1st dose Covid -19 vaccinations with AstraZeneca began on 5th March 2021, Country vaccinations started on week of 8th March 2021
- Administration of 2nd Dose AstraZeneca began on 28th May 2021.
- Vaccination with Moderna started on 24th August 2021, Johnson and Johnson 4th September 2021, Sinopharm 22nd September 2021 and Pfizer on 6th October 2021

***Table 1*: Vaccine Doses Dispensed as at Saturday 20th November 2021**

Current Status	Total doses Administered
Total Doses Administered	6,388,427
Total Partially Vaccinated	3,986,501
Total Fully vaccinated	2,401,926
2nd dose uptake	56.3%
Proportion of adults fully vaccinated	8.8%



Source: Ministry of Health

By 20th November 2021, the country had received accumulated total of 10.7 million vaccines, out of which about half were AstraZeneca (51%), almost a quarter were Moderna (22%), almost one fifth were Pfizer (17%) while the remaining 10% were Johnson & Johnson (8%) and Sinopharm (2%)

Out of 10.7 million doses of vaccines that the country has received, 6.4 million have been administered representing approximately 60% of the total, about a third have been partially administered while the proportion of the adults fully vaccinated stands at 8.8% as of 20th November 2021.

Table 2(b): Current vaccination status by County (20th November 2021)

Partially Vaccinated			
County	Partially vaccinated	Target population	Share
1. Nairobi	1,091,853	3,052,494	35.8%
2. Kiambu	352,875	1,623,545	21.7%
3. Nakuru	229,868	1,273,265	18.1%
4. Nyeri	159,021	510,028	31.3%
5. Muranga	141,365	675,364	20.9%
6. Machakos	122,376	905,172	13.5%
7. Kisumu	116,233	656,147	17.7%
8. Uasin Gishu	108,784	693,570	15.7%
9. Mombasa	101,072	804,202	12.6%
10. Meru	98,615	949,186	10.4%
11. Kirinyaga	97,006	413,708	23.4%
12. Kajiado	88,161	663,201	13.3%
13. Bungoma	86,061	843,735	10.2%
14. Kakamega	83,977	982,838	8.5%
15. Nyandarua	74,650	376,776	19.8%
16. Makueni	73,007	584,379	12.5%
17. Laikipia	71,314	306,448	23.4%
18. Embu	66,386	395,980	16.8%
19. Trans Nzoia	57,697	518,077	11.1%
20. Kericho	52,339	508,980	10.3%
21. Siaya	51,615	536,031	9.6%
22. Kitui	49,656	624,506	8.0%
23. Migori	48,145	557,657	8.6%
24. Homa Bay	45,137	608,326	7.4%
25. Nandi	44,729	492,652	9.1%
26. Busia	44,274	465,190	9.5%
27. Vihiga	43,946	329,317	13.3%
28. Taita Taveta	43,052	213,335	20.2%
29. Kisii	41,915	697,445	6.0%
30. Kilifi	40,642	784,567	5.2%
31. Nyamira	34,827	341,397	10.2%
32. Tharaka Nithi	33,504	246,699	13.6%
33. Bomet	31,154	465,963	6.7%
34. Baringo	28,163	338,937	8.3%
35. Kwale	22,972	451,261	5.1%
36. Elgeyo-Marakwet	22,628	243,690	9.3%
37. Narok	21,583	548,229	3.9%
38. Turkana	10,938	468,878	2.3%
39. West Pokot	9,313	283,727	3.3%
40. Garissa	8,113	399,358	2.0%

Fully Vaccinated			
County	Partially vaccinated	Target population	Share
1. Nairobi	755,340	3,052,494	24.7%
2. Kiambu	242,544	1,623,545	14.9%
3. Nakuru	121,941	1,273,265	9.6%
4. Nyeri	103,043	510,028	20.2%
5. Mombasa	75,588	804,202	9.4%
6. Uasin Gishu	73,542	693,570	10.6%
7. Machakos	71,623	905,172	7.9%
8. Muranga	69,705	675,364	10.3%
9. Kisumu	63,572	656,147	9.7%
10. Kajiado	55,490	663,201	8.4%
11. Nyandarua	42,411	376,776	11.3%
12. Meru	42,357	949,186	4.5%
13. Kericho	41,665	508,980	8.2%
14. Kirinyaga	41,428	413,708	10.0%
15. Kakamega	37,932	982,838	3.9%
16. Embu	37,464	395,980	9.5%
17. Laikipia	36,916	306,448	12.0%
18. Bungoma	36,615	843,735	4.3%
19. Makueni	35,409	584,379	6.1%
20. Trans Nzoia	34,774	518,077	6.7%
21. Nandi	26,038	492,652	5.3%
22. Taita Taveta	25,675	213,335	12.0%
23. Kilifi	24,785	784,567	3.2%
24. Siaya	24,613	536,031	4.6%
25. Kisii	22,620	697,445	3.2%
26. Kitui	22,044	624,506	3.5%
27. Migori	21,735	557,657	3.9%
28. Homa Bay	21,108	608,326	3.5%
29. Nyamira	20,554	341,397	6.0%
30. Busia	19,414	465,190	4.2%
31. Tharaka Nithi	19,342	246,699	7.8%
32. Vihiga	17,605	329,317	5.3%
33. Baringo	16,379	338,937	4.8%
34. Kwale	15,212	451,261	3.4%
35. Bomet	14,077	465,963	3.0%
36. Elgeyo-Marakwet	12,468	243,690	5.1%
37. Narok	11,970	548,229	2.2%
38. Garissa	7,628	399,358	1.9%
39. Turkana	7,612	468,878	1.6%
40. Wajir	6,098	337,296	1.8%

