RHAP
Rural Health Advocacy Project

HEALTH SYSTEM STRENGTHENING POST-COVID-19

FULL REPORT

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December 2022

PUBLISHED BY RURAL HEALTH ADVOCACY PROJECT
a division of Wits Health Consortium (Pty) Ltd
www.witshealth.co.za

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FULL REPORT

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ACRONYMS AND ABBREVIATIONS

Ag-RDT	Antigen-Detecting Rapid Diagnostic Tests
AMCs	Advance Market Commitments
ARDS	Acute Respiratory Distress Syndrome
ART	Antiretroviral Treatment
CCMDD	Central Chronic Medicines Dispensing and Distribution
CEPI	Coalition for Epidemic Preparedness Innovations
CHBAH	Chris Hani Baragwanath Academic Hospital
CHW	Community Health Worker
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
COVAX	COVID-19 Vaccines Global Access
COVID-19	Coronavirus Disease 2019
CSIR	Council for Scientific and Industrial Research
CST	Community Screening and Testing
CTICC	Cape Town International Convention Centre
DATCOV	NICD South African COVID-19 Daily Hospital Surveillance Database
DSFSI	Data Science for Social Impact
DHIS	District Health Information System
DTP	Diphtheria, Tetanus and Pertussis Vaccine
EC	Eastern Cape Province
ED	Emergency Department
EPI	Expanded Programme of Immunisation
EVDS	Electronic Vaccination Data System
FS	Free State Province
fT3	Free Tri-iodothyronine
GP	Gauteng Province
GAVI	The Vaccine Alliance
GIS	Geographic Information System
GSH	Groote Schuur Hospital
HBA1C	Glycated Haemoglobin
HCW	Healthcare Worker
HFNO	High-Flow Nasal Oxygen
HIC	High-Income Country
HIV	Human Immunodeficiency Virus
HIVST	HIV Self-Testing
HTS	HIV Testing Services
HPV	Human Papillomavirus
HSRC	Human Sciences Research Council
ICBF	Intermediate Care Bed Facility
ICU	Intensive Care Unit
IPC	Infection Prevention and Control
J&J	Johnson & Johnson
KZN	KwaZulu-Natal Province
LIC	Low-Income Country
LMIC	Lower-Middle-Income Country
LPDR	Lao People's Democratic Republic
LP	Limpopo Province
MAC	Ministerial Advisory Committee

MCH	Maternal and Child Health
MERS	Middle East Respiratory Syndrome
MEURI	Monitored Emergency Use of Unregistered Interventions Framework
MOVs	Missed Opportunities for Vaccination
MP	Mpumalanga Province
NAPHISA	National Public Health Institute of South Africa
NC	Northern Cape Province
NCD	Non-Communicable Disease
NDoH	National Department of Health
NEMLC	National Essential Medicines List Committee
NHLS	National Health Laboratory Service
NICD	National Institute for Communicable Diseases
NIOH	National Institute for Occupational Health
NIV	Non-invasive Ventilation
NGO	Non-Governmental Organisation
NMC	Notifiable Medical Condition
NPHI	National Public Health Institute
NW	North West Province
OECD	Organization of Economic Cooperation and Development
PHC	Primary Health Care
PHDC	Provincial Health Data Centre
PHM	Public Health Medicine
PLHIV	People Living with HIV
PMBs	Prescribed Minimum Benefits
PMTCT	Prevention of Mother to Child Transmission
PN	Professional Nurse
PPE	Personal Protective Equipment
POPIA	Protection of Personal Information Act
PTD	Provincial Cumulative Timeline Testing Dataset
PUI	Persons Under Investigation
PVD	Provincial Vaccinations Dataset
RT-PCR	Reverse Transcriptase-Polymerase Chain Reaction
SARS	Severe Acute Respiratory Syndrome
SAPHRA	South African Health Products Regulatory Authority
SAMRC	South African Medical Research Council
SOP	Standard Operating Procedure
SVD	SAcoronavirus Vaccination Dataset
TAT	Turnaround Time
TD	Testing Dataset
TB	Tuberculosis
TBH	Tygerberg Hospital
TSH	Thyroid Stimulating Hormone
UMIC	Upper-Middle-Income Country
USA	United States of America
UK	United Kingdom
UNICEF	United Nations Children Fund
WC	Western Cape Province
WHO	World Health Organization
XACT	Xpert for Active Case Finding

Despite the efforts and investment of government, many people in the rural areas of South Africa still lack access to quality healthcare.

INTRODUCTION

Although South Africa has large urban centres in Gauteng, the Western Cape and KwaZulu-Natal, the rural population comprised 32.15% of the total population as of 2021.[1] Of South Africa's nine provinces, up to seven could be classified as rural, depending on the definition used (share of agricultural employment, population size and density,[2] and presence of infrastructure and sanitation services[3]). The rural communities of South Africa account for a considerable part of the population.

Despite the efforts and investment of government, many people in the rural areas of South Africa still lack access to quality healthcare.[4] The health system in South Africa is made up of a private sector, which serves about 20% of the population, and a public sector that serves the remaining 80%.[5] In 2015, it was estimated that more than 70% of South African doctors worked in the private sector[6] which is for the most part based in urban areas. In addition to fewer healthcare professionals available in rural areas, many of the rural poor have to travel over an hour to get to the nearest clinic or hospital (15% and 20%, respectively).[4]

The Coronavirus Disease 2019 (COVID-19) pandemic caused disruptions in health services on a global scale due to lack of access from lockdowns and repurposing of health resources to fight COVID-19.[7] This was further exacerbated by demand-side issues, such as fear of contracting the COVID-19 disease.[7] Although the impact of COVID-19 on populations, health systems and geographic areas is still unfolding, particularly in rural areas, the pandemic has further exposed inequities in the health system.[8] At the same time it has allowed for innovation in service delivery.[8]

This study examines the response of the South African health system to COVID-19, with a particular focus on innovation or scale-up of current interventions, to use the lessons learned to improve future pandemic preparedness and health system resilience, improve provision of essential health services in stable periods, and highlight the relevance of these factors to rural areas.

The study focuses on three areas – diagnostics, therapeutics and vaccinations – each with specific objectives:

Diagnostics

- To use publicly available data and literature (published literature or trusted grey literature) to understand how and where COVID-19 diagnostic interventions were delivered.
- To understand how diagnostic services for non-COVID-19 conditions (HIV/TB/MCH/NCDs) were impacted.
- To develop a set of recommendations on strengthening of diagnostic services, particularly at primary healthcare (PHC) level (and possibly leveraging current public–private partnerships).

Therapeutics

- To use publicly available data and literature (published literature or trusted grey literature) to understand innovations in COVID-19 therapeutics (particularly oxygen availability and clinical protocols).
- To understand how therapeutic services for non-COVID-19 conditions (HIV/TB/MCH/NCDs) were impacted.
- To develop a set of recommendations on strengthening of therapeutic services, particularly at PHC level (and possibly leveraging current public–private partnerships).

Vaccinations

- To use publicly available data and literature (published literature or trusted grey literature) to understand how and where COVID-19 vaccines were delivered.
- To understand how preventative (especially vaccination) services for non-COVID-19 conditions (HIV/TB/MCH/NCDs) were impacted.
- To develop a set of recommendations on strengthening of preventative services, particularly at PHC level (and possibly leveraging current public– private partnerships).

METHODOLOGY

Literature review

Literature was obtained through searches conducted on Pubmed, Google and Google Scholar, as well as from the bibliographies of other journal articles. Both peer-reviewed and grey literature were included.

Multiple searches were conducted at various stages of the literature review. The search terms that were used included, but were not limited to, the following Medical Subject Headings (MeSH) terms: COVID-19; COVID-19 testing; diagnosis; South Africa; public sector; private sector; laboratories; HIV; tuberculosis; maternal and child health; guidelines; COVID-19 treatment; therapeutics; oxygen; critical care; health services; healthcare worker; health system; COVID-19 vaccines; vaccines; vaccine hesitancy; rural communities; and data quality. Further searches were conducted based on gaps in literature and need.

Review of topic areas

Topic areas were reviewed by a team of three public health researchers. Further reviews by public health medicine (PHM) specialists working in the relevant fields (diagnostics, therapeutics and vaccines) focussed on the recommendations in each section and provided key informant insights for the COVID-19 response for their specific fields and experience of the health system.

Data analysis

Data analysis and visualisations were performed by a data analyst.

Period of analysis

The period used for the analysis of COVID-19 data for the study is 1 March 2020 to 25 June 2022. The start date of analysis was chosen because the first COVID-19 case was identified in South Africa during week 10 of 2020. This period of analysis is used for content related to COVID-19 diagnostics and therapeutics, unless otherwise stipulated. Given that vaccinations were only rolled out in South Africa as of the 17 February 2021, the period used for COVID-19 vaccine analysis is 17 February 2021 to 25 June 2022, unless otherwise stipulated. Vaccine-related analysis for waves and between-wave periods therefore only includes time periods after the second wave onwards.

COVID-19 waves

The definition of COVID-19 waves proposed by the National Institute for Communicable Diseases (NICD) for retrospective analysis defines the start of a COVID-19 wave as the point at which a weekly incidence of >30 cases per 100,000 persons is reached. The end of a wave thus occurs when weekly incidence falls below that number.[9] Using this definition, the COVID-19 waves in South Africa were as follows:

- First wave: week 24 to 34 of 2020 (7 June 2020 to 22 August 2020)
- Second wave: week 47 of 2020 to week 5 of 2021 (15 November 2020 to 6 February 2021)
- Third wave: week 19 to 37 of 2021 (9 May 2021 to 18 September 2021)
- Fourth wave: week 47 of 2021 to week 3 of 2022 (21 November 2021 to 22 January 2022)

Furthermore, the periods outside of the COVID-19 waves would be as follows:

- Before the first wave: week 10 to 23 of 2020 (1 March 2020 to 6 June 2020)
- Between the first and second waves: week 35 to 46 of 2020 (23 August 2020 to 14 November 2020)
- Between second and third waves: week 6 to 18 of 2021 (7 February 2021 to 8 May 2021)
- Between third and fourth waves: week 38 to 46 of 2021 (19 September 2021 to 20 November 2021)
- After the fourth wave: week 4 to 25 of 2022 (23 January 2022 to 25 June 2022)

It is important to note that no fifth wave was officially declared and has therefore not been included in this analysis.

Data sources used

Data on COVID-19 diagnostics in South Africa were obtained from:

- The Coronavirus COVID-19 (2019-nCoV) Data Repository and Dashboard for South Africa hosted by the Data Science for Social Impact research group (DSFSI). This group collated COVID-19 data from the NICD and National Department of Health (NDoH) to create specific datasets. The datasets used for this analysis include:
    - The provincial cumulative timeline testing dataset (PTD), and
    - The testing dataset (TD)

The PTD contains data on COVID-19 tests and positive tests by province from 9 May 2020 to 16 July 2022, while the TD contains the total number of COVID-19 tests conducted at a national level from 11 February 2020 to 22 July 2022.

Media Hack COVID-19 data and dashboard was used as a confirmatory source of data. No analysis of the data from this source was done. The Media Hack Collective, in partnership with the Bhekisisa Centre for Health Journalism, collated COVID-19 data from various sources and created dashboards for South Africa.[10] The Media Hack datasets that were used begin as early as Thursday, 5 March 2020 (when the first case of COVID-19 was diagnosed in South Africa) and end on 7 April 2022. The data is thus organised in weeks from Friday to Thursday, compared to the convention of Sunday to Saturday used by the NICD. In addition, the Media Hack dashboard does not represent the entire period of analysis used in this study. Nonetheless, there are a few useful comparisons to draw between this study and the Media Hack dashboard.

- The NICD dataset included fields for the type of test conducted (for example RT-PCR or Antigen test), the facility type at which the test was done or requested, and the age group of the person being tested. However, the data for these fields were incomplete or inconsistently captured and we were thus unable to use this dataset for meaningful analysis.

Data on COVID-19 therapeutics in South Africa were obtained from:

- The NICD South African COVID-19 Daily Hospital Surveillance (DATCOV) database, is a sentinel hospital surveillance system for COVID-19 hospital admissions in South Africa.[11] DATCOV was developed by the NICD, and hospitals from both public and private sectors were able to register and use this platform.[11] DATCOV was officially implemented on 1 April 2020 and enabled the collection of data from admissions with respect to patient demographic data; clinical information including comorbidities; clinical care, including intensive care unit admission, ventilation and drugs received; and, outcomes such as death, discharge, transfer or continued admission.[11]

Data on COVID-19 vaccinations in South Africa were obtained from two datasets:

- SAcoronavirus vaccination dataset (SVD) sourced from the NDoH Electronic Vaccination Data System (EVDS) Github site.
- Provincial vaccinations dataset (PVD) sourced from the DSFSI Github site.

The definition used for rural provinces of South Africa

Many methods to define a rural area have been proposed: some authors recommend using population size and density;[2] some countries use the proportion of the population engaged in agricultural employment;[2] and some definitions include water and sanitation service delivery. One study found that defining rural areas by both agricultural setting and traditional authority (such as traditional chiefs) more accurately represented the reality in South Africa.[3]

The three top provinces in terms of population size and percentage of the total population are: Gauteng (26.6%), KwaZulu-Natal (19.0%) and Western Cape (11.9%).[12] The province with the smallest population is the Northern Cape (2.2%), followed by the Free State (4.8%) and North West (6.9%).[12] The lowest population densities as of 2017 are in Northern Cape (3 people per km^2), Free State (22 people per km^2), North West (37 people per km^2), the Eastern Cape (38 people per km^2) and Limpopo (46 people per km^2).[13]

Table 1: Provincial population sizes and proportions for South Africa[12]

	EC	FS	GP	KZN	LP	MP	NC	NW	WC
Proportion of population	11.0%	4.8%	26.6%	19.0%	9.8%	7.8%	2.2%	6.9%	11.9%
Population size	6.7m	2.9m	16.0m	11.5m	5.9m	4.7m	1.3m	4.1m	7.2m

As of 2021, the provinces with the highest share of agricultural households were Limpopo (37.9%), Eastern Cape (33.4%), Mpumalanga (32.2%), KwaZulu-Natal (20.4%) and the Free State (20.2%), all above the national average of 17.2%.[14]

According to a report by Statistics South Africa (Stats SA), the provinces with the most rural nodes are KwaZulu-Natal (seven rural nodes), the Eastern Cape (five rural nodes) and Limpopo (two rural nodes).[15] These rural nodes are characterised by poor infrastructure, access to services and living conditions.[15]

LIMITATIONS OF THE STUDY

Literature review

The literature reviewed in this study included journal articles and grey literature sources. Given the extensive amount of COVID-19 related literature, content was selected based on both search terms and need. Many of the peer-reviewed studies, particularly for the therapeutics section, were case studies. As such, the literature selected may not be entirely representative of all experiences in South Africa.

Period of analysis

The period of analysis used for our study represented the national COVID-19 waves as per the NICD definition.[9] However, it should be noted that provinces may have had different peaks.

Limitations of the datasets used

1. Diagnostics

The PTD contains data on COVID-19 tests and positive tests by province from 9 May 2020 to 16 July 2022. This means that the period before the first wave does not include weeks 10 to 18 of 2020 and, therefore, the data will be underreported for that period.

The TD contains the total number of COVID-19 tests conducted at a national level from 11 February 2020 to 22 July 2022. However, the breakdown of tests conducted in the private versus the public sector is only available for the period between 13 November 2020 and 22 July 2022. Although this allowed for a cumulative assessment of tests conducted in the private versus public sector over the entire time series, the breakdown across waves is somewhat incomplete. Since the second wave began on 15 November 2020, meaningful analysis for testing can only be done from the second wave onwards.

2. Therapeutics

Due to the lack of integrated data systems, certain analyses, such as COVID-19 admissions as a proportion of total cases, were not possible. Furthermore, the voluntary nature of DATCOV reporting may limit the generalisability of the analysis done here.

3. Vaccines

The SVD comes from the NDoH EVDS which has published data on a Github site. This dataset shows the total number of individuals at least partially vaccinated (i.e. having received a Johnson & Johnson [J&J] vaccine or the first Pfizer dose). As it does not indicate whether individuals are completely vaccinated (having had both Pfizer doses), it overestimates vaccination numbers. This dataset also only includes individuals who are 18 years old or older.

The provincial vaccinations data dataset from DSFSI includes data collected from the NDoH.[16] This dataset shows the total number of vaccines administered, including booster doses. The number of vaccinations administered may thus be an overestimation of the number of individuals vaccinated. While an assumption could be made that it includes all age groups, the age range of individuals included in this dataset is not specified.

When considering the proportion of the South African population that is fully vaccinated, using the SVD dataset would result in an overestimation (as it contains individuals who have been at least partially vaccinated) and the PVD dataset would also result in an overestimation (as it includes all vaccines administered including booster doses).

In addition, to obtain the population data needed as a denominator from a different data source (e.g. Statistics South Africa) would be problematic and a large amount of data transformation would have to be done.

It is for these reasons that vaccine coverage for the total population of South Africa or by province was not calculated. Having data on vaccine coverage would be useful in determining the success of the COVID-19 vaccination programme both in South Africa as a whole and at a provincial level.


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Both HIV and TB testing declined in South Africa and, while HIV testing did rebound after lockdown, this rebound was not complete. The decline in testing for both HIV and TB has significant implications for treatment initiation, linkage to care and reducing transmission of these infectious diseases.

SECTION ONE

COVID-19 DIAGNOSTICS

SOUTH AFRICA'S COVID-19 TESTING STRATEGY AND ASSOCIATED CHALLENGES

This section describes the chronological changes in South Africa's COVID-19 testing strategies and guidelines from February 2020 to November 2021. It also reports on the factors likely to have influenced the demand for testing, such as changes in the case definition for persons with suspected SARS-CoV-2 infection, as well as local and international supply issues, to contextualise the health system's response in terms of its COVID-19 diagnostic strategies.