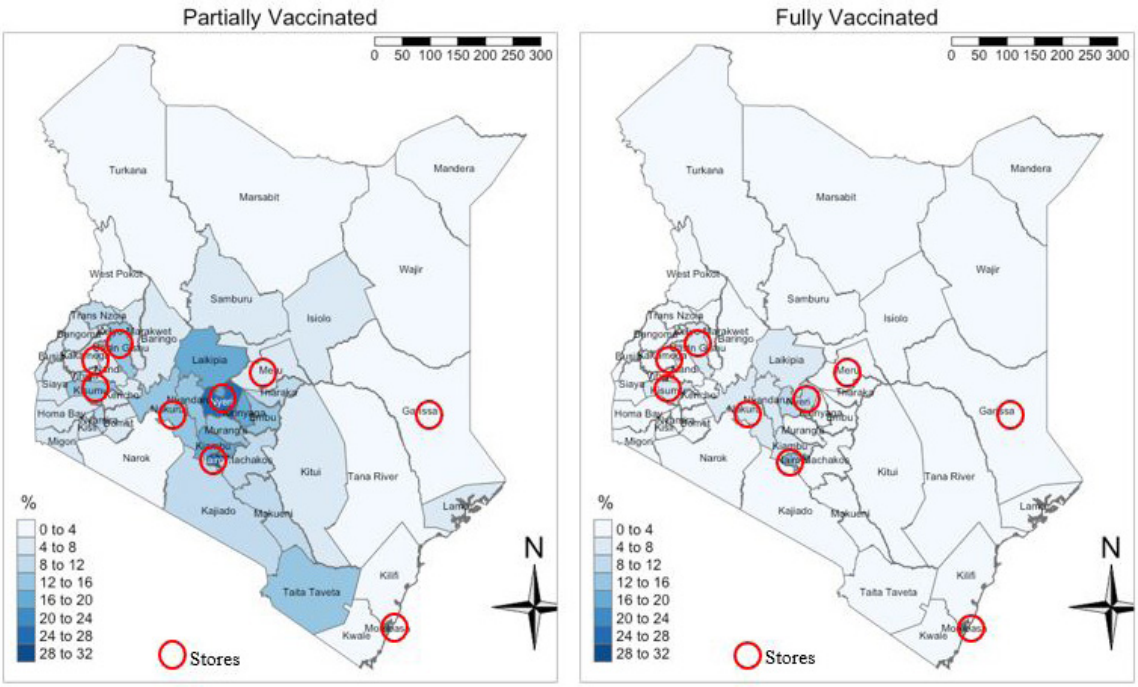
Partially Vaccinated			
County	Partially vaccinated	Target population	Share
41. Samburu	6,931	145,608	4.8%
42. Mandera	6,506	341,857	1.9%
43. Lamu	5,961	83,433	7.1%
44. Isiolo	5,892	133,358	4.4%
45. Wajir	5,152	337,296	1.5%
46. Tana River	3,871	151,051	2.6%
47. Marsabit	3,222	219,170	1.5%
Total	3,986,501	27,246,033	14.6%

Fully Vaccinated			
County	Partially vaccinated	Target population	Share
41. Mandera	5,159	341,857	1.5%
42. Samburu	4,971	145,608	3.4%
43. West Pokot	4,474	283,727	1.6%
44. Isiolo	3,586	133,358	2.7%
45. Marsabit	2,805	219,170	1.3%
46. Tana River	2,607	151,051	1.7%
47. Lamu	1,988	83,433	2.4%
Total	2,401,926	27,246,033	8.8%

Nairobi leads in both partially as well as fully vaccinated residents at 35.8% and 24.7% respectively. The least county is Marsabit at 14.6% and 1.3% respectively, depicting wide variations across the counties.

Geographical distribution of the counties with high vaccinations are mainly around Nairobi and the surrounding vaccine distribution centres, this is further illustrated in the Figure 4:-

Figure 4: Geographical distribution of current vaccination status by County, 20th November 2021



Source: Ministry of Health

With exception of Garissa, the geographical distribution of both partially and fully vaccination is mainly in the vicinity of regional stores which are mainly centred in former provincial headquarters. These include: Nairobi, Mombasa, Kisumu, Nyeri, Nakuru and Kakamega. Other towns being; Eldoret and Meru.

Table 3: Vaccination status by Priority group 20th, November 2021

Priority group	Fully vaccinated	Target population	% Fully vaccinated by Occupation
Health Workers	**183,468**	208,418	88.0%
Security Officers	**141,079**		
Teachers	**262,007**	330,671	79.2%
Above 58 years Old	**476,800**	2,594,585	18.4%
Others	**1,329,959**		
Inmates	**8,613**	49,000	17.6%
Total	**2,401,926**	27,246,033	8.8%

Source: Ministry of Health

The status by 20th of November 2021 of the vaccination rate of the priority group identified under Phase 1 (see Figure 1), shows that more than three quarters of healthcare workers (88%) and teachers (79%) had been fully vaccinated, however, vaccination rate of the population above 58 years' old (18.4%), inmates (17.6%) and other priority groups is less than a quarter for each of these groups.

3

3.0 Methodology

3.1. Simulation Analysis

Simulation analysis is a technique that allows researchers to draw or imitate various "what if" scenarios under logical assumptions with the main objective of analyzing the outcome of these scenarios.

A scenario is a setting given certain plausible assumptions or policy alternatives.