South Africa's testing strategy was introduced in the first stage of the government response to the COVID-19 pandemic for three main purposes: 1) to guide clinical care; 2) for containment through prevention strategies; and 3) to guide resource allocation through surveillance.[17] This testing strategy has had to be adapted in response to both the evolving epidemic (demand) and resource availability (supply).[17]

The initial case definition for persons with suspected SARS-CoV-2 infection in South Africa was published in the guidelines released by the NICD and the NDoH on 5 February 2020.[18] Persons to be tested were to:

1) Have at least one symptom of an acute respiratory infection (fever, cough, sore throat or shortness of breath) AND
2) In the 14 days prior to the onset of symptoms, have had close contact with a confirmed or suspected case of COVID-19; or travelled to areas with community transmission; or worked in or attended a health facility where COVID-19 patients were being treated.[18]

In addition, testing was to be done on patients who had been admitted to hospital with a severe pneumonia of unknown aetiology.[19]

This definition was in place before lockdown and prior to the identification of the first case of COVID-19 in South Africa.[17] At the time, the focus was on building testing capacity by using existing infrastructure from Human Immunodeficiency Virus (HIV) programmes; expanding testing from the NICD to private and research laboratories; and preparing for contact tracing with testing or isolation/quarantine.[17] The intention of the narrow initial case definition was to prevent unnecessary testing by "asymptomatic worried-well people".[17]

Following the diagnosis of the first imported case of COVID-19 in South Africa, on 5 March 2020, testing began to increase. However, the restrictive travel criteria in the case definition at that time, impaired containment efforts which would have required widespread testing to effectively use the 'test/isolate' and 'contact-tracing/quarantine' strategies. This inadvertently created conditions in which ongoing community transmission could occur.[17] In addition, most testing was taking place in the private sector at that time.[17]

A national lockdown (level 5) began on 27 March 2020[17] at which point 1,170 cases had been identified and the doubling time was two days.[20] While the lockdown did succeed in slowing the doubling time to 15 days,[20] the changes in testing guidelines that would allow for active case-finding were not drafted until 10 April 2020.[17,21] These changes included removal of the following as requirements for testing: contact with a case of COVID-19 (for symptomatic individuals), travel history, and exposure at a healthcare facility.[21] As mentioned above, this delay impaired containment efforts and allowed for ongoing community transmission.

At this stage (approximately two weeks after national lockdown began), public sector laboratory capacity had been increased, and a community screening and testing (CST) programme was introduced in 993 socially vulnerable, high-density communities.[17] Community health workers (CHWs) from HIV and tuberculosis (TB) services were used in this CST programme to screen for signs and symptoms of COVID-19 and, if appropriate, refer people for testing at mobile testing units or primary healthcare (PHC) facilities. Community health workers were also utilised to raise awareness of the non-pharmaceutical interventions that could help to contain the spread of SARS-CoV-2.[17] The goal of the CST programme was active case-finding; however, between 8 April and 8 June 2020, the proportion of positive tests from the CST programme remained below 10%, which indicates low levels of community transmission.[17]

The level 5 lockdown ended on 30 April 2020 and the government introduced a strategy of "hotspot identification and mitigation" to investigate clusters of cases and prevent the spread of these outbreaks.[17] The CST teams were redirected to this programme.[17]

As the lockdown restrictions eased in South Africa, the numbers of cases began to rise.[17]

The gold standard for diagnosis of SARS-CoV-2 infection is the reverse transcriptase–polymerase chain reaction (RT-PCR) test.[17] With high global demand, and South Africa's reliance on foreign suppliers, a shortage of (RT-PCR) test kits, reagents and swabs arose.[17,22] In addition, the increase in testing demands – as the epidemic entered its exponential phase in South Africa – meant that the capacity of laboratories, particularly in the public sector, was exceeded. By mid-May of 2020 the turnaround time (TAT) for test results in the public sector increased from the recommended 12 to 24 hours to 5 to 14 days.[22] This prolonged TAT had implications for both the CST programme and for the diagnosis and management of hospitalised patients. Those identified for testing through CST would be at risk of getting their results when they were no longer infectious, rendering the CST programme ineffective, particularly in high-prevalence areas.[22] This crisis led to criticisms of the CST programme and the recommendation that it be used instead as an advocacy tool in communities to promote non-pharmaceutical interventions for reducing the transmission of SARS-CoV-2.[22]

The burden on hospitals was also increased by the prolonged TAT, as patients admitted as suspected COVID-19 cases were triaged into special wards until the diagnosis was confirmed, after which they were allocated to either a dedicated COVID-19 ward/ICU (if positive for COVID-19) or to a non-COVID ward/ICU (if negative for COVID-19).[22]

As the number of COVID-19 admissions began to increase, the prolonged TAT led to bottlenecks, with the risk of the system being overwhelmed. In response to this situation, a group of infectious disease specialists and public health specialists wrote a number of opinion pieces

recommending that testing capacity be focused on hospital admissions and symptomatic healthcare workers (HCW) to save lives and prevent nosocomial spread.[22,23]

At the beginning of June 2020, with the first wave imminent, the backlog of tests at public sector laboratories was so great that the same specialists were advocating for urgent action. Test supplies were in danger of running out and TAT was unacceptably high.[23] Those calling for urgent action recommended the following:

- Discarding of samples older than 48 hours as degradation of the virus's genetic code would create a high risk of false-negative results.[23]
- Discarding tests and retesting of hospitalised patients whose initial tests could not be done immediately; and that tests from the CST programme in high-prevalence areas be discarded regardless of when they were taken, as these results would have little impact on the epidemic.[23]
- Halting of the testing strategy proposed by the Department of Labour and the Department of Sports, Arts and Culture. At the time, these departments were planning testing strategies for return to work and non-contact sports, respectively, under level 3 of lockdown. These tests would have placed an additional burden on the overwhelmed laboratories and would also have used scarce testing resources.[23]
- Expediting the publication of a prioritisation strategy for testing target populations that was already in the process of being developed.[23]

The above targeted testing strategy, which was realised in July 2020,[24] divided people into high-, medium- and low-priority categories to prioritise available testing capacity where it offered the greatest clinical benefit.[17] The high-priority group focused on hospitalised patients and HCWs, with a view to save lives, reduce nosocomial transmission and preserve healthcare capacity.[17] The medium-priority group included those in care facilities and symptomatic essential services staff, in order to prevent outbreaks; and the low-priority group included those from active case-finding programmes in the community.[17]

With limited testing capacity and the first wave heading to its peak, this strategy created a trade-off between saving lives in the hospitals and containing community spread.[17]

On 25 June 2020, during the first wave, the case definition for suspected COVID-19 patients was updated to include the symptoms of anosmia (loss of the sense of smell) and dysgeusia (alteration of the sense of taste) when they emerged as "relatively common, early and moderately specific" symptoms of COVID-19.[25] Fever was classified as a non-essential symptom and listed along with weakness, myalgia and diarrhoea.[25]

On 20 October 2020, in the lead up to the second wave, there was an update to the prioritised testing guidelines following an increase in the laboratory capacity (combining National Health Laboratory Services [NHLS] and private laboratories), and high positivity rates signalling the need for containment.[26] This update prioritised the testing of hospitalised patients; all people with symptoms suggestive of COVID-19; and close contacts of confirmed cases, including those who were asymptomatic.[26]

Another key update to the guideline was that asymptomatic people returning to work and/or school, sportspeople, and those who had completed isolation, did not need to be tested.[26]

October 2020 also saw the approval of antigen-detecting rapid diagnostic tests (Ag-RDT) for SARS-CoV-2 by the South African Health Products Regulatory Authority (SAPHRA) for use in South Africa.[24] As of 8 October 2020, the antigen tests were rolled out to ports of entry into South Africa and used to test incoming asymptomatic travellers who had failed to comply with the requirement of a negative polymerase chain reaction (PCR) test <72 hours old; as well as for those neighbouring countries without the capacity to conduct PCR tests for those travelling to South Africa.[27]

On 11 December 2020 South Africa released its first antigen testing guidelines, which stated the potential uses for antigen testing in South Africa. However, with low in-country validation data and sufficient RT-PCR capacity at the time, only the first phase of the guideline – testing at ports of entry – had been implemented.[28]

The current antigen testing guidelines were approved on 21 July 2021.[24] Antigen tests provided a feasible alternative to the RT-PCR in that they have a faster TAT (<30 minutes), cost less and can be done in laboratories or at the point-of-care, which creates scope for decentralised testing.[24] Both the antigen and the PCR tests can be performed for the same indications. However, it should be noted that the results of the antigen test are most accurate when SARS-CoV-2 viral loads are highest, that is, 1 to 3 days prior to symptom onset and within the first 5 to 7 days of illness.[24] The antigen testing guidelines further recommend that in high-prevalence settings, negative results should be followed up with an RT-PCR and that in low-prevalence settings, positive results should be followed up with an RT-PCR.[24]

All antigen test results were to be reported to the NICD within 48 hours via Trakcare, the NICD API or on the web-based COVID-19 screening app (CSA) which was developed to capture all data from private or non-NHLS laboratories.[24] In November 2021, the NDoH announced that validated antigen test data would be incorporated into COVID-19 surveillance data for the country.[29]

DATA ANALYSIS

Total tests conducted

For the period 1 March 2020 to 25 June 2022, according to the TD, 25.7 million COVID-19 tests were conducted in South Africa. There was a difference of just under 2.5 million tests between the PTD and the TD for the total number of COVID-19 tests conducted, with the PTD total at 23.3 million. This difference is in part due to the fact that PTD data were only recorded from 9 May 2020 and do not necessarily account for the entire difference between the totals.

The majority of these tests were conducted during the COVID-19 waves in South Africa, with the third wave accounting for over a quarter of all tests conducted (25.7% [TD] and 27.0% [PTD]) followed by the second wave, the fourth wave and the first wave. Over 60% of COVID-19 tests in South Africa were conducted during the COVID-19 waves (Table 2).

The period after the fourth wave (23 January 2022 to 25 June 2022) represented the second highest percentage of all tests conducted (14.3% [TD] and 14.6% [PTD]). This may be explained by the resurgence of COVID-19 cases driven by Omicron sub-variants in that period,[30,31] which, despite not meeting the criteria for a fifth wave, would have seen testing numbers increase.

Table 2: Percentage of total tests conducted per period

Waves	Percentage of total tests (TD)	Percentage of total tests (PTD)*
<1	3.5%	2.5%
1	10.3%	9.0%
1><2	6.1%	5.1%
2	13.1%	13.1%
2><3	8.5%	9.9%
3	25.2%	27.0%
3><4	6.9%	7.2%
4	12.1%	11.5%
>4	14.3%	14.6%

**excludes weeks 10-18 of 2020*

Percentage of positive tests

Only the PTD contained data on the number of people testing positive for COVID-19.

Although it accounted for the largest proportion of tests conducted, the third wave had the lowest proportion of positive tests of all the COVID-19 waves in South Africa (21.8% of all tests conducted in that period). The highest proportion of positive tests was in the fourth wave (27.4% of all tests conducted in that period) (Table 3). This was followed by the first wave (25.3%) and the second wave (23.7%). The number of tests conducted in order to yield a positive result was thus slightly higher in the third and second wave compared to the fourth and first wave (Table 4).

Table 3: Proportion of positive tests per period

Waves	Number of tests (TD)	Percentage of total tests (PTD)*
<1	46,366	8.0%
1	531,912	25.3%
1><2	132,550	11.1%
2	724,989	23.7%
2><3	125,684	5.5%
3	1,372,319	21.8%
3><4	48,529	2.9%
4	731,785	27.4%
>4	430,347	12.7%

**excludes weeks 10-18 of 2020*

Table 4: Number of tests conducted per positive test

Waves	Tests	Positive tests	Tests per positive test
<1	576,437	46,366	12.4
1	2,102,874	531,912	4.0
1><2	1,193,898	132,550	9.0
2	3,055,555	724,989	4.2
2><3	2,298,818	125,684	18.3
3	6,288,509	1,372,319	4.6
3><4	1,675,824	48,529	34.5
4	2,674,351	731,785	3.7
>4	3,396,454	430,347	7.9

**excludes weeks 10-18 of 2020*

Predictably, the periods before, between and after the waves represented much lower proportions of positive tests than those in the waves (Table 3). The period after the fourth wave had a relatively high proportion of positive tests (12.7%), perhaps accounted for by the resurgence of COVID-19 cases in that period, as mentioned above. The period between the first and second wave also showed a relatively high proportion of positive tests (11.1%).

In October 2020, an update to the prioritised testing guidelines was released due to high positivity rates.[26] This update allowed for testing in all people with COVID-19 symptoms, as well as close contacts of confirmed COVID-19 cases, regardless of symptoms.[26] This was in the lead up to the second wave, in which the Beta variant was dominant.[32] In Figure 1, the tests conducted (blue) and positive tests (red) follow the waves of COVID-19 in South Africa. The troughs between the waves are more marked for the positive tests (red), which fits the notion that between waves more tests would need to be conducted to yield a positive result. The reverse waveform of number tests conducted in order to yield a positive test (yellow) confirms this, with the largest spike between the third and fourth wave.

The Media Hack dashboard shows that, as of 7 April 2022, a total of 24 million COVID-19 tests had been conducted in South Africa.[10] Of these, 3.7 million were positive,[10] which amounts to 15.6% of all tests conducted in that period (5 March 2020 to 7 April 2022).

The side-by-side graphics[10] showing average daily tests conducted per week versus average daily positive results per week versus the weekly number of tests conducted per positive result,[10] yielded some insights: both the total number of tests conducted and the positive test results per week represented in graphic form follow the pattern of the four COVID-19 waves. However, similar to the primary analysis done above, the troughs between waves are more marked in the positive-test-results graphic than in the total-tests-conducted graphic.

This finding is confirmed in the number-of-tests-per-positive-result graphic, which shows a reverse wave pattern. In other words, the troughs in this latter graphic align with the COVID-19 waves, and the peaks are between the COVID-19 waves. This again aligns with the fact that fewer tests would have to be conducted to yield a positive result during a wave while the converse is true between waves, when a greater number of tests would have to be conducted to yield a positive result. Furthermore, the number-of-tests-conducted-per-positive-result graphic also confirms our finding that there was a relatively high proportion of positive results

between waves one and two, with a peak of 13.2 tests conducted per positive result for the week of 30 October 2020 to 5 November 2020.[10] This is compared to the maximum number of tests (26.0) conducted per positive result between waves two and three for the week of 2 to 8 April 2021; and between waves three and four of >90 (the exact figure is not given) for the week of 5 to 11 November 2021.[10]

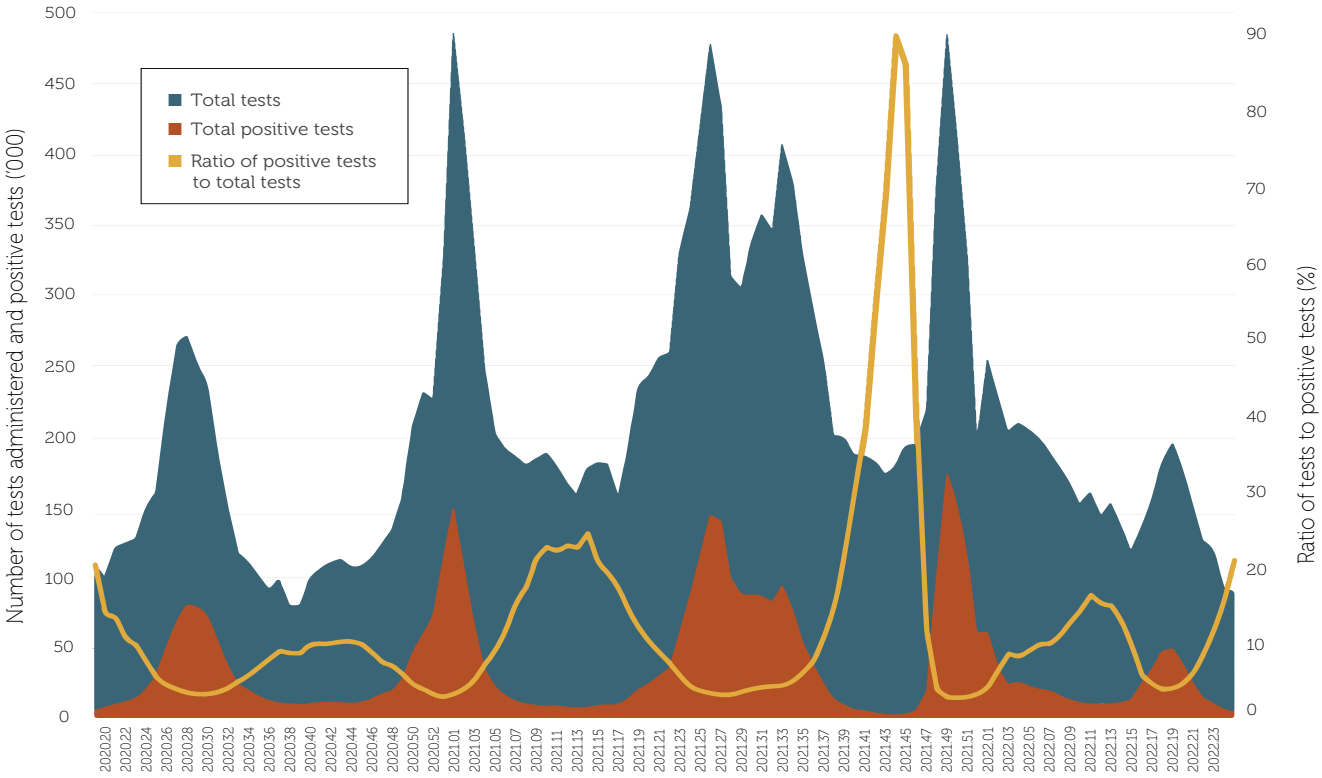

Figure 1: Total tests conducted, positive tests and number of tests per positive test per week

Source: Data Science For Social Impact (DSFSI) Research Group, University of Pretoria; Coronavirus COVID-19 (2019-nCOV) Data Repository for South Africa, Available at https://github.com/dsfsi/covid19za

Test totals and percentages for private versus public for the whole period of study

The total number of tests for the period during which public versus private sector data was collected was 21 million – 53.6% in the private sector and 46.4% in the public sector. The absolute difference between the numbers of COVID-19 tests conducted in the private versus the public sector, amounted to nearly 1.5 million tests in that period. This again highlights the inequity in access to testing between private and public sectors.

The breakdown for private versus public sector testing was recorded on the Media Hack dashboard from 4 May 2020.[10] According to the dashboard, the total number of COVID-19 tests conducted up until 7 April 2022 was 24 million, of which 13 million (54.4%) were conducted in the private sector and 11 million (45.6%) in the public sector.[10] Proportions of private versus public sector testing are similar to the primary data analysis of the TD and PTD data, despite the difference in the period evaluated. The absolute difference in numbers of COVID-19 tests conducted in the private versus public sector is around 2 million for the period tracked by the Media Hack dashboard.

Percentage of tests conducted in private versus public sector per wave period

Due to the data constraints highlighted previously, all analyses regarding the public versus private sectors only contain data from just before the second wave and onwards.

Through all the periods assessed, the percentage of tests done in the private sector remained higher than in the public sector. The difference between the two sectors was lowest in the third wave, with the private sector representing 50.7% of all tests conducted and the public sector 49.3%. Aside from the two days leading up to the second wave (13 to 14 November 2020), the greatest difference between the two sectors was noted after the fourth wave, with the private sector having conducted 56.9% of all tests, and the public sector having conducted 43.1% (Table 5). As the private sector provides medical care for roughly 20% of the country's population, the higher proportion of tests conducted in this sector suggests a considerable inequity in access to testing.[5] However, it is possible that a proportion of the tests conducted in the private sector were paid for in cash by those without medical aid.[5] It should also be noted that without further disaggregation of data it is not possible to assess the difference in access between urban and rural areas within the public sector.[33] Such an analysis could give greater insight into equity of access to testing within the public sector itself.

Table 5: Public vs private tests conducted per period

Waves	Tests private (%)	Tests public (%)
<1 and 1	Private vs public only available from 13 November 2020 onwards	
1><2	61.2%	38.8%
2	54.5%	45.5%
2><3	54.8%	45.2%
3	50.7%	49.3%
3><4	52.1%	47.9%
4	54.9%	45.1%
>4	56.9%	43.1%

It would have been useful to analyse private versus public sector data for the periods before, during and after the first wave because this was when an increase in TAT in the public sector (due to many factors including shortage of test supplies) decreased the efficacy of the testing strategy[22] but data for the stipulated time period was not available.

Positive tests in the private versus public sectors

Due to limitations of the datasets, an analysis of positive tests in private versus public sectors was not possible. It would likely have provided insights into whether or not unnecessary testing was conducted, in both sectors, by assessing the number of tests conducted per positive result. Since there were suggestions that unnecessary testing took place in the private sector,[5] this analysis would have been useful to support or refute such reports.

Turnaround time (TAT) for private versus public sectors

An analysis of TAT for private versus public sectors was also not possible due to limitations of the dataset. It would likely have provided insight into factors such as the effect of guideline and policy changes on TATs particularly for the public sector.

Tests conducted in each province per period

The PTD excluded weeks 10 to 18 of 2020. The data for the period before the first wave is thus underreported.

Gauteng Province consistently had the highest proportion of COVID-19 tests conducted, with all periods exceeding 30% of the total number of tests. The highest proportion was after the fourth wave (40.1%), followed by the fourth wave itself (38.4%) and the first wave (35.2%). It is likely that Gauteng represented such a high percentage of the tests because of its large population size[12] and high population density.[13] KwaZulu-Natal had the second highest proportion of tests for all periods except before the first wave, followed by the Western Cape (Table 6). These two provinces also represent the second and third largest percentages of the total population of South Africa, respectively.

The Eastern Cape's testing proportions (between 10.8% before the first wave to 10.0% in the second wave) were initially in keeping with its population size (11.0% of South Africa's population[12]) but after the second wave, it appears that for the remainder of the study period testing in the Eastern Cape dropped off. Limpopo, which makes up 9.8% of the population,[12] had consistently low proportions of testing for all periods, ranging from 2.3% to 3.4% of the country's testing per period. Likewise, North West and Mpumalanga (6.9% and 7.8% of the population respectively[12]) demonstrated testing proportions consistently lower than expected based on population size, whereas in the Free State (4.8% of the population[12]) proportions were consistently higher than expected, except in the second wave (Table 6).

Table 6: Proportion of tests conducted per province per period

Waves	Unknown	EC	FS	GP	KZN	LP	MP	NC	NW	WC
<1	1.2%	10.9%	6.8%	31.8%	15.4%	2.5%	2.8%	0.9%	2.1%	25.7%
1	1.8%	10.8%	7.1%	35.2%	20.0%	2.7%	4.6%	1.6%	3.3%	12.9%
1><2	0.3%	10.8%	8.9%	30.4%	17.0%	2.8%	5.3%	4.7%	4.2%	15.6%
2	0.2%	10.0%	4.0%	30.4%	25.2%	3.4%	6.1%	1.9%	2.8%	16.1%
2><3	0.2%	6.2%	6.6%	33.2%	20.9%	2.5%	6.2%	3.3%	5.1%	15.9%
3	0.0%	8.6%	5.9%	34.7%	17.6%	3.0%	5.2%	3.2%	5.4%	16.3%
3><4	0.0%	8.4%	5.6%	34.3%	20.1%	2.3%	5.2%	2.8%	5.3%	16.0%
4	0.0%	7.7%	5.2%	38.4%	18.1%	2.9%	4.7%	2.1%	4.9%	16.1%
>4	0.6%	6.5%	5.9%	40.1%	19.1%	2.3%	5.1%	2.0%	4.6%	13.7%

**excludes weeks 10-18 of 2020*

Proportion of positive tests in each province per period

The proportion of positive tests for the first COVID-19 wave was highest in the Eastern Cape (30.3%), followed by North West and Gauteng. In the second wave, Limpopo had the highest proportion of positive tests (35.6%), followed by Western Cape and KwaZulu-Natal. Limpopo also had the highest proportion of positive tests in both the third (30.8%) and fourth waves (33.7%). In the third wave, Limpopo was followed by North West and Northern Cape, while in the fourth wave it was followed by the Western Cape and Northern Cape (Table 7).

Despite their small populations, low population densities and relatively small proportion of the total COVID-19 tests conducted, the Northern Cape, North West, Free State and Mpumalanga had proportions of positive tests comparable with other provinces. The Northern Cape and North West even ranked amongst the highest proportion of positive tests in some of the COVID-19 waves (Table 7).The Northern Cape also had the highest proportion of positive tests between COVID-19 waves with 23.6% (between waves one and two), 13.7% (between waves two and three) and 9.1% (between waves three and four). Similarly, the Free State had the second highest proportion, with 20.6%, 10.0% and 5.2% for the same periods respectively (Figure 2). North West and the Eastern Cape also showed high proportions of positive tests in certain of these periods. Although it is unclear exactly what could account for these high proportions of positive tests between waves, particularly in the more rural provinces, it is possible that they may have experienced COVID-19 waves that did not align entirely with the nationally defined waves or that between-wave periods gave the health system the opportunity to conduct testing.

Table 7: Proportion of positive tests per province per period

Waves	Unknown	EC	FS	GP	KZN	LP	MP	NC	NW	WC
<1	11.5%	9.9%	1.1%	2.7%	0.6%	2.5%	2.4%	1.1%	3.3%	20.9%
1	17.2%	30.3%	23.6%	26.0%	17.3%	24.2%	25.8%	22.0%	27.8%	24.3%
1><2	4.5%	18.4%	20.6%	6.5%	14.7%	6.6%	12.1%	23.6%	16.8%	8.5%
2	7.1%	25.3%	16.0%	18.8%	35.6%	25.9%	22.9%	18.3%	22.9%	29.3%
2><3	2.6%	1.9%	10.0%	4.8%	6.6%	3.5%	8.5%	13.7%	9.6%	4.6%
3	15.6%	17.5%	20.0%	23.8%	30.8%	16.4%	23.2%	25.3%	25.4%	22.5%
3><4	1.6%	3.4%	5.2%	1.8%	1.9%	2.7%	2.9%	9.1%	3.0%	3.4%
4	7.3%	25.8%	25.5%	26.3%	33.7%	28.1%	27.4%	28.6%	28.2%	29.0%
>4	9.8%	11.0%	10.8%	12.4%	12.4%	11.8%	12.0%	13.8%	11.5%	16.9%

**excludes weeks 10-18 of 2020*

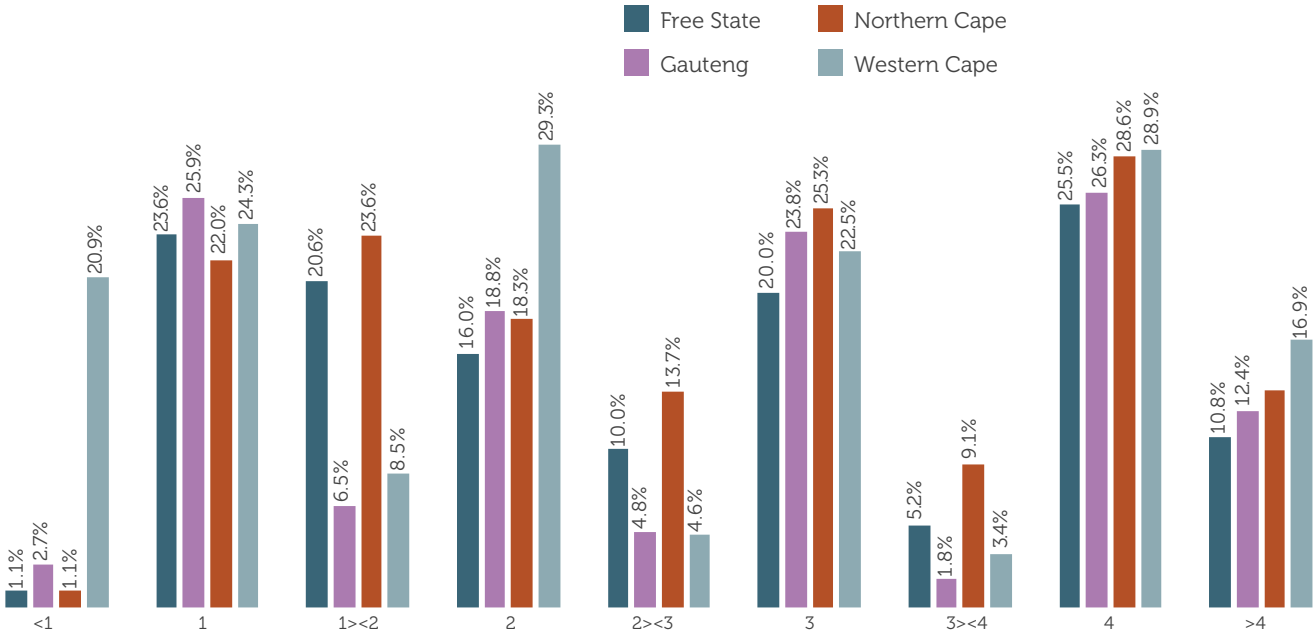

Figure 2: Positivity rate of tests administered by province per period, comparing Gauteng and Western Cape with Northern Cape and Free State.

Source: Data Science For Social Impact (DSFSI) Research Group, University of Pretoria; Coronavirus COVID-19 (2019-nCOV) Data Repository for South Africa, Available at https://github.com/dsfsi/covid19za

IMPACT ON NON-COVID-19 CONDITIONS AND HEALTH SERVICES

HIV and TB

1. How existing HIV and TB programmes enhanced the diagnostic response to COVID-19

South Africa's existing infrastructure for HIV viral load measurements allowed for a rapid transition to testing for SARS-CoV-2 using the global gold standard: RT-PCR tests.[17] In addition, the GeneXpert point-of-care test used to diagnose TB in South Africa provided an alternative rapid-testing technology for SARS-CoV-2, although global demand for this Xpert® Xpress SARS-CoV-2 test limited its use in South Africa.[17,34] The molecular surveillance systems in place for HIV also allowed for whole genome sequencing and phylogenetic analysis of SARS-CoV-2 by January 2020, and enabled early identification of the Beta variant in November 2020.[34]

When the CHWs already working in the HIV and TB services were diverted to the COVID-19 CST programme,[34] it not only allowed for active case-finding but also presented opportunities to increase community awareness of COVID-19 and promote non-pharmaceutical interventions to prevent its spread, in many socially vulnerable South African communities.[17]

Testing infrastructure and human resources already in place for the HIV and TB programmes in South Africa were thus leveraged to enhance the rapid response to the COVID-19 pandemic.[34]

2. How HIV and TB diagnostics were affected by the COVID-19 pandemic

The national level 5 lockdown had an impact on both HIV and TB services because it limited access to medical care for non-COVID conditions.[34] Many people were also reluctant to visit healthcare facilities during that time because they were afraid of being exposed to SARS-CoV-2.[34]

A review that compared NHLS data of pre-lockdown to lockdown periods, found that there was a 22% decline in HIV viral load testing and a 33% decline in CD4+ cell testing.[34] Similarly, an analysis of data from 65 PHC clinics in KwaZulu-Natal found a 47.6% decrease in HIV testing in April 2020, which limited antiretroviral treatment (ART) initiation and thus potentially increased the risk of new infections.[34] However, as lockdown restrictions were eased, HIV testing rates gradually returned to pre-lockdown levels, suggesting that the disruption to services was temporary.[34] Another study assessed the impact of COVID-19 on routine PHC services using District Health Information System (DHIS) data and compared the period of March 2020 to December 2020 with similar data from 2019.[35] This study also found that HIV testing declined by 22.3% in 2020 compared to 2019, with the largest decline from April to July 2020.[35] Furthermore, every month in 2020 had lower numbers of tests than in the corresponding month for 2019,[35] indicating that the rebound noted in the review study was not complete. The provinces with the largest decline in HIV testing for the period March 2020 to December 2020 were: Western Cape (36.1%), Gauteng (31.4%) and Northern Cape (29.2%).[35]

According to the NHLS data review, between March and June 2020, TB notifications in South Africa declined by more than 50% and the weekly average of microbiologically confirmed TB cases decreased by 33%.[34] The average number of TB tests decreased to 24,620 a week

during lockdown, from 49,109 a week in the seven weeks before lockdown.[34] In addition, a decline of 48% was seen in Xpert MTB/RIF Ultra tests between 3 February 2020 and 3 May 2020 according to NICD data. Similarly, the Xpert positive tests declined by 33% during lockdown, but also returned to previous levels as COVID-19 restrictions were eased.[34,35] The NICD confirmed that these decreases in TB testing were not attributable to reduced testing capacity but rather to restrictions on the movement of people.[36]

The aforementioned DHIS study found that in the period between March 2020 and December 2020, screening for TB symptoms had decreased by 19.2% compared to 2019.[35] Furthermore, the analysis of NHLS data showed a 26% decline in GeneXpert tests between 2019 and 2020, and that the proportion of positive tests declined by 18%.[35]

There is limited literature regarding the effect of COVID-19 on HIV and TB services in the rural or outlying areas of South Africa; one study conducted in the Mopani district of Limpopo sought to address this deficit.[37] Mopani district is considered to be one of the most rural districts in South Africa,[37] and as such could offer unique insights into the rural experience of the pandemic.

The spread of COVID-19 to rural areas was slow; and thus the actual COVID-19 disease had less of an impact than lockdown on routine services during the first wave.[37] During the second wave, however, this dynamic changed.[37] Using DHIS data, indicators for HIV, TB and prevention of mother-to-child transmission (PMTCT) were assessed for the district.[37] During the April 2020 lockdown, HIV testing showed statistically significant declines in children over 18 months of age and in adult age groups.[37] While there was some improvement in the following months, HIV testing decreased again at the end of the first wave and had not shown any improvement by December 2020.[37] This in turn affected ART initiations, which showed similar declines.[37]

In Mopani, HIV testing is routinely offered when a patient visits the clinics for other reasons.[37] Thus the statistically significant decline in overall healthcare facility visits compared to 2019[37] would have had a profound impact on this service. Furthermore, there was no improvement in facility visits post-lockdown or at the change to alert level 1 in September 2020, and a further decline was noted in December 2020 with the second wave.[37] While positive TB tests decreased by 33% in April 2020 (the largest decrease of all TB indicators for that month), no statistically significant effect of lockdown on TB indicators was found in Mopani.[37]

This decline in testing for both HIV and TB has significant implications for treatment initiation, linkage to care and reducing transmission of these infectious diseases.[35]

Maternal and child health (MCH)

The abovementioned study using DHIS data also examined the number of antenatal first visits done before 20 weeks of pregnancy in South Africa.[35] This first visit is important for diagnosing pre-existing and pregnancy-related conditions that may affect the pregnancy outcome as well as the health of the mother and baby. At the first antenatal visit, blood pressure is taken, urine is checked for protein and glucose, an HIV rapid test and TB screening are conducted, and syphilis serology, haemoglobin and Rhesus blood group tests are completed.[38] Thus, amongst other things, PMTCT would be impacted by attending this first visit.[39]

For the whole of South Africa, the number of antenatal first visits between 2019 and 2020 remained similar.[35] However, there were differences between provinces: Mpumalanga, Limpopo and KZN showed an increase in visits over the period; while Free State, Gauteng,

Northern Cape, Western Cape and North West showed a decrease in visits over the same time. Eastern Cape showed similar numbers between 2019 and 2020.[35]

In an October 2020 article by UNAIDS, researchers calculated the ratio of pregnant women tested for HIV in antenatal care, comparing numbers for January 2020 to each of the subsequent months in the same year. They found that in South Africa, numbers for February 2020 to June 2020 were all lower than those for January 2020 (thus creating ratios <1), with the greatest difference noted in April 2020.[40] According to the article, by June or July 2020, 14 of the 17 countries analysed had returned to their February 2020 testing levels, including South Africa.[40] Furthermore, the *South African Health Review 2021*, which included an analysis of all antenatal first visits, reported that pregnant women attended clinics later in the 2020/21 financial year than in the previous financial year, and that while there was no significant change in numbers of antenatal visits, births increased in the same period by 3.6%.[41] They also reported a marked movement of pregnant women to more rural provinces for delivery in the 2020/21 financial year,[41] which may explain the differences between provinces noted in the study that used DHIS data mentioned above.[35]

The Mopani district study in rural Limpopo showed no statistically significant change in PMTCT indicators for lockdown, including for HIV PCR tests in children younger than 18 months of age.[37] In addition, despite overall declines in healthcare facility visits, antenatal visits were relatively unaffected, with only a slight increase in May 2020 (again likely due to women returning to their rural homes for level 5 lockdown).[37] Thus, although the number of antenatal first visits remained similar in 2020 compared to previous years, the increase in births could be an indication that some pregnancies were not attended to by the health service. This fact, coupled with the delay in seeking care, could have implications for MCH outcomes that are yet to be realised or detected.