A healthcare worker administers an Oxford/AstraZeneca COVID-19 vaccine to her colleague at Mutuini Hospital in Nairobi. Kenya on March 3, 2021. Photo by Dennis Sigwe/SOPA Images/LightRocket via Getty Images

3.2. Why simulation?

Advantages of using simulation tool in the estimation of the cost of vaccination in Kenya is because it enables us to;

- Identify and assess (predict) various policy options
- Factor uncertainties
- Make a choice out of the various alternatives

3.3. Objectives of simulation of COVID 19 vaccination drive in Kenya

- Assess the cost of vaccines under various scenarios
- Assess the impact of uncertainties on the cost of vaccines
- Identify the best mix/choice out of the various scenarios
- Provide information to serve as a basis for budgeting and public discourse

3.4. Key parameters in the simulation of COVID 19 vaccination drive in Kenya

Target population	As per the government's policy, the eligible population is Kenyans aged 15 years and above with priorit being given to frontline workers and the most vulnerable groups
Approved vaccines	By November 2021, at least five vaccines have been approved by the Pharmacy and Poisons Board (PBB) to be administered in Kenya. These include: AstraZeneca, Moderna, Pfizer, Johnson & Johnson and Sinopharm.
Efficacy of the vaccines	High efficacy vaccines such as Pfizer and Moderna reduce the infection rates. Pfizer has also been recommended by government to be administered to individuals aged between 15 years to 18 years. On the other hand, AstraZeneca, Johnson & Johnson and Sinopharm have relatively low efficacy rates and hence may increase the need for issuance of booster shots for enhanced protection thus driving up the overall cost
Dosage of the vaccines	Single dosage vaccines such as Johnson and Johnson significantly reduces logistical and operational cost compared to its 2-dosage counterparts
Cost of vaccines	Cost per dose of vaccines such as Pfizer and Moderna cost thrice as much as vaccines such as AstraZeneca and thus impacting on the overall cost of vaccination drive
Logistical/Operational costs	Besides the cost of vaccines, logistical and operational costs such as *cold chain equipment, surveillance and communication, data management, planning and coordination* were considered
Other uncertainties e.g. Fluctuation in prices and/or forex	Market uncertainties such as fluctuation in the prizes of the vaccines and the exchange rate are some of the factors that may impact on the actual prizes of the vaccines, especially given the fact that Kenya currently is importing all the five approved vaccines

3.5. Scenarios

Table 4: Cost simulation scenarios considered for this analysis include:

Scenario 1:	Population (18 years +), adult
Scenario 2:	Population (58 years +), at risk
Scenario 3:	Population (70%), herd immunity
Scenario 4:	Population (70%), herd immunity + booster (58 years +)
Scenario 5:	Population (15 years +), all eligible population

Source: Author's Computation

Justification for the selection of the scenarios is mainly based on government vaccination plan over the three phases illustrated in Figure 2. That is, in Phase I apart from the frontline workers and those with underlying health conditions, the prioritised group include the most vulnerable. While in Phase II, mass vaccination mainly targets vaccination of adult population. Phase III targets open mass vaccination targeting all adult population including the younger population groups subject to approval by. The herd immunity scenario is included as an extra alternative for policy actors.

Table 5: Estimation of the target population

	Actuals					Assumption			
	2016	2017	2018	2019	2020	Dec 2021	Jun 2022	Dec 2022	
Overall Population (Million)	44.3	45.3	46.4	47.6	48.7	49.9	50.5	51.1	
Growth rates (%)		2.26%	2.43%	2.59%	2.31%	2.42%	2.42%	2.42%	The current average growth rate is assumed to remain constant
-1- Population (18 yrs +), 53.91% (Mn)				25.66	26.25	26.89	27.22	27.54	
-2- Population (58 yrs +), 6.62% (Mn)				3.15	3.22	3.30	3.34	3.38	
-3- Population (70%), % (Mn)				33.32	34.09	34.92	35.34	35.76	The 2019 KPHC ratio is assumed to remain constant
-4- Population (70%+6.62%), % (Mn)				36.47	37.31	38.22	38.68	39.14	
-5- Population (15 yrs +), 63.54% (Mn)				30.25	30.95	31.70	32.08	32.46	

Source: Author's Computation

Estimation of the target population is based on the 2019 Kenya Population and Housing Census (KPHC 2019). For instance, Kenya had a total population of 47.6 million growing at an annual average rate of 2.42%. On the other hand, adult population was estimated at 26 million (53.9% of total population), the elderly population was 3.2 million (6.6% of total population) while population that is 15 years and above was 30.2 million (63.5% of total population). A constant annual average rate was applied across the age groups from 2020 through 2022, justification being that the period is short for significant changes in the population structure.

Table 6: Approved vaccines, 10th October 2021

		Assumption			
		Dec 2021	Jun 2022	Dec 2022	
AstraZeneca	4,317,740	57.55%	57.55%	57.55%	
Moderna	1,760,780	23.47%	23.47%	23.47%	
Pfizer	830,320	11.07%	11.07%	11.07%	The current proportions of the vaccines so far received to remain constant
Johnson & John	393,600	5.25%	5.25%	5.25%	
Sinopharm	200,000	2.67%	2.67%	2.67%	
Total	**7,502,440**	**100.00%**	**100.00%**	**100.00%**	

Source: Author's Computation

By 10th October 2021, of the 7.5 million vaccines that had been received mainly through donations, which comprised; AstraZeneca (57.6%), Moderna (23.5%), Pfizer (11.0%), Johnson & Johnson (5.3%) and Sinopharm (2.7%).

Table 7: Vaccine efficacy rates

	Efficacy rate (%)	Probability of disease re-occurrence (%)
AstraZeneca	72%	28%
Moderna	94%	6%
Pfizer	95%	5%
Johnson & Johnson	79%	21%
Sinopharm	79%	21%

Formular =

$$\frac{\text{Risk among unvaccinated group} - \text{Risk among vaccinated group}}{\text{Risk among unvaccinated group}} \times 100\%$$

Source: Author's Computation

Efficacy rate is the measure of the proportionate reduction in cases among vaccinated persons computed using the above formular. AstraZeneca with the efficacy rates of 72% and Johnson & Johnson and Sinopharm at 79% have among the lowest efficacy rates thus implying that they have high probability of disease re-occurance. On the other hand, Pfizer and Moderna have efficacy rates above 94% implying they have the lowest probability of disease re-occurance.

Table 8: Vaccine dosage

AstraZeneca	2
Moderna	2
PFIZER	2
Johnson & Johnson	1
SINOPHARM	2

Johnson & Johnson is administered as one dosage while the rest of the four vaccines require two dosages.

Source: WHO

Table 9: Market Prices of the Vaccines

	Single Dosage	Full Dosage	
Type of Vaccine	US $	US $	Source
AstraZeneca	6	12	Source: UNICEF,WHO
MODERNA	25	50	Source: UNICEF,WHO
PFIZER	18	37	Source: UNICEF,WHO
Johnson & Johnson	10	10	Source: UNICEF,WHO
SINOPHARM	20	40	Source: Oxfam

Market price for a full dosage of AstraZeneca and Johnson & Johnson are among the cheapest. Sinopharm is US$ 40 together with Moderna are at the high end of the scale.

Table 10: Logistical/Operational costs

Description	Total Cost (Ksh Mln)
Cold Chain Equipment Capacity Expansion	918.2
Trainings & Capacity Building	321.9
Planning & Coordination	104.4
Data Management, Monitoring & Surveillance	568.1
Advocacy, Communication and Community Mobilization Initiatives	962.0
Total	2,875

Estimates by the Ministry of Health shows that total logistical and operational costs amount to approximately Ksh 2.9 billion, with Cold Chain Equipment and Community Mobilization being the largest components

Source: Ministry of Health

Table 11: Fluctuation in Forex

	Actuals					Assumption			
	2016	2017	2018	2019	2020	Dec 2021	Jun 2022	Dec 2022	
Exchange rate (Ksh / US $)	101.5	103.41	101.29	101.99	106.47	110.8	112.5	114.1	FOREX will depreciate assuming the average rate for the last thr
Growth rates (%)		1.88%	-2.05%	0.69%	4.39%	4.04%	3.04%	3.04%	

Source: Ministry of Health

Before the onset of COVID 19 in January 2020, the Kenya shillings was valued at Ksh 106 per 1US$. However, by the October it exchanged at Ksh 110.6 per 1US$. Given the historical trends, the shilling is expected to vary within the margin of 3.04% over the the course of 2022.

Scenario 3: Population (70%), herd immunity						
	AstraZeneca	Moderna	Pfizer	Johnson & Johnson	Sinopharm	TOTAL
VACCINE COST						
Key Variables						
Current proportions of vaccines	58%	23%	11%	5%	3%	100%
Dosage	2	2	2	1	2	
Price per each dose (US$)	6	25	18	10	20	
Price per each dose (Ksh)	670	2769	2032	1108	2215	
Population (70%), herd immunity	20.09	8.19	3.86	1.83	0.93	34.92
Vaccines already received, Million	4.32	1.76	0.83	0.39	0.20	7.50
Doses to be administered, Million	39.48	16.32	7.68	1.79	1.85	67.12
COST						
Mix (Ksh)	26,454,903,195	45,190,846,026	15,608,781,373	1,985,488,836	4,102,008,055	93,342,027,485
AstraZeneca (Ksh)						44,982,191,596
Moderna (Ksh)						185,876,824,777
PFIZER (Ksh)						136,359,238,657
Johnson & Johnson (Ksh)						74,350,729,911
SINOPHARM (Ksh)						148,701,459,822

Source: Author's Computation

Six "what if" set of possibilities were considered;

a the first being "the Mix" which considers a situation where all the five approved vaccines were to be inclusively procured and administered

b The rest being, if individual vaccines were to be exclusively procured and administered

A constant proportion of the cumulative stock of the vaccines that Kenya has so far received, by 10th October 2021, reflects her preference and is maintained. That is, Kenya will continue to place highest preference on AstraZeneca (58% of new vaccines) in the course of procuring new vaccines, this is

followed by moderna (23%), Pfizer (11%), Johnson & Johnson (5%) and Sinopharm (3%). For "the Mix", the proportions are multiplied by the eligible target population (e.g. 70% of all population, in the case of the above scenario) which is then multiplied by the required dosage to determine the total number of the doses of each vaccine in "the mix" to be procured. The vaccines already received, by 10th of October 2021 are then subtracted from the resulting figure to determine the net total number of vaccines. The total cost is then determined by multiplying the net number of net vaccines by the price of each vaccine.

For the individual vaccines, the total number doses to be procured is determined by multiplying the required dosage for the respective vaccine with the eligible target population (for example, 70% of all population, in the case of the above scenario). The vaccines already received are then subtracted from the resulting figure to determine the net total number of vaccines. The total cost is then determined by multiplying the net total number of vaccines by the price of each vaccine.

The overall cost is determined by adding the logistics and operational cost, which is maintained at a constant of Ksh 3 billion to the overall cost of the vaccines.