Non-communicable diseases (NCDs)

Almost half (41%) of healthcare use in a rural setting in South Africa is linked to managing non-communicable diseases (NCDs).[42] Therefore, the overall decline in PHC visits from 2019 to 2020 (from 99.6 million to 81.2 million respectively)[35] is likely to have had a major impact on the diagnosis, treatment and follow-up of patients with NCDs.

A study conducted at the NHLS Chemical Pathology laboratory at Tygerberg Hospital (TBH) in the Western Cape explored laboratory request volumes for the period 1 March to 30 June in 2017, 2018, 2019 and 2020. The study aimed to measure the effect of the COVID-19 lockdown on communicable diseases, NCDs, and neonatal services.[43] The findings showed that the most affected laboratory requests were those linked to NCDs, such as dyslipidaemia, diabetes and thyroid pathology and included lipid profiles, creatinine, glycated haemoglobin (HbA1c), thyroid-stimulating hormone (TSH) and free tri-iodothyronine (fT3). For the same four-month period, they found a decrease in magnitude of the following laboratory requests from 2019 to 2020: 59% for lipids, 64% for creatinine and HbA1c, 80% for TSH and 81% for fT3.[43] HbA1c serves as a marker of diabetic follow-up and lipid profiles as a marker of dyslipidaemia.[43] The likely implications of the study's findings are that there would be a delayed detection of abnormal HbA1c and dyslipidaemia, thus increasing the risk of complications such as cardiovascular disease.[43] The TSH and fT3 tests are routinely requested to follow-up on thyroid malignancies and hypothyroidism. The pronounced decrease in these could indicate the negative impact of COVID-19 on the treatment of thyroid cancer.[43] While laboratory testing increased as lockdown levels eased, the June 2020 levels were still lower than June 2019 levels.[43]

Another study conducted in two primary care sites in the Cape Town Metro showed a decline of up to 59% in HbA1C tests performed in March and April 2020 when compared to the same period in 2019. The HbA1C tests that were performed showed an increase in the proportion of uncontrolled diabetics of up to 11%.[36] It is therefore possible that the decline in blood tests performed for diabetes resulted in many missed cases of uncontrolled diabetes.

Routine services for NCDs were greatly affected by South Africa's COVID-19-related lockdown. Follow-up visits for patients with NCDs were postponed to decrease the burden on hospitals, and HCWs were redeployed to assist with management of COVID-19 cases.[43] In addition, near TBH, several peripheral clinics were temporarily closed for decontamination following confirmation of a case of COVID-19,[43] another example of how COVID-19 affected routine health services, including those for NCDs.

The impact of the COVID-19 pandemic on the South African health system could be profound, with major backlogs for routine services, and management of the complications resulting from delayed diagnosis of NCDs.[43] This, coupled with the high burden of NCDs in South Africa, has potentially severe implications for people living with NCDs.

NOVEL COVID-19 DIAGNOSTIC INTERVENTIONS OR SERVICES

Drive-through testing sites

1. International

On 23 February 2020, South Korea implemented a drive-through testing site in the city of Daegu, based on models they had previously used for point of dispensing for bioterrorism and drive-through clinics for an influenza pandemic.[44] By 12 March 2020, drive-through testing sites had been implemented at 68 more locations.[44] They found that using the patient's car as the specimen collection room, minimised the need for ventilation and sanitisation of testing areas, which made this approach faster than traditional testing. In addition, it minimised contact between HCWs and patients, as well as between patients themselves, because the cars also replaced the waiting room. These drive-through testing sites also minimised staffing needs and use of personal protective equipment (PPE) because conventional PPE (which in South Korea consisted of a double layer of gloves, hooded gown, eye- or face-shield and an N95 respirator) was not changed between each test performed.[44] This was supported by findings from a drive-through testing site at the Mayo Clinic in Florida where the drive-through method reduced the use of masks by 96%, the use of gowns by 97% and the use of gloves by 47%.[45]

While drive-through testing was found to be safe and efficient, this method is not without limitations. These include: the person being tested needs to have their own car; potential contamination of samples by PPE that is not changed between each test; and potential for misuse of resources if indiscriminate testing is allowed.[44] To minimise possible contamination of samples, disposable gloves and aprons were worn in addition to conventional PPE at the South Korea drive-through testing sites.[44] These additional disposable aprons and gloves were changed between people being tested, and alcohol-based hand sanitiser was also used.[44]

2. South Africa

In South Africa, drive-through testing sites were already in place by the end of March 2020,[46] which indicates that the country was staying abreast of international best practices. The Dischem Pharmacy group was one of the main providers of drive-through testing sites, citing their initiative as a form of private sector support of the government's COVID-19 testing efforts.[47] Not only did South Africa's drive-through testing require that a patient have their own car, but it was also was privately run and carried a substantial fee for each test.[47,48] The high cost of this private service likely made it inaccessible to the majority of South Africans.

Self-testing options

One recommendation made to reduce the costs and resource use in COVID-19 testing – as well as increase the testing rate in South Africa – was to encourage self-collection of upper respiratory tract swabs.[49] Another option was self-testing at home using rapid antigen tests for SARS-CoV-2. Even though it is likely this would quickly identify infected individuals and allow them to isolate at a relatively low cost, it has not been allowed in South Africa.[50] Self-testing was first approved by the United States (US) Food and Drug Administration (FDA) in November 2020 and by 2021 was a well-established practice in most developed countries.[50]

Debates about self-testing include issues such as test sensitivity, adequacy of the sample and correct interpretation of the results.[50] A US study showed that one in three people misinterpreted their rapid antigen test result, and that clear communication of information in a variety of formats was critical to successful interpretation of results.[50] While a German study showed that microbiomes on the swabs did not differ between staff-collected and self-collected swabs,[49] a recent United Kingdom (UK) study showed that laboratory staff were better at performing the test than laypeople.[50]

It is likely that factors such as literacy, age, social circumstances and information provided would affect the quality of the self-collected swab[50] and that these factors may play a role in a South African setting too. Despite these concerns, with proper official guidelines and clearly communicated information, self-testing could provide a feasible approach to controlling COVID-19 transmission.[50]

Mobile testing units

1. International

In the Australian state of Victoria, plans to develop a mobile testing unit or 'LabVan' were initiated in September 2020; it was deployed in July 2021.[51] The TAT in the LabVan – from sample collection to results – was approximately two hours, compared to the main laboratory where TAT was around 19 hours, thus it was concluded that the LabVan was useful in facilitating rapid public health responses.[51] This difference in TAT was mainly due to the type of molecular test done (the LabVan used a rapid PCR test) and the time between sample collection and receipt by the laboratory (LabVan samples were delivered 'on demand' while the main laboratory samples were delivered by couriers in batched time frames).[51]

Ghana, likewise, conducted a pilot study on a mobile laboratory van to evaluate how this tool could accelerate COVID-19 diagnostics in their country. Initially, Ghana's COVID-19 testing capability was limited to two central laboratories and later, a few regional and institutional

laboratories were added to bolster their testing strategy.[52] The mobile van was evaluated to assess its ability to reduce TAT for COVID-19 testing, reduce workload on central laboratories and decentralise testing to aid in community testing and tracing efforts.[52] The TAT when using this mobile laboratory was reduced to an average of three hours, compared with three to four days with RT-PCR testing in central laboratories.[52] While this mobile testing unit had its limitations (e.g. smaller test volume capacity than central laboratories), the authors of the study concluded that it could potentially facilitate rapid clinical and public health decision-making and decrease the potential impact of unnecessary quarantining on the country's economy.[52]

2. South Africa

South Africa introduced mobile testing units much earlier on in the pandemic than Australia. The Minister of Health announced deployment of an additional 60 mobile testing vans (which brought the total to 67) on 1 April 2020, as part of the country's CST programme.[53] The vans were equipped to function as NHLS mobile laboratories with specialised equipment for handling COVID-19 samples and performing COVID-19 tests.[54,55] The initial focus was to do nasopharyngeal swabbing for RT-PCR and Xpert® rapid PCR tests in otherwise hard-to-reach communities.[53,55] However, with global demand causing a shortage of Xpert® rapid PCR test assays for SARS-CoV-2, the ability to do on-site testing was likely limited initially. The CST programme therefore contributed to the backlog of COVID-19 tests in NHLS laboratories early in the pandemic.[23]

In March 2021, the Xpert for Active Case Finding (XACT) study rolled out 10 mobile TB clinics.[56] Noting the large declines in TB case detection as a result of the COVID-19 pandemic, the study sought to "win the battle against TB" by assessing the feasibility of community-based TB testing and active case-finding.[57] In addition, the feasibility of screening for COVID-19 at the same mobile testing units was to be assessed.[57] Innovations from the battle against COVID-19 may therefore help to regain lost ground, and perhaps even further efforts to curb other epidemics.

Locally produced rapid tests

While not necessarily a novel intervention, the local production of rapid COVID-19 tests was an important step in South Africa's fight against COVID-19, as it reduced reliance on overseas test-kit supplies.[58]

In mid-2020 the South African Medical Research Council (SAMRC), in conjunction with government, academia and industry, set out to develop and manufacture locally produced rapid tests.[58] In under a year, the Council for Scientific and Industrial Research (CSIR), in collaboration with a local biotechnology company, created a single-step test to detect SAR-CoV-2.[59] The result is a locally produced rapid PCR test kit, including reagents, for SAR-CoV-2 that has passed testing by the NHLS and has been approved by SAPHRA.[60] It was released onto the local market in August 2021 in the hope that it would reduce TAT of testing in South Africa.[59] In addition, December 2021 saw SAPHRA approve a locally developed and produced rapid COVID-19 antigen test.[58]

Such innovations allow South Africa to supply both local and African markets with test kits thus reducing competition with developed countries for such products.[60] It highlights the necessity for collaboration with other sectors and industries in order to boost pandemic preparedness and response.

Application-based technology

1. International

In their opinion piece published in the *Daily Maverick* at the beginning of June 2020, Mendelson et al. suggested that South Africa use a mobile phone application (app) or web-based platform to screen for COVID-19 symptoms and provide advice to the user (in place of extensive community based testing).[23] Similar technologies were used in the UK and other high-income countries when they faced shortages of RT-PCR tests.[23]

The COVID Symptom Study app, released in the UK and the US in March 2020, managed to garner 2.8 million users by May 2020.[61] The app allowed self-reporting of risk factors, symptoms, test results and many other parameters. This in turn allowed for geospatial mapping of COVID-19, the ability to determine which symptom clusters have a good predictive value for a positive COVID-19 test, and other functions with the potential to guide resource allocation.[61]

2. South Africa

South Africa launched two COVID-19 mobile phone applications: the COVIDConnect app and the COVID Alert South Africa app. COVIDConnect was launched in May 2020 by the NDoH and provided two services: 1) general information about COVID-19 (health checks, statistics, symptoms etc.) and 2) a way to obtain COVID-19 test results.[62] Users could access the app via SMS or WhatsApp, which meant it could be used on any mobile phone, not only smartphones.[62] Because the app could be used on all mobile phones, many more South Africans were able to engage with this service. However, either airtime or data (Wi-Fi or mobile data) were required to use the app, which may have limited access and thus reduced its effectiveness.[62] In addition, the app required users to remember who they had been in contact with to alert those individuals of COVID-19 exposure.[62] South Africa was the first country in the world to use a WhatsApp channel in this way for COVID-19 and the model was borrowed by the WHO for global implementation.[62]

The COVID Alert South Africa app was launched in August 2020 as an exposure notification app (for contact tracing). If someone with the app on their phone tested positive for COVID-19, and authorised the app to do so, it would alert other app users who had been in close proximity to them in the last 14 days that they had been in contact with a COVID-19-positive person.[62] For the contract-tracing function to be effective, most of the population would have to be registered on the app.[62] Although it is free and zero-rated (i.e. no data costs are incurred when using it), Wi-Fi or mobile data are still required to download the app.[62] In addition, its usefulness was probably limited because it was only compatible with recent versions of Android and iOS; and the app also required constant activation of Bluetooth for its contact-tracing function to work.[62]

Another limiting factor for both apps was public mistrust regarding the collection and use of personal information, despite government assurances that the apps complied with the Protection of Personal Information Act (POPIA).[62]

COVID-19 HEALTH SYSTEMS EXPERIENCES FROM OTHER COUNTRIES

Challenges with testing in Africa

As of the 17 January 2022 the African continent reported 10 million cases of COVID-19 (3.2% of global cases) and 234,566 related deaths (4.2% of worldwide death burden) despite representing 16% of the global population.[36] There are many hypotheses as to why this is the case, one of which cites flawed capacity for large-scale testing and reporting.[36] Many African countries experienced a shortage of test kits and supplies, which forced governments to severely restrict testing for COVID-19.[63] An article in *Lancet Microbe* in May 2020, outlines the following testing challenges experienced in Africa:

1. Nigeria

In April 2020, Nigeria had conducted about 7,000 tests, compared to the US where nearly 4 million tests were conducted over the same period.[63] Nigeria's Centre for Disease Control increased their daily testing capacity for COVID-19 to 2,500 tests by mid-April 2020 by involving the existing viral haemorrhagic fever laboratory network and other national laboratories. However, their testing capability was limited by sample transport challenges from the point of collection to the laboratory.[63] The health start-up, LifeBank, and its partners were in the process of helping Nigeria to create mobile testing centres at the time the article was written.[63]

2. Ghana

By May 2020, testing for SARS-CoV-2 in Ghana was only available at two central laboratories: Noguchi Memorial Institute for Medical Research in Accra and Kumasi Centre for Collaborative Research.[63] While this had serious implications for testing capacity, an on-demand drone delivery service in Ghana called Zipline, stepped up to transport samples from over 1,000 hard-to-reach health facilities to the designated testing sites,[63] which helped those in remote areas access testing.

3. Uganda

By late April 2020, Uganda had only 60 confirmed cases of COVID-19. This was, however, attributed to the low number of tests conducted.[63] Like South Africa, Uganda's framework for managing active and drug-resistant TB meant that GeneXpert machines were readily available and could be repurposed for SARS-CoV-2 testing.[63] However, it is likely that, as was the case in South Africa, global demand and stockpiling of these tests by the US[17] limited use of the Xpress SARS-CoV-2 test in Uganda as well.

Disruption of routine health services

The impact of the COVID-19 pandemic on the disruption of routine health services was universal, and affected both high- and low-income countries. A Harvard study measured the effect of the pandemic on 31 health services in 10 countries: two low-income countries (LICs) – Ethiopia and Haiti, six middle-income countries (MICs) – Ghana, Lao People's Democratic Republic (LPDR), Nepal, Mexico, South Africa and Thailand – and two high-income countries (HICs) – Chile and South Korea – to assess the resilience of their healthcare systems.[7] The study found that health service disruptions had a tendency to be greater in metropolitan regions in most of the countries except South Korea and that overall, the countries that experienced disrupted services from the beginning of the pandemic in 2020, still had lower than expected utilisation of these services 15 months later.[7]

HIV testing

A multi-site cohort study, conducted in 1,059 facilities in 11 sub-Saharan countries (Angola, Burundi, Cote d'Ivoire, Democratic Republic of Congo, Eswatini, Ethiopia, Kenya, Mozambique, South Sudan and Zambia)[36] found that lockdown measures had a negative impact on HIV testing (and thus, ART initiation). However, there was a rapid recovery as lockdown measures eased.[36] Another study in Nairobi, Kenya showed a decrease in HIV testing of 50.5% over the period of March 2020 to February 2021, compared to the pre-pandemic period.[36]

TB testing

The COVID-19 pandemic has affected TB services in other countries in a similar way to South Africa. For example, state TB programmes in India reported a significant drop in TB notifications for January to July 2020 compared to the same period in 2019.[64] Comparable findings in other high burden TB countries like China, South Korea and Nigeria have also been reported.[64] In certain cities in Zimbabwe, Kenya and Malawi, reductions in TB diagnosis of 30%, 28% and 19% respectively, were noted for the period of March 2020 to February 2021 compared to the pre-pandemic period.[36] However, Malawi had no official lockdown to account for this decrease in TB diagnosis.[36] A global decrease in TB diagnosis of 18% occurred between the 2019 and 2020 periods.[36]

Many innovations have arisen to combat the COVID-19 related disruption in TB services. In India, state governments mandated combined testing of TB and COVID-19 by District TB Officers.[64] In addition, the Indian Ministry of Health and Family Welfare released guidance for bi-directional screening of COVID-19 and TB for all influenza-like illnesses or severe acute respiratory infection patients.[64] Bi-directional screening involves screening for TB in all confirmed cases of COVID-19 and for COVID-19 in all confirmed TB cases.[65]

Other countries have also experimented with combined screening, including Indonesia, some provinces in South Africa and other African countries.[64] In Kaduna state in Nigeria, the World Health Organization (WHO), along with the government and the KNCV Tuberculosis Foundation,[i] put in place mobile diagnostic facilities that could test for both TB and COVID-19; and Bangladesh initiated a mobile x-ray van to help diagnose TB.[64]

i De Koninklijke Nederlandse Centrale Vereniging tot bestrijding der Tuberculose

Even though transport restrictions, lockdowns and repurposing of healthcare services have affected those seeking care,[64] many innovations in various countries have demonstrated the potential to strengthen healthcare services going forward and offer a buffer against the effects of future pandemics.