4

4.0 Findings

4.1. Results of cost of vaccination under various scenarios

Table 12: Summary of the results of cost of vaccination under various scenarios

Scenario 1: Population (18 yrs +), adult	Vaccine Costs (Ksh Billion)	Logistics & Operational Costs (Ksh Billion)	Total	as % Health Budget	as % MDAs	Per Capita (Ksh)
Mix	72	3	75	62%	3.9%	1,495
AstraZeneca	35	3	37	31%	2.0%	749
Moderna	143	3	145	121%	7.7%	2,916
Pfizer	105	3	107	90%	5.7%	2,155
Johnson & Johnson	57	3	60	50%	3.2%	1,201
Sinopharm	114	3	117	97%	6.2%	2,344
Scenario 2: Population (58 yrs +), at risk	**Vaccine Costs (Ksh Billion)**	**Logistics & Operational Costs (Ksh Billion)**	**Total (Ksh Billion)**	**as % Health Budget**	**as % MDAs**	**Per Capita (Ksh)**
Mix	8	3	11	9%	0.6%	220
AstraZeneca	4	3	7	5%	0.3%	132
Moderna	15	3	18	15%	1.0%	366
Pfizer	11	3	14	12%	0.7%	284
Johnson & Johnson	6	3	9	8%	0.5%	181
Sinopharm	12	3	15	13%	0.8%	304
Scenario 3: Population (70%), herd immunity	**Vaccine Costs (Ksh Billion)**	**Logistics & Operational Costs (Ksh Billion)**	**Total (Ksh Billion)**	**as % Health Budget**	**as % MDAs**	**Per Capita (Ksh)**
Mix	93	3	96	80%	5.1%	1,929
AstraZeneca	45	3	48	40%	2.5%	959
Moderna	186	3	189	157%	10.0%	3,784
Pfizer	136	3	139	116%	7.3%	2,791
Johnson & Johnson	74	3	77	64%	4.1%	1,548
Sinopharm	149	3	152	126%	8.0%	3,039
Scenario 4: Population (70%), herd immunity + booster (58 yrs +)	**Vaccine Costs (Ksh Billion)**	**Logistics & Operational Costs (Ksh Billion)**	**Total (Ksh Billion)**	**as % Health Budget**	**as % MDAs**	**Per Capita (Ksh)**
Mix	102	3	105	88%	5.5%	2,108
AstraZeneca	49	3	52	43%	2.8%	1,046
Moderna	204	3	207	172%	10.9%	4,141
Pfizer	149	3	152	127%	8.0%	3,053
Johnson & Johnson	81	3	84	70%	4.5%	1,691
Sinopharm	163	3	166	138%	8.8%	3,325

Scenario 5: Population (15 yrs +), all eligible population						
	Vaccine Costs (Ksh Billion)	Logistics & Operational Costs (Ksh Billion)	Total (Ksh Billion)	as % Health Budget	as % MDAs	Per Capita (Ksh)
Mix	85	3	88	73%	4.6%	1,755
Moderna	169	3	171	143%	9.0%	3,436
Pfizer	124	3	126	105%	6.7%	2,536

Source: Author's Computation

Within each of the five scenarios, it is notable that the unit cost of the dose is the main driver of the overall cost of the vaccines, the second factor being the dosage. It is for this reason that, across all the scenarios, AstraZeneca is the cheapest, followed by Johnson & Johnson and "the Mix" is the third whose overall prize is the weighted average of all the five approved vaccines. Moderna is relatively more expensive compared to Pfizer by virtue of its relative high prize.

The five scenarios reveal that:

Scenario 1: for the government to vaccinate all the adult (population aged 18 years and above), use of AstraZeneca vaccine is still the cheapest at Ksh 37 billion, followed by Johnson & Johnson (Ksh 60 billion), "the Mix" (Ksh 75 billion). On the other hand, the most expensive option is Moderna (Ksh 145 billion), Sinopharm (Ksh 117 billion) and Pfizer (Ksh 107 billion). The relative low cost among different vaccine deployment options in this scenario is mainly explained by difference in the market prices of the vaccines dosage.

Scenario 2: for the government to vaccinate all the population at risk (population aged 58 years and above), use of AstraZeneca vaccine is still the cheapest at Ksh 7 billion, followed by Johnson & Johnson (Ksh 9 billion), "the Mix" (Ksh 11 billion). On the other hand, the most expensive option is Moderna (Ksh 18 billion), Sinopharm (Ksh 15 billion) and Pfizer (Ksh 107 billion). The relative low cost when compared with other scenarios is mainly explained by the low number of the target population.

Scenario 3: for the government to achieve the desirable herd immunity (i.e. vaccinate at least 70 percent of all the population), use of AstraZeneca vaccine is still the cheapest at Ksh 48 billion, followed by Johnson & Johnson (Ksh 77 billion), "the Mix" (Ksh 96 billion). On the other hand, the most expensive option is Moderna (Ksh 189 billion), Sinopharm (Ksh 152 billion) and Pfizer (Ksh 139 billion).

Scenario 4: for the government to achieve the most desirable herd immunity (i.e. vaccinate at least 70 percent of all the population), use of AstraZeneca vaccine is still the cheapest at Ksh 52 billion, followed by Johnson & Johnson (Ksh 84 billion), "the Mix" (Ksh 105 billion). On the other hand, the most expensive option is Moderna (Ksh 207 billion), Sinopharm (Ksh 166 billion) and Pfizer (Ksh 152 billion). The relative high cost when compared with other scenarios is mainly explained by the high number of target population including the booster shots.

Scenario 5: for the government to vaccinate all eligible population (population aged 15 years and above), use of "the Mix" (Ksh 88 billion) is the cheapest followed by Pfizer (Ksh 126 billion). On the other hand, the most expensive option is Moderna (Ksh 18 billion). For the population aged between

15 years and 17 years high efficacy vaccines (Pfizer and Moderna are recommended). It is assumed that "the Mix" will entail prioritizing administering the high efficacy vaccines to this young age group and the most vulnerable population group (population aged 58 years and above). NB:

It is desirable for the government to achieve the herd immunity as shown in scenario 3. The relative cost for the cheapest vaccine option under this scenario is AstraZeneca, Ksh 48 billion which is equivalent to 40% of national health budget and 2.5% as share of MDAs, 2.5%. On a per capita basis it is Ksh 1,046 (which is below the country's food poverty line of Ksh 1,954 in rural areas). While the third scenario is the basic desired plausible policy alternatives for policy makers in not only reducing the emergence of new variants such as delta and omicron, it is also vital in reducing hospitalizations and fatalities (WHO, 2021).

Notably, more the donations that the country receives, the lower the cost for each of the scenario.

4.2. Sensitivity Analysis

4.2.1. Impact on the overall cost of vaccination

Table 13: Estimation of the extra cost incurred due to re-vaccination

Scenario 1: Population (18 yrs +), adult						
	Efficacy rate (%)	Probability of disease re-occurrence (%)	Population (to be re-vaccinated) Million	Extra Cost (re-vaccination) Ksh Billion	Total initial Cost of Vaccination Ksh Billion	Extra Cost as % of Total initial Cost of Vaccination
AstraZeneca	72%	28%	4.3	5.8	37	15.5%
Moderna	94%	6%	0.4	2.1	145	1.4%
Pfizer	95%	5%	0.1	0.6	107	0.6%
Johnson & Johnson	79%	21%	0.3	0.3	60	0.5%
Sinopharm	79%	21%	0.2	0.7	117	0.6%
Scenario 2: Population (58 yrs +), at risk						
	Efficacy rate (%)	Probability of disease re-occurrence (%)	Population (to be re-vaccinated) Million	Extra Cost (re-vaccination) Ksh Billion	Total initial Cost of Vaccination Ksh Billion	Extra Cost as % of Total initial Cost of Vaccination
AstraZeneca	72%	28%	0.53	0.7	7	10.8%
Moderna	94%	6%	0.05	0.3	18	1.4%
Pfizer	95%	5%	0.02	0.1	14	0.5%
Johnson & Johnson	79%	21%	0.02	0.0	9	0.2%
Sinopharm	79%	21%	0.04	0.2	15	1.3%
Scenario 3: Population (70%), herd immunity						
	Efficacy rate (%)	Probability of disease re-occurrence (%)	Population (to be re-vaccinated) Million	Extra Cost (re-vaccination) Ksh Billion	Total initial Cost of Vaccination Ksh Billion	Extra Cost as % of Total initial Cost of Vaccination
AstraZeneca	72%	28%	5.6	7.5	48	15.8%
Moderna	94%	6%	0.5	2.7	189	1.4%
Pfizer	95%	5%	0.2	0.8	139	0.6%
Johnson & Johnson	79%	21%	0.2	0.2	77	0.3%
Sinopharm	79%	21%	0.5	2.1	152	1.4%

Scenario 4: Population (70%), herd immunity + booster (58 yrs +)						
	Efficacy rate (%)	Probability of disease re-occurrence (%)	Population (to be re-vaccinated) Million	Extra Cost (re-vaccination) Ksh Billion	Total initial Cost of Vaccination Ksh Billion	Extra Cost as % of Total initial Cost of Vaccination
AstraZeneca	72%	28%	6.2	8.3	52	15.8%
Moderna	94%	6%	0.5	3.0	207	1.4%
Pfizer	95%	5%	0.2	0.8	152	0.5%
Johnson & Johnson	79%	21%	0.2	0.2	84	0.3%
Sinopharm	79%	21%	0.5	2.3	166	1.4%
Scenario 5: Population (15 yrs +), all eligible population						
	Efficacy rate (%)	Probability of disease re-occurrence (%)	Population (to be re-vaccinated) Million	Extra Cost (re-vaccination) Ksh Billion	Total initial Cost of Vaccination Ksh Billion	Extra Cost as % of Total initial Cost of Vaccination
Moderna	94%	6%	0.4	2.5	171	1.4%
Pfizer	95%	5%	0.2	0.7	126	0.6%

Source: Author's Computation

Vaccines with high efficacy rates such as Moderna and Pfizer have low probability of re-occurrence of the COVID 19 infection (holding other factors constant, such as emergence of new variants) and hence relatively low cost due to re-vaccination. Overall, AstraZeneca have highest "Etra Costs" as a result of low efficacy rate and the its large usage out of all the vaccines (has the highest proportion of usage, this is explained in Table 6 and Table 14).

4.2.2. Change in the prices of vaccines

Table 14: Variation in the vaccine prices in the event of a shock

Scenario 1: Population (18 yrs +), adult		
IMPACT ON THE COST DUE TO CHANGE IN THE PRICES OF VACCINES (assumming 10% variation)		
	Initial Cost Per Single Dose of Vaccine (US $)	Variation (+/-) in Vaccine Costs (Ksh Billion)
Mix	--	7.17
AstraZeneca	6.05	3.45
Moderna	25.00	14.26
Pfizer	18.34	10.46
Johnson & Johnson	10.00	5.70
Sinopharm	20.00	11.41

Ksh Billion
2.03
3.48
1.20
0.15
0.32

Source: Author's Computation

Other potential risk can arise from the change in the price of the unit of the respective vaccine. Assuming a flat rate of 10% variation from the prevailing market rates, it is observed that vaccines in at the high end of the scale such as Moderna, Sinopharm and Pfizer varying as high as Ksh 14.26 billion, Ksh 11.41 billion and Ksh 10.46 billion respectively while the least variation is expected to be with AstraZeneca at Ksh 3.45 billion, for the case of the first scenario: vacination of all the adult population (18 years +).