Non-communicable diseases (NCDs)

According to the Harvard study on healthcare system resilience, the impact of the pandemic on NCD services was considerable. Screening for breast cancer, for example, was one of the services most affected, with large and persistent declines. This is illustrated by decreases in breast cancer screening of 69% in Mexico and 96% in Chile after the pandemic was declared.[7] Similarly, cervical cancer screening was also significantly impacted, declining by 67% in Mexico.[7] Furthermore, there was a more than 20% decrease in consultations for diabetes and hypertension in six of the countries reviewed (Chile, Haiti, Mexico, Nepal, South Africa and Thailand) and a decrease in mental health services of 51% and 84% in Mexico and Chile.

RECOMMENDATIONS

Agile and adaptive governance

South Africa's initial testing guidelines and case definition were developed before the country had identified its first case of COVID-19. The deliberately narrow case definition was intended to preserve resources by preventing unnecessary testing by the public.[17] The first suspected case of community transmission was identified on 13 March 2020 and the national lockdown was implemented on 27 March 2020.[66] However, as the focus turned to containment efforts through active case-finding and contact-tracing with isolation and quarantine, there was a significant delay in changing the case definition to make these efforts effective. This delay in policy change was noted again as the pandemic entered its exponential phase before the first wave. At this point, CST efforts at containment had been rendered ineffective by backlogs in the state laboratories resulting from a shortage of test kits and reagents caused by global demand, as well as by internal planning issues in private and public laboratories.[23] Despite calls to change the testing strategy in light of the resource constraints from mid-May 2020,[22] the new prioritised testing strategy was only implemented in July 2020.[24]

The scenario outlined here highlights the importance of agility and adaptability in governance in response to an evolving pandemic, constantly emerging evidence and resource challenges. An article using the Netherlands response to the COVID-19 pandemic to garner lessons on agile and adaptive governance found that responses in a crisis like the pandemic may need to change over time.[67] With monitoring of a situation and continued learning, adaptation can occur, recognizing that interventions that worked and served a purpose initially may no longer do so.[67]

The agility that enables a quick response to changes in circumstances, which is vital in a pandemic, can result in overemphasis of one issue over another.[67] South Africa's innovative redeployment of CHWs for active case-finding and using existing HIV and TB infrastructure for COVID-19 testing are examples of agile responses. However, as the epidemic evolved and resource demands exceeded availability, a change in response was needed to serve those in hospital settings more effectively. Although this eventually happened, the sluggishness of the changes had implications for their effectiveness.

The Netherlands article found that having structures and institutions in place prior to the crisis allows for adaptability while maintaining stability, which is also necessary to maintain public trust and buy-in.[67] Essentially, adaptive governance involves preparing for various contingencies. Adaptive governance has its roots in evolutionary theory and thus the greater the variety of possible response strategies available prior to the crisis emerging, the greater the ability to adapt once the crisis hits.[67] The lessons we are deriving from COVID-19 must be used to prepare for these contingencies now to ensure better responsiveness to future pandemics.

The COVID-19 strategic preparedness and response plan for the African region published by the WHO[68] aligns with this approach and could be used as a framework for developing contingencies in preparation for future pandemics. Furthermore, in order to create a resilient health system for future pandemics and routine healthcare, one option proposed is the 'whole-of-society' approach, which provides the opportunity for government structures and community stakeholders to collaborate, enabling an increased awareness of and response to the diverse and rapidly changing needs of communities.[69] The community-based health networks and infrastructure provide a 'bottom-up' aspect to governance and capacity building that allows for rapid adaptation in a crisis. Another approach includes the development of an ethical and values-driven priority-setting mechanism that will guide resource allocation and decision-making in a community-involved and context-specific manner, and can be adapted to guide efforts during public health emergencies.[70]

Local production of test supplies

Locally produced rapid PCR and antigen tests were developed and approved later in the COVID-19 pandemic.[58,60] Taking note of how the Xpert® technology was rapidly adapted from TB testing to SARS-CoV-2 testing it is possible that if South Africa has existing testing technology it may also be quickly adapted and approved for newly arising pathogens in the response to future pandemics. This would aid in containment efforts and allow supply of both South Africa and other African countries, while decreasing dependence on foreign supply chains.[60]

Integration of health services

According to Arsenault et al., "During a health crisis such as the COVID-19 pandemic, high-quality and resilient health systems have two tasks: respond to the crisis and maintain provision of other essential health services."[7]

The disruption of other health services in South Africa as a result of the COVID-19 pandemic has implications in terms of the burden of disease they represent and the associated morbidity and mortality.[35] Many countries addressed this issue through integration of services: for example, screening and testing for TB and COVID-19 at the same time, given that both present with respiratory symptoms.[64] The ongoing XACT trial is investigating dual use of mobile laboratory vans for TB testing and COVID-19 screening.[57] Services could also be integrated at health facilities and in the community. For example, nurses administering HIV or NCD services could be trained in screening and reporting of COVID-19[71] and the extensive infrastructure and resources available for HIV could also be used for detection and management of other chronic diseases.

Self-testing, self-screening and self-assessment

Self-testing not only offers a way to increase testing for COVID-19 but also testing for diseases such as HIV. HIV self-testing (HIVST) is recommended by the WHO as an additional approach to HIV testing services (HTS).[72] The National HIV Self Screening Guidelines South Africa released in 2018 outlined the need for clear instructions, support via multimedia platforms (telephonic hotlines, videos and brochures), and assisted and unassisted HIVST.[73]

During assisted HIVST, a CHW, trained counsellor or peer educator demonstrates the method and guides the person performing the self-test so that they become comfortable performing the test.[73] Assisted HIVST is recommended for adolescents, for people with a low level of literacy and for people who are unsure or uneasy about the procedure.[73] If a test is positive, the person is encouraged to go to a facility for a confirmatory test.[73] An ongoing study in South Africa, to assess the linkage to care following HIVST offers self-reporting options via telephonic, interactive voice response, Progressive WebApp and WhatsApp messaging platforms. In this same study, test kits are distributed via community-based, public-sector facilities, key population and private sector facilities (pharmacies etc.).[72]

While this model has the potential to increase levels of HIV testing in stable periods, it is particularly promising in the setting of a pandemic such as COVID-19 where at various times movement of people and health facility attendance are restricted. In addition, as health technology evolves to include self-testing for various conditions, and as the population becomes more comfortable and familiar with self-testing platforms for HIV it should become more feasible to introduce this kind of testing for other pandemics or health conditions. The sample collection for the HIVST involves oral swabs as well as finger pricks, which will lend versatility to the self-testing response to future pandemics. In addition, CHWs, peer educators and counsellors that train for HIVST could also be involved in training self-testing of COVID-19 and other conditions as they arise.

There is an increasing body of evidence in high-income settings for the success of cardiometabolic self-testing in assessing an individual's risk of certain NCDs.[74] A pilot study conducted in Soweto, South Africa, has assessed the feasibility of such cardiometabolic self-assessment in a low-income setting.[74] The self-measurements performed in this study included blood pressure, resting heart rate, height, waist circumference (assessing for obesity) and a urine dipstick (to assess for glucose or protein).[74] The study found high levels of agreement between participant self-measurements and measurements made by the researchers for blood pressure, heart rate and height, with less reliability for the urine dipstick measurements.[74] Although further research is needed in this area, including to determine how the necessary equipment could be made available for this at scale, this study succeeded in showing that this type of cardiometabolic self-assessment is a feasible option even in areas with low health literacy.[74] Furthermore, the qualitative element of the study found that people demonstrated a desire to take control of their own health,[74] which supports the potential of self-testing as a way to increase agency.

Self-screening could also be used as an adjunct to healthcare-based screening for TB and for diseases such as breast cancer, which were significantly affected by the COVID-19 pandemic in South Africa.[7,34] If the research, education and upskilling of the population for self-testing are put in place now, before any future pandemic crisis, self-testing will be available as an option to ensure an adaptive and resilient health system in times of crisis.

Integration with technology

In South Africa, COVID-19 mobile phone apps were met with mixed reactions.[62] Their widespread use in the country was limited by factors such as the cost of airtime and data; compatibility with older phone technology and suspicion regarding which personal data was collected by the app.[62] Nonetheless, it is likely that technology will play an ever-increasing role in health programmes and pandemic responses. For example, the COVID Symptom Study app released in the UK and the US showed great potential for disease surveillance. It also demonstrated how prospective collection of data regarding emerging symptoms that were predictive of positive COVID-19 test results could help guide resource allocation.[61]

In South Africa, the likelihood of the widespread use required to make such functions feasible is lower but does not negate the use of technology as a tool in the pandemic response, especially if it is used in conjunction with other services, such as teams of CHWs.

The self-screening function on the South African COVIDConnect app had been used by 2.5 million people a month after its release.[62] Thus, as Mendelson et al. suggested, this kind of technology can be used for symptom self-screening and offering advice to the user, particularly in light of potential test supply shortages and laboratory backlogs.[23] Furthermore, this kind of technology is likely to become a more integral part of linkage to care and self-reporting in other health programmes such as in HIV self-testing[72] and may become more familiar and acceptable to the public for use in health-related reporting.

Gaining public trust and buy-in for these technology platforms before a public health emergency occurs, will increase the likelihood that they will be accepted and used during times of crisis. Possible mechanisms to do this might include the use of a social listening mechanism similar to that used in addressing vaccine misinformation and risk communication,[75] to identify and address the concerns of the public regarding these technology tools. As stated above, stability is key to adaptive governance. In times of crisis "institutionalised mechanisms tend to work well" as "people can cope with them because they are familiar".[67]

Community screening and testing

1. Community health workers

While the CST programme came under criticism when COVID-19 test backlogs in the laboratories grew, and rendered the test/isolate or trace/quarantine strategies ineffective,[22,23] it still has the potential to be effective in future pandemics. As Mendelson and Mahdi commented, even when there are test-kit shortages and laboratory backlogs, the CHWs could continue to encourage communities to use non-pharmaceutical interventions (social distancing, hand-washing, cough etiquette, etc.) to slow the spread of SARS-CoV-2[22] and keep people informed of symptoms, which assists in self-screening. Locally produced rapid test kits would also make many containment activities possible. These activities include screening and referring to mobile testing units; educating and assisting communities with self-testing; contact tracing; and, advising on isolation or quarantine based on test results.

If self-testing is realised, it is likely that the CHWs would play a vital role, not only in educating in the use of self-tests but also in reporting of test results from the communities, especially in rural communities. They would likely do this either through encouraging self-reporting via

phone technology or by assisting with reporting via the mobile app technology similar to that used for COVID-19. Furthermore, integration of services would allow them to continue to play a vital role in the continuity of other essential health services, such as TB screening, HIV testing, and screening or testing for other conditions .

2. Mobile testing units

A study done in Australia, and another done in Ghana both showed that mobile testing units or mobile laboratories had the ability to facilitate access to testing for hard-to-reach populations and decrease TAT for test results thus aiding in test, trace and isolate/quarantine efforts.[51,52] Both above models used rapid tests for SARS-CoV-2 in the van itself. In South Africa however, multiple mobile testing units were rolled out but access to Xpert ®Xpress SARS-CoV-2 assays was limited due to global demand.[23] Thus, samples collected were referred to central laboratories and contributed to the backlog there, which hindered efforts at containing the spread of SARS-CoV-2.

In light of this fact, as well as the findings from the Australia and Ghana studies, it is recommended that to be effective mobile testing units should be fitted with the capability to do point-of-care testing as well as sample collection. Point-of-care testing in mobile units would also enhance their ability to serve remote and rural populations in South Africa, both for future pandemics and for routine health services in stable periods.

Later in the pandemic, locally produced rapid PCR and antigen tests were developed for SARS-CoV-2.[58,60] If this locally produced rapid testing technology could be used in mobile testing units, it would decrease the (TAT) of results and thus aid containment efforts for future pandemics. It would also decrease reliance on foreign supply chains.

Public–private collaboration

In South Africa, both public and private laboratories contributed to testing for COVID-19. Similar to the results of the data analysis done here, an article on 24 June 2020 noted that approximately half of the tests done at that point had been done in the private sector, which serves only about 20% of the population.[5] Although South Africa's private sector was one of the few in Africa to be actively involved,[63] questions arose about it testing too liberally at a time when there were test supply shortages.[5]

While public sector laboratories struggled with a large backlog and TAT of 5-14 days for test results,[22] the private sector consistently kept the TAT to <2 days.[5] Those without medical aid also had the option to pay for the test directly in the private sector.[5] With innovations such as drive-through testing sites[47] and the COVID Alert South Africa app (developed by Discovery Limited)[62] the private sector made an undeniable contribution in the pandemic.

Recommendations in this regard include that in a pandemic situation private sector involvement should be supervised by government,[48] particularly with regard to guidelines and eligibility for testing, to ensure that resources are appropriately allocated. In addition, government regulation of the cost of testing during a pandemic could increase access to testing and provide financial risk protection for South Africans. Stipulations of this nature are in line with principles of adaptive governance, in which it is accepted that "crisis legitimizes central authority" to ensure that decisions are made within reasonable limits.[67] In addition, there should be negotiation for spare testing capacity in private laboratories to be allocated to address backlogs in the public sector, as was part of the NHLS plan during the first wave of the COVID-19 pandemic in South Africa.[5]


SOUTH AFRICA STR

The South African health system response required to meet the therapeutic demands of the COVID-19 pandemic was vast and complex. It necessitated a coordinated and multifaceted approach, implemented at various levels of the health system and within a resource-limited setting.

SECTION TWO

COVID-19 THERAPEUTICS

SOUTH AFRICA'S COVID-19 TREATMENT GUIDELINES AND ASSOCIATED CHALLENGES

This section describes the changes in South Africa's COVID-19 treatment guidelines between March 2020 and June 2022 chronologically. Changes related to specific patient populations as well as guidelines related to preventing facility-based infection are outlined here.

The two main goals of the clinical management of COVID-19 cases were: to reduce the resulting morbidity and mortality, and to minimise transmission of SARS-CoV-2 to uninfected contacts.[76] The guidelines and health system response were thus geared towards achieving these goals. To do this, the guidelines for the clinical management of COVID-19 disease included the following categories: i) management of asymptomatic or mild COVID-19 disease; ii) admission and treatment of moderate to severe COVID-19 disease; iii) infection prevention and control (IPC); and iv) recording and reporting.[76]

In the early treatment guidelines released by the NDoH and NICD, much of the evidence used to inform recommendations was from systematic reviews and observational studies for the treatment of SARS (severe acute respiratory syndrome), MERS (Middle East respiratory syndrome) and influenza.[76] As the epidemic evolved and COVID-19-specific evidence emerged, guidelines were amended accordingly.

The first three sets of guidelines for the clinical management of COVID-19 disease were released in rapid succession between 13 March 2020 and 27 March 2020 following the identification of the first COVID-19 case in South Africa, and in the time leading up to the national lockdown.[76–78]

The fourth version of the guidelines, released on 18 May 2020, was the first to include a section on the management of special populations, including children, newborns, pregnant and breastfeeding women and people living with HIV (PLHIV).[79] In addition, version 4 was the first to include COVID-19 rapid reviews on therapeutic interventions as part of the methodology used to inform the guidelines.[79] These rapid reviews were conducted by the COVID-19 subcommittee of the National Essential Medicines List Committee (NEMLC).[79] The NEMLC worked in conjunction with the South African GRADE Network, Cochrane South Africa and the Centre for Evidence-Based Health Care, using an adapted version of Cochrane's rapid review methodology to evaluate evidence on potential therapeutic interventions.[80] The reviews, which were produced in 7 to10 days, aimed to assist the NDoH in making evidence-based decisions when formulating National Guidelines.[80]

The reviews were also useful in terms of procurement of medications when considering the increasing global demand.[80] The updated 7th version of the drug therapy module (released on 13 December 2021) stated that the NEMLC decision process took a "clinical public-health perspective with consideration of affordability, equity, feasibility and acceptability in addition to considering the balance of benefits and harms" when making drug therapy recommendations for the treatment or prevention of COVID-19 disease.[81]

Later versions of the guidelines for the clinical management of COVID-19 disease were released in modular format to allow for updates of individual sections of the guidelines. Therefore, only the module on drug therapy has a 7th version.[81]

The following sections discuss the treatment protocols (outlined in the guidelines for clinical management of COVID-19 disease) that are relevant to the South African health system response. Treatment protocols reviewed demonstrate what would have been required by the health system response to prevent transmission of SARS-CoV-2, equip facilities, regulate the use of medications for the treatment of COVID-19 disease and procure PPE for HCWs.

Management of asymptomatic or mild COVID-19 disease

In version 1.1 of the guidelines, which was released on 13 March 2020, asymptomatic patients and those with mild COVID-19 disease were to be managed at home.[76] To reduce transmission of SARS-CoV-2, they were to self-isolate; remain separate or distanced from other household members; wear masks in shared spaces; use cough and sneeze etiquette; perform frequent hand hygiene; follow instructions on waste disposal; and, frequently sanitise surfaces in communal spaces (e.g. kitchens and bathrooms).[76] In terms of reducing morbidity and mortality for cases managed at home, patients needed to fulfil the following criteria: they were to have no risk factors for severe disease, be counselled on who to contact should they deteriorate, and be followed up by their local health department.[76]

In version 2 of the guidelines released on 19 March 2020, the main change for asymptomatic patients and those with mild COVID-19 disease was regarding the de-isolation period. Asymptomatic cases could de-isolate 14 days after their positive test and mild cases could de-isolate 14 days after their symptoms began, without the need for further PCR testing, in both cases.[77]

The next change to this section was only in version 4 of the guidelines, and was related to the criteria for home management of mild cases. Provided that patients were able to self-isolate, they could be managed at home. This included those with risk factors for severe disease who displayed only mild symptoms.[79] Recognising that not all South Africans would be able to safely self-isolate at home, designated government facilities were provided for this purpose.[79]

In version 5 of the guidelines, the de-isolation period was reduced to 10 days after a positive test for asymptomatic patients and 10 days after symptom onset for those with mild disease (the latter recommendation was made based on new evidence relating to periods of infectiousness).[82]

There were no further updates in version 6 of the guidelines (published 20 Sept 2021),[83] i.e. version 5 and version 6 are identical for this group of patients.