4.2.3. Fluctuation in the exchange rate

Table 15: Impact on the cost of the variation in the exchange rate

Scenario 1: Population (18 yrs +), adult

IMPACT ON THE COST DUE TO CHANGE IN THE EXCHANGE RATE (assumming 3.04% variation), between Dec 2021 & Dec 2022

Upper limit	*114.14*
Exchange rate (Ksh / US$)	*110.77*
Lower limit	*107.40*

		comprises of	Ksh Billion
Mix	**2.18**		
AstraZeneca	**1.05**		*0.62*
Moderna	**4.34**		*1.06*
Pfizer	**3.18**		*0.36*
Johnson & Johnson	**1.73**		*0.05*
Sinopharm	**3.47**		*0.10*

Source: Author's Computation

If the current annual average rate, of approximately 3.04%, at which the shilling has been depreciating against the dollar were to be maintained, the overall cost will vary upwards approximately Ksh 1.05 billion for AstraZeneca (Ksh 1.05 billion), Johnson & Johnson (Ksh 1.73 billion), Pfizer (Ksh 3.18 billion), Sinopharm (Ksh 3.47 billion) and Moderna (Ksh 4.34 billion). The variation is largely explained by the prize of the cost of the respective vaccines.

Key Messages

i) Enhance the prioritization on vaccination to minimize on opportunity costs

The analysis shows that, with enhanced prioritization, it is affordable for the government of Kenya to vaccinate its citizens. For instance, given a cost of approximately 2.5% of the total MDA budget for the case of use of AstraZeneca, it is possible for the government to procure and vaccinate at least 70% of the population within the existing budgetary framework. After all, this would be a one-off expenditure. Due to the containment measures instituted by the government to contain the spread of the virus, the economic activities were disrupted in key sectors such as hospitality, transport and education which contributed to the negative growth. Mass vaccination is key in achieving WHO's vaccine equity targets will substantially increase population immunity globally, protect health systems, enable economies to fully restart, and reduce the risk of new variants emerging. While, the scenarios have not taken into account the financial, logistical assistance, planning and coordination costs that may be provided by the county governments, the overall cost is likely down with their support.

ii) Engage the private sector in vaccine financing model

With transparency and accountability guaranteed the government can engage the private sector in vaccine financing discussions or a role that they can play in the vaccination programme - especially given fiscal constraint.

iii) Explore the pooled procurement mechanisms

Other option that the government can pursue in improving bargaining power or lowering the price of vaccines is pooled procurement mechanisms especially with a country(ies) that Kenya already has close bilateral ties. Even though, it is understandable that the procurement process under this option is likely to take relatively longer due to the procedures that may be required.

iv) Ensure operationalization of the contingency fund

Lessons that Kenya learns from the emergencies that have been experienced in the past three years; from locust infestation, severe floods, drought and famine and the COVID pandemic in early march 2020, is the need for enhanced preparedness. For the purposes of adequately planning for eventualities such as these and many others, the current Contingency Fund which is currently capped at Ksh 5 billion ought to be increased and operationalized as part of the mitigation programme to hedge against these uncertainties.

v) The best mix of the vaccine is AstraZeneca followed by Johnson and Johnson due to relatively lower cost

The analysis shows that out of the five vaccines approved in Kenya, AstraZeneca is the cheapest followed by Johnson & Johnson. The wide use of these vaccines in Kenya without major incidences of side effects. AstraZeneca is thus the most affordable, considering factors such as cost, affordability, storage and even wastage. Procurement of these vaccines is thus key in boosting vaccine deployment plan and enhancing the vaccine equity in the country

vi) Pfizer and Moderna, though have high cost, they have higher efficacy rates and hence can be exclusively be prioritized on the elderly and children (15-17 years)

Following the recent approval and recommendation of vaccination of the underage population aged 15 - 17 years with high efficacy rate vaccines such as Pfizer, even though costly, the procurement plan by government should include these vaccines to be administered to such target groups. Other groups to be considered include individuals with pre-existing health conditions and the elderly.

Appendix

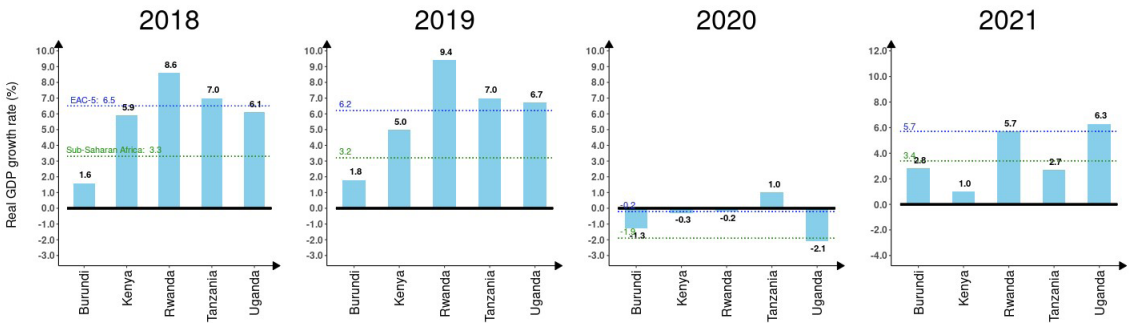
Annex I: Vaccine received in the Country as at 20th , November 2021

Vaccine Arrival Date	Vaccine	Quantity Received	Country
03/03/2021	AstraZeneca	63,810	COVAX FACILITY EX- INDIA
03/03/2021	AstraZeneca	956,190	COVAX FACILITY EX- INDIA
11/03/2021	AstraZeneca	100,000	DONATION INDIA
29/05/2021	AstraZeneca	72,000	COVAX FACILITY EX-SUDAN
22/06/2021	AstraZeneca	358,700	DONATION DENMARK
08/07/2021	AstraZeneca	182,400	DONATION FRANCE
31/07/2021	AstraZeneca	410,000	DONATION UK
06/08/2021	AstraZeneca	180,000	DONATION GREECE
17/08/2021	AstraZeneca	407,040	COVAX DONATION UK
23/08/2021	Moderna	880,460	COVAX DONATION USA
02/09/2021	AstraZeneca	459,300	COVAX DONATION CANADA
03/09/2021	Johnson & Johnson	141,600	GOVERNMENT OF KENYA/AVAT
04/9/2021	AstraZeneca	55,200	DONATION LATVIA
06/09/2021	Moderna	880,320	COVAX DONATION USA
12/09/2021	AstraZeneca	211,200	POLAND DONATION
17/09/2021	PFIZER	830,700	COVAX FACILITY USA DONATION
18/09/2021	SINOPHARM	200,000	CHINA DONATION
06-10-2021	Johnson & Johnson	252,000	GOVERNMENT OF KENYA/AVAT
08/10/2021	AstraZeneca	160,000	SLOVAKIA
08/10/2021	AstraZeneca	401,900	COVAX FRANCE
08/10/2021	AstraZeneca	300,000	COVAX GERMANY
21/10/2021	Johnson & Johnson	504,000	GOVERNMENT OF KENYA/AVAT
28/10/2021	PFIZER	990,990	COVAX DONATION USA
09/11/2021	AstraZeneca	765,600	DONATION DENMARK
15/11/2021	AstraZeneca	376,800	DONATION DENMARK
18/11/2021	Moderna	564,480	SPAIN
Total Doses Received		**10,704,690**	

Source: Ministry of Health

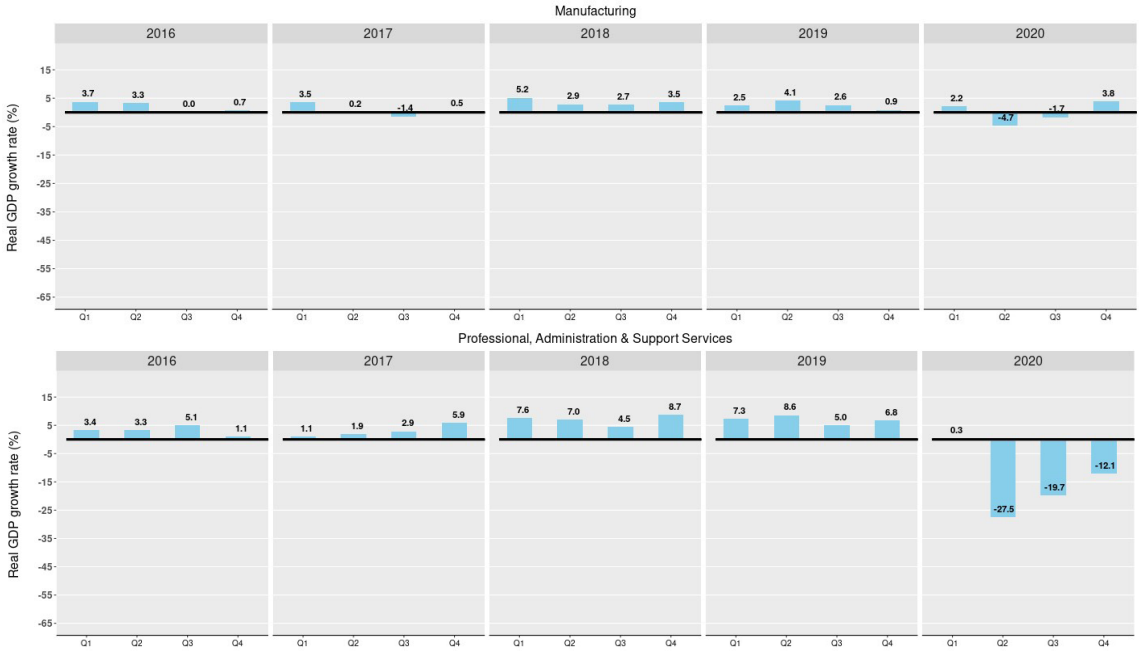
** Total vaccines received since the start of Covid -19 vaccination exercise in the country

Annex II: Trends in Kenya's Economic performance against its EAC peers



Source: IEA-Kenya | COVID Tracker

Annex III: Trends in Kenya's Economic performance (sectors)



Source: IEA-Kenya | COVID Tracker

Annex IV: Illustration of the loss of Gross Domestic Product (real) due to COVID pandemic

Opportunity loss

	2016	2017	2018	2019	2020	2020
GDP (CONSTANT, Ksh Mn)	**7,594,064**	7,883,816	8,327,604	8,742,413	8,714,771	9,162,799
Growth rate		3.8%	5.6%	5.0%	-0.3%	
Average growth				4.8%		
Opportunity loss (Ksh Mn)						448,028

Source: Author's Computation

Using the rebased GDP figures by the Kenya National Bureau of Statistics (KNBS), between 2017 and 2019, Kenya's economic growth was approximately 4.8%. Had this pre-COVID economic growth been maintained, additional Ksh 448 billion would have been realized. However, a negative growth of -0.3% was instead realized in 2020 thus indicating huge opportunity loss. The negative growth was mainly as a result of containment measure.

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