Management of moderate to severe COVID-19 disease

According to version 1.1 of the guidelines, those triaged and found to have moderate or severe disease were to be admitted to hospital (preferably to facilities designated to manage COVID-19 cases, if this was feasible).[76] The recommended early supportive treatment for this group included supplemental oxygen via nasal cannula, a face mask, or face mask with reservoir bag for those with low oxygen saturation; conservative fluid management; empiric treatment of suspected co-infections; and close monitoring for clinical deterioration.[76]

The use of corticosteroids for the treatment of COVID-19 disease was advised against based on evidence from studies for SARS, MERS and influenza which reported that they were ineffective in these diseases and had the potential to cause harm.[76] In addition, there was no evidence at that stage to support any treatment directed at suppressing the SARS-CoV2 virus and unlicensed treatments were only to be administered in "the context of ethically approved clinical trials or the Monitored Emergency Use of Unregistered Interventions Framework (MEURI),[ii] with strict monitoring".[76]

Once a patient developed hypoxemic respiratory failure and acute respiratory distress syndrome (ARDS), ventilation was to be considered. High-flow nasal oxygen (HFNO) or non-invasive ventilation (NIV) were only recommended in selected patients due to evidence of a high risk of treatment failure in MERS patients treated with the latter.[76] The recommended treatment for those with ARDS was intubation and lung-protective mechanical ventilation in consultation with an Intensivist.[76] Discharge and de-isolation were only permitted if there were no indications for admission, if symptoms had improved or resolved, and if there were two consecutive negative RT-PCR tests at least 24 to 48 hours apart.[76]

Changes in version 2 of the guidelines for this group of patients included adding chloroquine as a treatment option for those with severe disease or those with mild disease at risk of developing severe disease.[77] It was recommended that where possible, patients be enrolled in clinical trials to access drugs under investigation for the treatment of COVID-19 disease (such as Remdesivir) with appropriate monitoring and ethical oversight.[77] Furthermore, de-isolation could occur 14 days after achieving clinical stability without the need for repeat PCR tests, and the isolation period could be completed at home for hospitalised patients who had become clinically stable.[77] These changes would have reduced the unnecessary use of test, hospital and human resources.

Version 3 reverted to having no specific drug recommended for the treatment or prevention of SARS-CoV-2 and the recommendation regarding chloroquine, from the previous version, was removed. Instead, version 3 again emphasised enrolling patients into clinical trials.[78] In addition, any treatment under investigation administered outside a clinical trial setting was to be reserved for hospitalised patients and administered under the MEURI framework.[78] To use the MEURI framework the following principles were to be met: preliminary data must exist from at least laboratory or animal studies to support the intervention's efficacy and safety; approval must be obtained from the relevant human research ethics committee; informed consent must be obtained from the patients; there must be adequate resources to mitigate the intervention's risk; and the results of the intervention should be documented and shared with the wider

ii This framework is intended to provide safe and ethical access to trial treatments under emergency circumstances where an outbreak has high mortality rates.[78]

medical and scientific community.[78] Version 3 of this guideline was also the first to decisively caution that HFNO and NIV carry the risk of aerosolisation of viral particles, necessitating use of a single patient room and airborne precautions.[78]

The main changes in version 4 for this group were related to HFNO and NIV; whereas HFNO and NIV were only recommended for selected patients in previous versions, version 4 recommended that when intubation was not indicated, these interventions could be considered for all COVID-19 patients with hypoxemic respiratory failure on standard oxygen therapy.[79]

It is unclear whether this change was due to new evidence on the effectiveness of HFNO and NIV in COVID-19 patients, or if it was a strategy in mitigation of the limited resources in the lead up to the first COVID-19 wave in South Africa. These factors were, however, addressed in subsequent versions.

With emerging evidence, the guidelines for management of this group of patients had the most frequent updates in terms of respiratory support and recommended medications. Version 5 of the guidelines, released on 24 August 2020 (after the first wave), expanded on the sections for HFNO and self-proning based on evidence that showed their potential for improved outcomes in COVID-19 patients.[82] High-flow nasal oxygen (HFNO) was shown to be an advantageous option particularly for lower-resourced settings because: it did not require ICU admission, ICU specialists or nursing staff; was less invasive; and allowed for patient participation in their own care (e.g. eating and self-proning).[82] Dispersion studies also showed that HFNO did not increase the risk of aerosolisation of microbial particles when compared to standard oxygen therapy, thus addressing the concern that it may increase transmission of SARS-CoV-2.[82] The risk of aerosolisation could be further reduced if patients wore surgical masks.[82]

This therapy option also presented a concern in terms of the amount of oxygen supply required; each facility had to assess their capacity for the number of HFNO patients they would be able to support.[82] Version 5 of the guidelines also included evidence-based recommendations on medication used in the treatment of COVID-19, such as the use of dexamethasone for patients on mechanical ventilation or supplemental oxygen.[82] Other changes included recommendations for the use of prophylactic heparin in all hospitalised COVID-19 patients and therapeutic doses in those with severe disease (the latter made on weak evidence and expert opinion).[82] Although Remdesivir was not recommended for use in the public sector due to its high cost and marginal benefit, it could be accessed in the private sector under section 21.[82] Furthermore, as evidence from randomised control trials (RCTs) showed no benefit when using chloroquine or hydroxychloroquine and Lopinavir/Ritonavir in the treatment of COVID-19 patients, the guidelines recommended against its use.[82] Lastly, for patients in this group, the de-isolation period was to be reduced to 10 days after clinical stability had been achieved.[82]

There were no updates to management of this group in version 6 of the guidelines for clinical management of COVID-19 disease. Version 7 of the drug therapy module adds one key recommendation: the use of Baricitinib, an immunomodulatory[iii] medication, for COVID-19 patients receiving oxygen support.[81] In addition, it outlined a list of drugs not recommended for COVID-19 patients based on the available evidence regarding efficacy and safety, as well as on cost and access to the various drugs.[81]

iii Immunomodulatory drugs modify the response of the immune system by increasing (immunostimulators) or decreasing (immunosuppressives) the production of serum antibodies.[84]

Infection prevention and control protocols

According to version 1.1 of the guidelines, infection prevention and control (IPC) should be initiated at the point of entry into facilities. Any patient with suspected COVID-19 disease, i.e. those who fit the case definition, were to: receive a medical (surgical) mask; be taken to a separate area, preferably an isolation room or be kept two metres from other patients; use cough and sneeze etiquette; perform hand hygiene; and limit their movement within the facility (e.g. use portable x-rays if possible).[76] IPC measures included: standard precautions (which are employed at all times to reduce transmission of pathogens); droplet and contact precautions; and precautions for aerosol-generating procedures.[76]

Droplet and contact precautions included: hand hygiene; HCW PPE consisting of gowns, gloves and medical masks; safe waste management; disposable or dedicated equipment (e.g. blood pressure cuffs); limiting patient movement and, where movement was unavoidable, patients were to wear masks.[76] For any aerosol-generating procedures (e.g. nasopharyngeal swabs for testing), HCW PPE had to include a gown, gloves, a fit-tested particulate (N95) respirator and eye protection (goggles or shield), and the procedure was to be performed in a well-ventilated single room.[76] These recommendations remained the same in all subsequent versions of the guidelines.

Recording and reporting protocols

Recording and reporting of cases provides valuable information regarding: the extent of the epidemic; patient care received both in and out of hospital; and lessons learned for strengthening South Africa's pandemic response.[76] In version 1.1 of the guidelines, this process included completing the following special forms: person of interest form (for suspected COVID-19 cases); notifiable medical condition (NMC) case notification form; admission form; daily monitoring form; discharge form; and homecare form.[76]

Version 4 of the guidelines included an amendment to the forms: the person of interest form fell away and the admission, daily monitoring and discharge forms were combined into a Clinical Platform for Hospitalised Patients document to record "comorbidities, clinical progression, treatment and outcomes".[79] The NMC case notification, which was previously completed for all patients meeting the case definition, would now only be required for confirmed cases of COVID-19.[79] Furthermore, a contact line list form was introduced for those being tested for COVID-19, to enable contact tracing; a laboratory specimen submission form was also introduced.[79] The homecare form (renamed home assessment form) remained and documented the outcomes for COVID-19 cases treated at home.[79] After these changes, there were no further updates.

Protocols for special populations

Special populations were first addressed in version 4 of the guidelines. For children, the presentation and recommended management was similar to that for adults.[79] One notable difference was that with children focus was placed on balancing the need to limit transmission of SARS-CoV-2, with their need for the love, care and support of their primary caregivers.[79] The guidelines also tried to address the importance of continued routine (e.g. HIV, TB, nutritional support) and emergency care services for children.[79]

The neonatal COVID-19 protocols also focused on balancing the need to limit spread with the need of the newborn for their mother, and described the protocols for various combinations of well/unwell baby with well/unwell mother.[79] Protocols encouraged breastfeeding or using expressed breast milk where feasible, while underscoring hand and respiratory hygiene, as well as mask-wearing by mothers with COVID-19 disease during breastfeeding or expressing milk.[79] Strategies for alternative caregivers were described to ensure that the needs of the infant were always met, even when their mother was unwell.[79] For pregnant women, the guidelines emphasised the need for routine antenatal services to continue to prevent pregnancy related complications.[79] Pregnant women with confirmed COVID-19 and no obstetric complications could delay any upcoming antenatal visit until after their isolation period.[79]

Outpatient and intrapartum protocols for pregnant women with COVID-19 disease recommended that they be treated in isolation rooms by dedicated midwives.[79]

For PLHIV, the focus of the guidelines was on initiating or continuing ART by employing strategies such as prescribing up to a six-month supply of ART at a time.[79] The goal was to encourage HIV viral suppression and thereby minimise the risk of respiratory diseases associated with HIV.[79] Additionally, HCWs had to maintain a high index of suspicion for other life-threatening respiratory diseases in HIV, such as Pneumocystis jiroveci pneumonia.[79] There were no further updates for special populations in subsequent versions of the protocol.

DATA ANALYSIS

General admission data

1. Total admissions

From 1 March 2020 to 25 June 2022 there were a total of 486,978 admissions related to COVID-19, of which 16,167 (3.3%) were due to multiple admissions for the same person.

2. Proportion of admissions per period

Each COVID-19 wave in South Africa was dominated by a particular variant of SARS-CoV-2.[2] The third wave accounted for the vast majority of COVID-19 admissions in South Africa, making up 30.3% of all admissions. This was driven predominantly by the Delta variant of SARS-CoV-2.[32]

The second wave, in which the Beta variant of SARS-CoV-2 was the dominant variant,[2] accounted for 21.7% of all admissions. The first wave (driven by the original strain of SARS-CoV-2)[32] accounted for 14.6% of all admissions, and the Omicron-variant-driven[32] fourth wave, 11.0% of all admissions.

The periods before and between COVID-19 waves accounted for relatively small proportions of the total admissions, ranging from 2.0% to 5.5%. However, the period after the fourth wave had a slightly higher proportion of all admissions (7.6%), which may be explained by the COVID-19 resurgence that was driven by sub-variants of Omicron.[30,31] Although this period did not meet the definition for a fifth wave, it seems to have resulted in an increase in admissions. These trends can be seen in Figure 3.

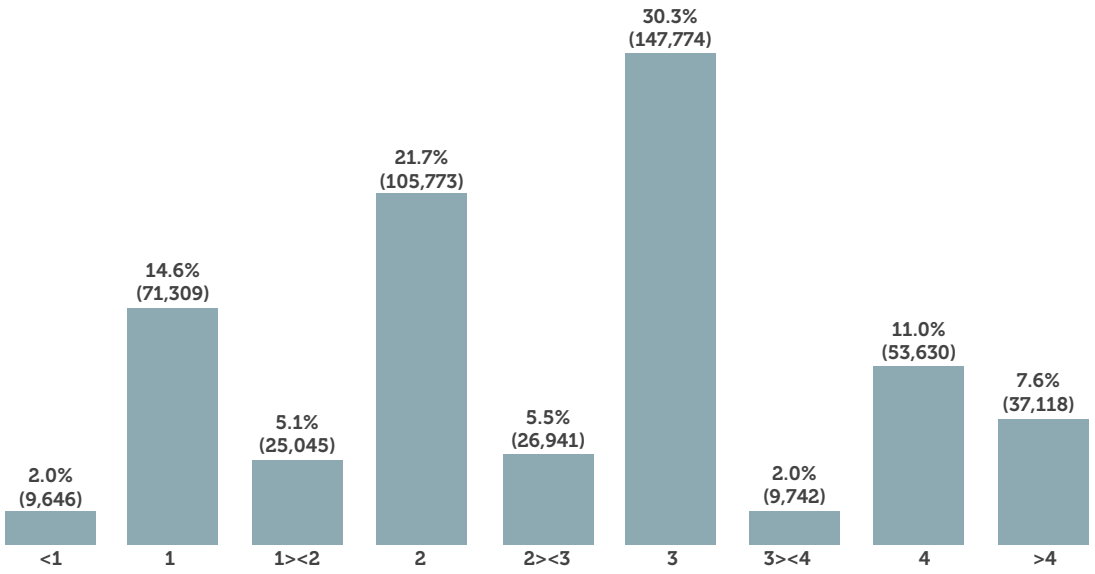

Figure 3: Proportions of admissions per period

Source: National Institute for Communicable Diseases COVID-19 Hospital Surveillance (DATCOV)

3. Private versus public admissions

For the period from 1 March 2020 to 25 June 2022, the proportion of admissions to private and public facilities was very similar, with private admissions making up 47.6% and public, 52.4%. Public facility admissions made up 61.5% of total admissions before the first wave, and 62.6% between the third and fourth wave. In general, the public sector had the greater proportion of admissions, with two exceptions: during the first wave, private sector admissions accounted for 50.8% and after the fourth wave for 53.6% of all admissions.

While the proportion of admissions between the two sectors seems fairly equal, it should be noted that although the private sector serves around 20% of the country's population,[5] it still accounted for close to half of all admissions. This suggests unequal access to healthcare in the two sectors.

4. Admissions per province

Three provinces accounted for two thirds of all admissions: Gauteng (30.9%), Western Cape (19.4%) and KwaZulu-Natal (17.1%), which are also the top three in terms of population size. Gauteng and KwaZulu-Natal also rank first and second respectively with regard to population density, and the Western Cape ranks fourth.[13] The Northern Cape, which has the smallest population size[12] and lowest population density[13] had the lowest proportion of total admissions (2.2%). The rest of the provinces made up the following proportions of total admissions: Eastern Cape (9.4%), North West province (6.4%), Free State (6.2%), Mpumalanga (4.4%) and Limpopo (4.0%).

5. Reasons for admissions

For the majority of admissions no reason for admission was captured (55.7%). Where a reason was captured, the most common was COVID-19 symptoms or suspected COVID-19 (33.4%), followed by the need for isolation (8.1%). It is not clear whether patients admitted for isolation were confirmed COVID-19 cases who could not isolate at home, or suspected COVID-19 patients admitted to isolation wards while they awaited results. Furthermore, the fact that the vast majority of admissions had no reason captured, supports the ongoing need to improve health data collection for monitoring and evaluation purposes.

6. Discharge status

The majority of patients admitted in South Africa from 1 March 2020 to 25 June 2022 were discharged alive (76.2%). A further 21.9% died of COVID-19 related causes, with only 0.1% of the admissions dying of non-COVID related illness; 1.6% of patients were transferred to another facility. The largest proportions of deaths related to COVID-19 were in the second and third waves, accounting for 28.5% and 26.1% of discharge reasons respectively. The fourth wave and the period thereafter had the lowest proportion of deaths due to COVID-19-related illness, accounting for 11.5% and 8.3% of discharge reasons, respectively. This may be due to many factors, such as the less severe disease caused by the Omicron variant and greater population immunity from a combination of previous COVID-19 infections and COVID-19 vaccinations[2] which were rolled out to the general population in May 2021.

Health system resources for admission and treatment

1. Levels of care for admissions

The type of ward to which a patient was admitted can give an indication of the severity of COVID-19 disease. As the disease progresses in individual patients, the need for different levels of care (general ward, high care or intensive care unit [ICU]) may change.

In this section we first discuss the wards to which patients were initially admitted (admitted directly to), followed by those patients who were ever in ICU or high care at some point in their admission and lastly, the highest level of care needed by admitted patients.

2. Level of care of initial/direct admissions

The proportion of COVID-19 patients initially admitted to a general ward was 88.0%, while admissions directly to ICU made up 6.4% and high care, 5.3%. A small proportion (0.3%) were admitted directly to isolation wards, which is notable in light of the finding that isolation was the reason for admission in 8.1% of patients.

The periods with the highest proportion of admissions directly to ICU included: between the second and third waves (8.4%), the first wave (8.0%), before the first wave (7.2%) and between the first and second waves (7.0%). One possible explanation for the high number of ICU admissions between waves is that there were fewer overall admissions in those periods and thus less strain on resources, meaning that those admitted were able to access ICU care if they needed it.

A similar trend is seen with high-care admissions, although it is less marked. The periods with the highest proportion of high-care admissions included: between the first and second waves (6.2%), between the second and third waves (6.2%), between the third and fourth waves (6.2%) and during the first wave (6.0%). The higher proportion of admissions directly to ICU and high care in the first wave may be explained by the clinical management guidelines for COVID-19 disease at that time. A few weeks prior to the first wave on 18 May 2020, version 4 of the guidelines was released in which HFNO was recommended for the first time in all patients with respiratory failure who had no indication for intubation.[79] Just after the first wave on 24 August 2020, the fifth version of the guidelines referred to the use of HFNO outside of ICU settings.[82] These guideline changes may have contributed to more patients being managed on HFNO in general wards in subsequent waves.

3. Proportion of patients who required ICU or high care at some point in their admission

Of individuals admitted, 13.4% and 8.7% were in ICU or high care, respectively, at some point during their admission. The breakdown per period for those who had ever been admitted to ICU showed the highest proportions in the following periods: between the second and third waves (16.4%), the first wave (16.3%), the third wave (14.8%) and before the first wave (14.2%). For high-care admissions, the most notable periods were between the second and third waves (11.7%) and between the third and fourth waves (10.0%) (Figure 4).

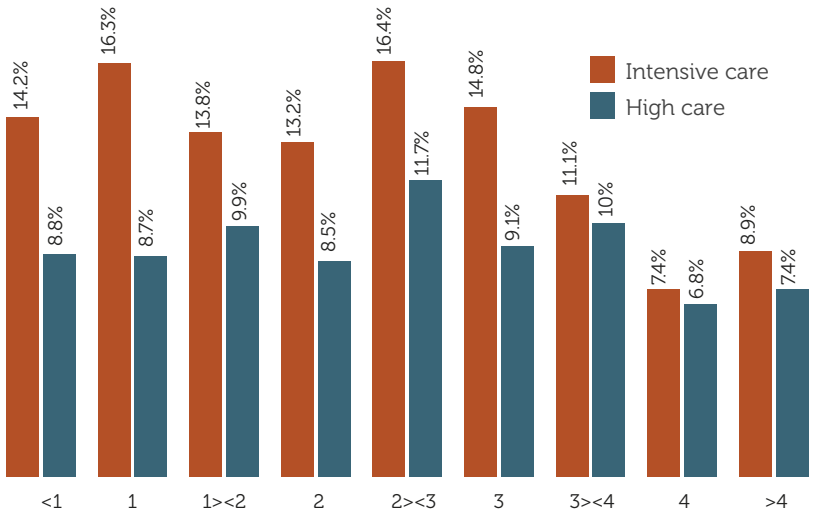

Figure 4: Proportion of admissions admitted to intensive care ■ or high care ■ per period

Source: National Institute for Communicable Diseases COVID-19 Hospital Surveillance (DATCOV)

4. Highest level of care required

For the entire period of study, 80.7% of patients required a general ward as the highest level of care; 5.9% required high care and 13.4%, ICU.

5. Admissions that required respiratory support

Another indication of the severity of disease in COVID-19 patients who were admitted, was the need for respiratory support.

The proportion of patients admitted that received some form of oxygen therapy was 40.7% and a total of 26.5% of patients admitted received supplemental oxygen. The periods with the highest proportions of patients receiving supplemental oxygen mirrored those receiving any form of oxygen therapy (in descending order): the second wave, the third wave and between the second and third waves. Furthermore, a total of 17.1% of patients admitted during the entire study period, received HFNO. The periods with the highest proportions of patients receiving HFNO differed slightly from those receiving supplemental oxygen (in descending order): the third wave, the second wave and between the second and third waves (Figure 5).

The proportion of patients who received some form of ventilatory support was 6.1% of patients admitted and a total of 3.7% received invasive ventilation. The periods with the highest proportion of patients receiving ventilatory support, and those receiving invasive ventilation, were the third wave and between the second and third waves (Figure 5).

The high proportions of patients receiving oxygen therapy in the second wave, third wave and between these two waves could be explained by the COVID-19 variants driving these waves. The dominant variant in the second wave was the Beta variant and for the third wave it was the Delta variant, both responsible for high rates of severe disease. The same is true when considering reasons for the higher proportion of ventilation in the third wave. Likewise, the Omicron variant, which caused less severe disease[32] was the dominant variant during and after the fourth wave, which had the lowest proportions for HFNO, ventilation and invasive ventilation.

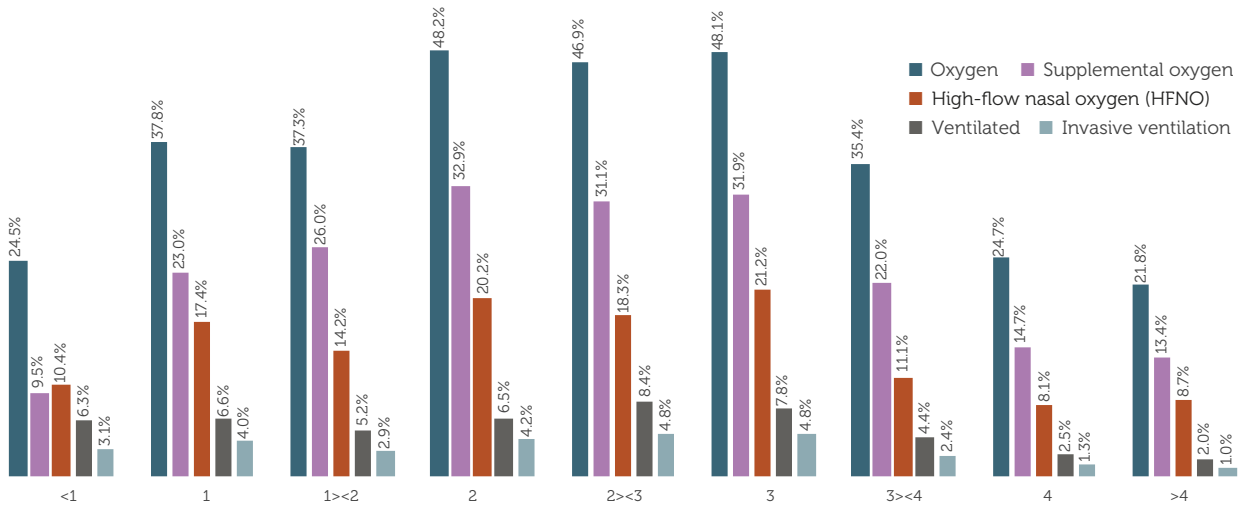

Figure 5: Proportion of admissions per type of respiratory support given per period
Source: National Institute for Communicable Diseases COVID-19 Hospital Surveillance (DATCOV)

6. Admissions by facility type

The greatest proportion of admissions per facility type was to private general hospitals which accounted for 48.3% of all admissions. This was followed by district hospitals (19.0%), regional hospitals (12.6%), provincial tertiary hospitals (7.1%) and national central hospitals (6.9%). The combination of district, regional, provincial tertiary and national central hospitals accounted for 45.6% of all admissions. It is worth noting that 3.3% of total admissions were to COVID-19 quarantine sites. Given the low proportion of admissions to quarantine sites, it would be prudent to assess whether this was a good allocation of resources.

7. Admissions per facility type per province

The facility type usage per province showed some notable differences. District hospital admissions made up a much higher proportion of admissions in some provinces, with the highest proportions being in Limpopo (35.3%), Eastern Cape (32.8%) and Mpumalanga (29.8%), all much higher than the total for South Africa (19.0%). These provinces are considered rural and their higher usage of district hospitals is thus reasonable. In addition, the proportion of district hospital admissions in the Eastern Cape was almost equal to those for private general hospitals (32.8% and 32.7% respectively).

Regional hospital admissions per province were highest in KwaZulu-Natal (17.2%), the Free State (14.4%) and Eastern Cape (14.0%). The North West province had the highest proportion of provincial tertiary hospital admissions, which made up 26.4% of all admissions in the province. Gauteng and the Western Cape had the highest proportion of national central hospital admissions (13.4% and 11.9% respectively). The Northern Cape was almost entirely responsible for the admissions to clinics, which made up 11.0% of the province's admissions (the national proportion was 0.3%).

Other than in the Eastern Cape, private general hospitals accounted for the highest proportion of admissions in all provinces (Figure 6). The highest being in Gauteng (56.2%), KwaZulu-Natal (52.2%) and Mpumalanga (51.2%). However, it should be noted that public sector facility

admissions were divided into the various levels (district, regional, provincial tertiary and national central hospitals) and thus, when added together, public hospital admissions are higher than private for Eastern Cape (60.6% vs. 32.7%); Limpopo (54.8% vs. 42.5%); and the Free State (46.8% vs. 45.7%).

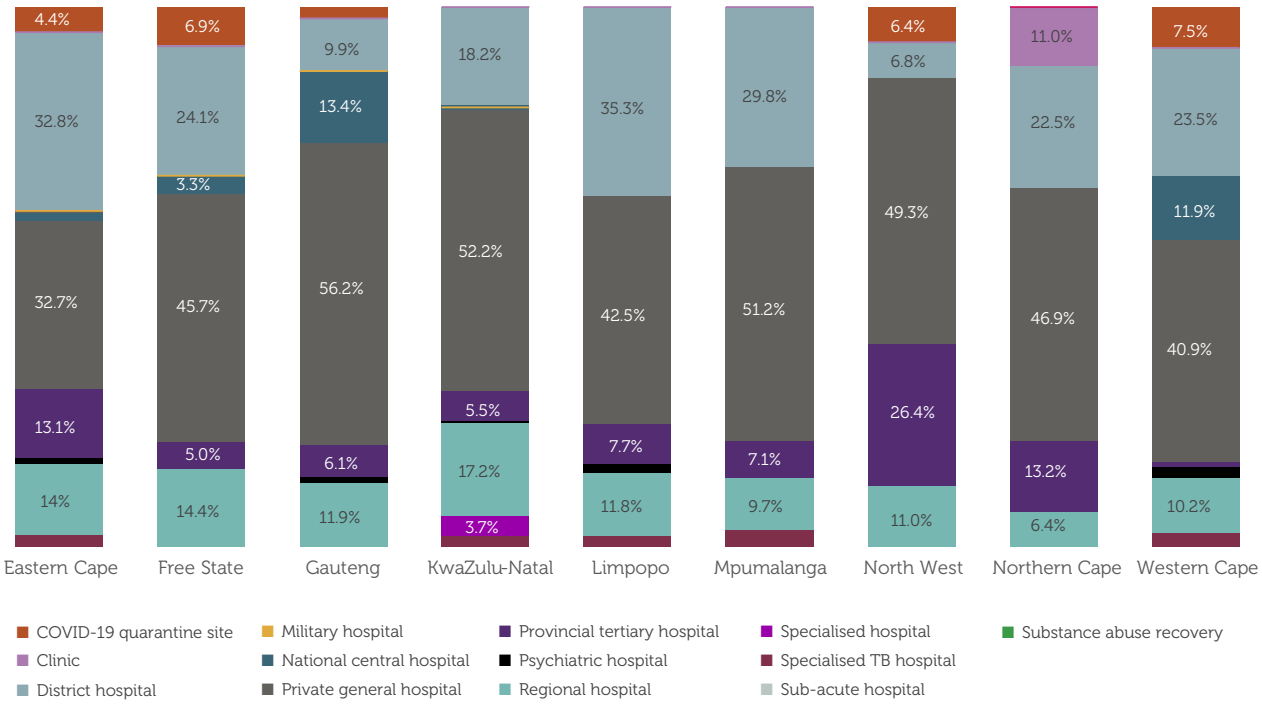

Figure 6: Proportion of admissions per facility type per province
Source: National Institute for Communicable Diseases COVID-19 Hospital Surveillance (DATCOV)

Patient factors in admission and treatment

1. Vaccination status

Vaccinations recorded in the DATCOV database were self-reported. Vaccinations for HCWs only began in February 2021[85] and for the general population in May 2021[86]; prior admissions would thus have had no vaccination status.

For the entire period of analysis, the proportion of patients who self-reported that they had been vaccinated was 3.6%. Those with unknown vaccination status made up 75.8% and those who reported not having the COVID-19 vaccine made up 20.6% of all admissions. For all periods up to and including the second wave, >90% of patients had an unknown vaccination status. Between waves two and three, 0.6% of admissions were vaccinated. Given the stage of COVID-19 vaccination campaign at that time, the majority of these are likely to have been HCWs. In the third wave 3.5% of admissions were vaccinated, between the third and fourth waves 5.9%, in the fourth wave 13.8% and after the fourth wave 11.5% of admissions were vaccinated.

The 3.6% of admissions who self-reported having had the COVID-19 vaccination, made up similar proportions of admissions to ICU and high care (both 4%). In addition, they made up similar proportions of those requiring respiratory support: supplemental oxygen (4%), HFNO

(4%) and invasive ventilation (3%). However, given the large number of unreported vaccination statuses in the dataset, it is difficult to ascertain the relationship between vaccination status and disease severity.

2. Healthcare worker admissions

Healthcare workers accounted for 2.4% of all admissions with the highest proportions of HCW admissions before the first wave (5.2%) and during the first wave (5.1%). This may be accounted for by initial shortages of PPE and incorrect donning and doffing of PPE.[87] The HCW category with the highest proportion of admissions was those reported as 'other' (72.1%). This is followed by nursing staff (15.5%), administrators and porters (6.8%) and allied health professionals (2.5%). Doctors accounted for 2.1% of all HCW admissions. The relatively high proportion of administrators and porters being admitted may be due to preferential allocations of PPE to frontline staff.

The proportion of patients ever admitted to ICU or high care that were made up of HCWs was very similar to the proportion of overall HCW admissions (2.4%). The proportion of HCWs admitted to ICU and high care at some point during their admission was 3% for both. Likewise, the proportion of HCWs requiring respiratory support was 3% for all interventions (supplemental oxygen, HFNO and invasive ventilation). However, limitations with the current data prevented a more rigorous analysis to accurately ascertain if HCWs were at greater risk of severe disease.

HEALTH SYSTEM RESPONSE TO COVID-19 THERAPEUTIC DEMANDS

In South Africa the response required of the health system to meet the therapeutic demands of the COVID-19 pandemic was vast and complex. It necessitated a co-ordinated and multifaceted approach, implemented at various levels of the health system and included stakeholders such as government ministries, provincial health departments, facility management structures and the health workforce. This rapid response to unprecedented demands also had to take place in a resource-limited setting. Using available literature, this response is described under the following five subsections: leadership and governance; preparation and management of facilities; availability of treatment options; health workforce; and, monitoring and evaluation. Under these subsections, the challenges encountered and lessons learned are highlighted.

Leadership and governance

An effective health system response requires good leadership at all levels of the health system.

1. Government level leadership and governance

The national lockdown implemented on 27 March 2020 by the South Africa government allowed time for the health system to build capacity and prepare resources like hospital beds, HCWs of various cadres, isolation facilities, medical equipment, oxygen and PPE.[88] The health response to the COVID-19 pandemic was led by the Minister of Health and the Members of the Provincial Executive Committees (MECs) with guidance from the Ministerial Advisory Committee (MAC) for COVID-19.[89] The MAC was established by the Minister of Health on 25 March 2020,[90] and its clinical subgroup was involved in making recommendations for the management of COVID-19 disease.[91] While part of the MAC's role was to advise on clinical management of COVID-19, there was criticism that the composition of the MAC was too biomedical and failed to address the behaviour modification aspects necessary to manage the pandemic effectively.[90]

This was echoed in an article based on a rural research project in the Eastern Cape and published in the Human Sciences Research Council (HSRC) Review. It noted that when staff members contracted COVID-19 many clinics and hospitals closed to await deep cleaning by the state.[92] This meant hundreds of patients were unable to access health care until the government had completed deep cleaning of the affected facilities.[92] The authors criticise the government's response as being "city-centric, biomedical and hospital-focused" and failing to address the fears of HCWs or account for the widespread mental illness prevalent in this group.[92]

2. Facility level leadership and governance

Groote Schuur Hospital (GSH) found that "pre-planning, adaptability, leadership, teamwork and good communication" were essential to the success of their critical-care services response to the COVID-19 pandemic.[93] In Johannesburg, a tertiary hospital managed to navigate and solve multiple challenges in its early response to the pandemic by establishing a co-ordinated, multidisciplinary management plan between various HCW cadres, the IPC team and hospital management.[87]

Long-standing issues in both provincial and facility governance were also exposed during the pandemic. A fire at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) on 16 April 2021 led to it being temporarily closed prior to the third wave of COVID-19 in South Africa.[94] This incident resulted in patients being diverted to nearby hospitals, such as Chris Hani Baragwanath Academic Hospital (CHBAH), which further burdened their scarce resources and increased pressure on these facilities.[95] CMJAH had passed a fire safety audit just weeks before the fire; the incident was thus attributed to poor leadership and oversight at multiple levels of the health system.[94]

Medication regulation

A major challenge presented by the novel coronavirus was the need to find pharmaceutical interventions to prevent or treat the disease.[80] In this context, and confronted with rapidly emerging evidence of variable quality, policymakers had to make decisions regarding treatment guidelines and regulators had to adapt to a faster pace of regulatory oversight.[96,97]

In South Africa, all medication must be approved by the (SAHPRA) as being both safe and efficacious before it is made available to the public.[98] SAHPRA, which is a relatively new public entity with a newly appointed chief executive officer, had to rapidly adapt to the challenges of the COVID-19 pandemic.[97] It moved away from previously used manual processes and instead worked with the academic scientific community to make quick decisions based on the best available evidence regarding diagnostic tests, medications and vaccines.[97]

After approval by SAHPRA, the NEMLC assesses the feasibility of a treatment option in the South Africa context.[98] In March 2020 the NEMLC COVID-19 subcommittee was formed to address the "urgent need for rapidly synthesised and appraised evidence to inform policy decisions".[96] Although full systematic reviews would have generated a high level of evidence, this was not feasible during the rapidly evolving pandemic because of the rigorous evidence appraisal and length of time involved.[96] Thus, the NEMLC COVID-19 subcommittee worked with the South African GRADE network and Cochrane South Africa to develop a rigorous rapid review process for potential interventions that not only addressed clinical questions, but also resource implications, practicality and equity.[80,96] These rapid reviews were used to formulate the national COVID-19 treatment guidelines and to inform policy decisions regarding provision of medication in the public sector.[96] Prescribed minimum benefits (PMBs) in the private sector were also informed by the NEMLC decision-making process.[96]

Preparation and management of facilities

1. Increasing capacity in existing facilities

Creating capacity did not only involve increasing the number of physical bed spaces; one of the strategies employed by facilities was cancellation or postponement of elective surgeries[87,93] and in outpatient departments, strategies included issuing repeat treatment scripts for multiple months or changing the medications used to reduce the need for laboratory monitoring and follow-up.[87] Government regulations such as alcohol bans and night-time curfews also created capacity by reducing the burden of trauma cases.[93]

2. Creating new facilities (field hospitals, isolation facilities)

The COVID-19 pandemic resulted in a shortage of hospital beds globally, leading to the construction of field hospitals to address the relevant shortfalls in each context.[99]

A retrospective study in Cape Town evaluated the role of the field hospital at the Cape Town International Convention Centre (CTICC) in providing surge capacity during the first wave of COVID-19 in South Africa.[99] This field hospital, which was set up as an intermediate care bed facility (ICBF), accepted patients who were either past the acute stage of the disease, assessed as having mild-moderate disease, or for palliative care.[99] It was established at considerable cost to the Western Cape Department of Health due to the medical infrastructure required and the large contingent of staff (both clinical and non-clinical) needed.[99] Medical infrastructure included the capacity to deliver oxygen therapy and HFNO, portable x-ray facilities, a pharmacy, medical waste management and designated IPC areas.[99]

The study found that the field hospital halved the predicted duration of stay in acute care hospitals; and since nearly 80% of its patients required oxygen therapy, admissions to the CTICC ICBF would have reduced the burden on the acute care facilities.[99] The field hospital was, however, considered unsustainable because it never exceeded 32% of its inpatient capacity and was thus relatively overstaffed. It was decommissioned in August 2020.[99]

In subsequent waves of the pandemic, the Western Cape had to adapt other facilities for a similar purpose, however, the decision was made to invest in sustainable facilities rather than temporary structures like the field hospital.[99] The protocols and operational models developed for the CTICC ICBF were used for other such facilities.[99]

3. Increasing critical care capacity

One requirement of the health system response to the COVID-19 pandemic was to increase the critical care capacity of hospitals to deal with the anticipated large numbers of patients that would present with severe ARDS.[93] An article on the experience of increasing and implementing critical care services at GSH highlighted the complexity of this task.[93]

One aspect of the managerial response was to use the Critical Care Society of Southern Africa triage tool in all wards and referring hospitals to limit unnecessary referrals to the ICU.[93] Other aspects of the managerial response for increasing critical care capacity included planning transport of critically ill COVID-19 patients; designation of COVID-19 specific wards and ICUs; providing bed space (with appropriate oxygen points, suction points and electrical sockets), equipment (such as ventilators and infusion pumps), staff for additional ICU bed capacity; and agreements with the private sector to allow transfers to their facilities at state cost should the need arise.[93]

As mentioned before, government regulations such as the ban of alcohol sales and night-time curfews greatly reduced trauma cases and, thus, the demand for ICU beds in the first wave, as did the halt on elective surgical cases, creating a relative increase in critical care capacity.[93] However, in the lead up to the second wave these same regulations were not yet in place, and elective surgeries were not halted, which saw a decrease in the number of available ICU beds for COVID-19 cases.[93] Alcohol bans were only reinstated on 28 December 2020,[100] well into the second wave.

Another example of critical care response occurred at a tertiary hospital in Johannesburg. Despite repurposing an existing six-bed ICU designated for epidemic diseases (such as viral haemorrhagic fever) for COVID-19 cases, the demand for ICU beds during the first wave led to an overflow of COVID-19 patients to beds in the adult multidisciplinary ICU.[87] A charitable foundation funded a new 29-bed ICU with 15 HFNO devices for this hospital, boosting government efforts to treat severely ill COVID-19 patients.[87] In addition to this, other donors facilitated the purchase of 200 mechanical ventilators and HFNO devices for the same Johannesburg hospital.[87]

While awaiting the arrival of delayed HFNO equipment, HCWs at Zithulele Hospital (a rural hospital in the Eastern Cape) were able to convert paediatric equipment used for bubble CPAP (continuous positive airway pressure) into an adult respiratory support device.[92,101] With a critical shortage of ventilators and few high-care beds, this innovation assisted in the management of COVID-19 patients needing respiratory support.[101]

4. Dedicated COVID-19 hospitals

A tertiary level hospital in Johannesburg was designated as a COVID-19 hospital early in the pandemic, due to its ability to provide specialist care.[87] Despite having medical specialists and advanced facilities, the hospital still faced many challenges.[87] One such challenge was a lack of district-level referral pathways, which led to unnecessary upward referrals of COVID-19 patients who could have been managed at lower levels of care, and added strain on its emergency department (ED).[87] To address this, bi-weekly meetings with referring clinics and hospitals were implemented to educate staff on COVID-19 disease.[87] In addition, strict referral criteria were put in place and later "all hospitals in the province were required to screen suspected COVID-19 cases and manage their positive patients".[87]

5. Dedicated COVID-19 wards

Delays by hospital management in creating dedicated COVID-19 areas at a tertiary hospital in Johannesburg potentially led to increased risk of infection of non-COVID-19 patients.[87] This was addressed by erecting tents outside the ED for COVID-19 screening, designating a low-risk and high-risk ward for persons under investigation (PUI) while awaiting results, and transferring confirmed cases to two dedicated COVID-19 wards.[87] As COVID-19 cases increased during the first wave, the number of wards allocated to PUI and confirmed COVID-19 cases increased to six (126 beds) and five (152 beds) respectively.[87] Similarly, during the first wave GSH increased its COVID-19 dedicated wards to 11 in total, managed by a team of 95 doctors from various disciplines.[93]

Availability of treatment options

1. Oxygen supplies

Because the mainstay of treatment for moderate to severe COVID-19 is supplemental oxygen therapy, oxygen supply was of paramount importance. Oxygen supply became a problem for GSH because of the high number of COVID-19 patients on HFNO and ventilators and led to the purchase of additional oxygen storage capacity after the first wave.[93] During the second wave, consumption of liquid oxygen at GSH increased to 10 to 15 times its normal usage.[93] Western Cape oxygen supplies were under threat of being exhausted during the second wave, and contingencies such as halting oxygen supply to other industries and importing oxygen from other provinces were put in place.[93]

Many public and private hospitals faced critical shortages of medical-grade oxygen during South Africa's second COVID-19 wave.[102] As a result, both Air Liquide SA and Afrox Healthcare, two of the main suppliers of oxygen to healthcare facilities in South Africa, bolstered their oxygen supplies and delivery capacity in preparation for the third wave.[102]

2. High flow nasal oxygen

As noted in the guidelines section, HFNO was not initially recommended due to the risk of aerosolisation but this later changed following new evidence.[93] With a shortage of ICU beds, GSH began using ward-based HFNO for patients who were not improving on conventional oxygen therapy and found that by reducing the need to intubate and ventilate patients, its use reduced ICU admissions.[93] Another advantage of HFNO is that patients using this therapy are able to perform many self-care tasks such as self-proning and eating; GSH was thus able to increase the capacity for HFNO from 8 to 44 machines without requiring additional nursing staff.[93]

Health workforce

1. Staffing requirements

One of the major COVID-19 health system response challenges was to ensure adequate staffing of healthcare facilities. GSH noted that the lack of ICU-experienced professional nurses (PNs) was the greatest limiting factor to increasing the capacity of their critical care services.[93]

Scarcity of skills can only be resolved in the long-run, and thus requires prioritisation now, at a national level, to prepare for future pandemic responses.[93] The countrywide demand for nursing staff, in both public and private sectors, meant many GSH nurses worked long shifts with short breaks, and exceeded normal overtime hours.[93] Another way to cope with this shortage was to reduce the PN to patient ratio in ICU from one PN caring for two patients to one PN caring for three patients (with help from other nursing cadres).[93] Furthermore, agency staff (including ICU-experienced PNs) that were usually available to GSH, were allocated to field hospitals during the first wave and to the private sector ICUs during the second wave.[93]

The ongoing shortage of staff was also a challenge for a tertiary hospital in Johannesburg and was exacerbated when HCWs were unable to work because they had been exposed to COVID-19.[87]

A qualitative study at a rural hospital in Limpopo described the staff shortages, particularly of nurses, due to COVID-19.[103] Absenteeism was caused when staff that contracted COVID-19, had to quarantine while awaiting COVID-19 tests results, or when family members contracted COVID-19.[103] Deaths of COVID-19-infected staff members also caused staff shortages, as did fear of contracting COVID-19 which led to resignations among staff or the retirement of certain staff members.[103]

Strategies to cope with these shortages included rearranging wards, redeploying staff, and overtime work.[103] Zithulele Hospital, a rural hospital in the Eastern Cape, hired an additional 20 nurses on contract to manage the COVID-19 surge during the first wave.[101]

2. Redeployment and task-shifting of healthcare workers (HCWs)

In GSH, staff redeployment from other disciplines during the first wave helped to address nursing shortages.[93] Redeployment also allowed for the formation of intubation and retrieval teams to streamline the transfer of patients to ICU, thus reducing the workload for ward and ICU staff.[93] As was the case at GSH, the staff at a Johannesburg tertiary hospital were initially reluctant to be redeployed to COVID-19 services.[87,93] However, for the latter, the positive feedback from staff members who volunteered their services motivated other staff members to do the same[87].

3. Protecting healthcare workers (HCWs)

Early on in the COVID-19 pandemic, South Africa experienced major challenges with procurement of PPE because of supply chain issues such as increased global demand for international supplies and transport limitations due to lockdowns around the world.[88] In addition, corruption was uncovered in the PPE tender process which had resulted in the procurement of poor quality PPE products at inflated prices.[88]

There were challenges regarding PPE procurement and management at facility level as well. Although the PPE available in the ICUs at GSH was in accordance with guidelines, an internal study showed that "all the KN95 brands available did not meet required safety standards to protect healthcare workers".[93] At a tertiary hospital in Johannesburg, mismanagement of funds in the procurement of PPE and failure to consult the relevant stakeholders resulted in acquisition of certain poor quality items.[87] Shortages were further exacerbated by the theft of PPE from the wards at this hospital.[87] These challenges were addressed by putting accountability practices in place and shifting stock control of PPE and disinfectants to the IPC team.[87] Meticulous records were kept for dispensed PPE and ward operational managers faced disciplinary action if PPE or disinfectant stock went missing.[87] PPE was also donated by NGOs.[87]

Anxiety about the pandemic led staff to overcompensate with PPE usage at a tertiary hospital in Johannesburg, which resulted in wastage in the context of existing shortages.[87] The hospital also found that incorrect donning and doffing of PPE by many staff members increased the risk of contamination.[87] Mitigation strategies included regular updates regarding PPE recommendations as new evidence emerged, daily training sessions on donning and doffing of PPE for staff members in ICU, and videos on donning and doffing for quick reference when needed.[87]

4. Staff support

Staff members at a tertiary hospital in Johannesburg who were anxious about contracting COVID-19 refused to treat COVID-19 patients.[87] To address this, daily debriefing sessions were introduced in high-risk areas of the hospital such as ICUs, and the IPC team held training sessions to educate both clinical and specific groups of staff (including radiographers, cleaners, security and administration staff) on COVID-19 disease.[87] The occupational health and safety clinic also provided assistance with psychological and emotional distress experienced by HCWs.[87] Emotional distress and burnout of staff members were thought to be considerable at GSH and thus weekly debriefing sessions, facilitated by a consultant psychiatrist and a clinical psychologist, were offered to doctors.[93] Counsellors held small group sessions with nurses on duty, and telephonic counselling services were available to all staff members.[93] Zithulele Hospital found that managing fear of COVID-19 among its staff was one of the biggest hurdles to overcome and that it was necessary to find effective ways to address this issue.[101]

In addition to support offered by the specific facilities, there were many volunteer organisations that rallied to offer mental health support to frontline HCWs.[104] Among those offering support were mental health non-governmental organisations (NGOs), as well as many volunteer psychologists and counsellors.[104] This resulted in telephonic and WhatsApp hotlines and pro bono telephonic counselling (telecounselling) services that were available to HCWs for debriefing, crisis intervention and therapy.[104]

Monitoring and evaluation

The Epidemiology and Response Branch of the South African Incident Management Team established a monitoring and evaluation framework to track the progress and impact of intervention strategies for COVID-19.[88] Initially, with no standardised, synchronised system for surveillance and reporting there was duplication of data and a lack of coordination between the COVID-19 response and other health programmes.[88] This was addressed by integrating COVID-19 data collection into the existing influenza and pneumonia surveillance system.[88] The branch also established a sentinel hospital surveillance system that allowed for monitoring of bed utilisation.[88]

DATCOV (as described previously) also allowed for the generation of reports to inform public health responses in terms of resource allocation and development of guidelines.[11] Although this addressed a gap in South Africa's COVID-19 response, because not all South African hospitals are registered on this system the data obtained may have limited representativeness.[11]

IMPACT ON NON-COVID-19 CONDITIONS AND HEALTH SERVICES

HIV

As was the case in other countries, the national lockdown in South Africa had the potential to disrupt HIV treatment.[34] Although ART initiations decreased temporarily during lockdown, ART provision was maintained through multi-month drug dispensing, as recommended in the COVID-19 management guidelines.[34,79] In addition, treatment delivery strategies (such as the Central Chronic Medicines Dispensing and Distribution [CCMDD]), that were already in place to manage the increasing numbers of patients on ART, helped to maintain ART provision during COVID-19.[34,105] There was, however, a decline in HIV-related admissions during level 5 lockdown as hospitals prepared for large numbers of COVID-19 admissions.[34] One study in rural KwaZulu-Natal analysed data from 11 primary healthcare clinics (PHCs) and showed that over the period from 27 January 2020 to 30 June 2020, the most common reason for clinic visits was ART follow-up care.[106] Adult HIV services at these clinics demonstrated resilience during the level 5 lockdown, with no decrease in HIV-related visits noted between the pre-lockdown and lockdown periods.[106]

Tuberculosis

In preparation for national lockdown, patients in South Africa were given two months' supply of TB treatment.[107] Similarly, patients admitted with drug-resistant TB (DR-TB) who were stable, were discharged with two months' supply of treatment, and educated on how to take it and what to do if they experienced problems.[107] As TB wards were to be repurposed for anticipated COVID-19 patients, DR-TB patients, who are often admitted at the time of diagnosis because they are very ill, or due to concerns regarding treatment adherence, were either discharged or not admitted.[107,108]

A directive issued by the NDoH late in April 2020 on management of DR-TB patients during lockdown, aimed to reduce the frequency of clinic visits, and thus, the risk of infection with COVID-19, by issuing multi-month treatment supplies.[107] Patients also missed appointments due to fears of contracting COVID-19 and fear of stigma because some of the symptoms for TB and COVID-19 overlap.[107,108] There were concerns that decreased clinic visits would affect treatment adherence and retention-in-care, leading to poorer outcomes and possible development of drug resistance.[108] Lockdown restrictions, which limited movement and called for people to remain indoors, may have inadvertently increased TB transmission within households and settings where TB patients live in close contact with others.[107,108] One sobering statistic is that during the first 18 months of the pandemic, 90,500 South Africans died from TB, while 88,754 died from COVID-19 over the same period.[109] This highlights the need to maintain essential services during a pandemic to minimise collateral morbidity and mortality.

Maternal and child health

Nationally, maternal and child health was negatively impacted by the COVID-19 pandemic. A study of primary healthcare services using data from the DHIS showed changes in maternal and child health care between March and December 2020, compared to the same period in 2019.[35] Nationally, there was a 3.7% increase in births in 2020; all provinces except KZN and the Free State showed an increase.[35] Institutional maternal mortality increased by 22.7% between March and December 2020 compared to the same period in 2019.[35] The Northern

Cape was the only province with a decline (of 38.5%) in maternal mortality; all other provinces demonstrated increases, with the largest in the Western Cape (82.1%).[35] Similarly, institutional neonatal mortality increased nationally by 4.8% in 2020 compared to the same period in 2019, with the largest increase in the North West province (25.1%).[35] Increases in maternal and neonatal mortality may have been due to COVID-19 disease itself, or due to the effect the pandemic had on accessing care in the context of both lockdowns and facilities focusing on COVID-19 treatment.[35] Unfortunately, the latter would have disproportionately affected rural and historically underserved areas.[35]

At 11 clinics in rural KZN, child health visits (for children <1 year and 1-5 years of age) suffered a 60% decline with level 5 lockdown.[106] These child health visits rebounded to pre-lockdown levels by June 2020.[106] A study conducted in rural KZN assessed the impact of COVID-19 lockdown levels on all hospital admissions at Hlabisa Hospital, from 1 January to 20 October 2020.[110] In this period, maternal and neonatal conditions were the most common reasons for admission.[110] Daily admissions significantly decreased for infants and children aged 1-5 years during level 5 of lockdown and, unlike the clinic visits, hospital admissions for children did not stabilise and return to normal levels.[110] Of concern, is that these findings could indicate that unwell children with common diagnoses such as pneumonia and gastroenteritis were not taken to hospital, which may have resulted in preventable mortality.[110] However, another explanation could be a decrease in circulating viruses due to school closures.[110]

Non-communicable diseases

The HSRC conducted a national survey to assess the knowledge, beliefs, practices, and attitudes of communities in response to the COVID-19 outbreak in South Africa.[111] They found that 13.2% of people indicated that they were unable to access their chronic medication during lockdown.[111] In addition, over 20% of people in informal settlements and rural areas (traditional tribal areas) said their chronic medication was difficult to access during lockdown.[111] Patients with NCDs are just one group of those who are unable to access their chronic medication; it is likely that patients on ARVs and TB medication were also affected.

A study conducted in 11 rural clinics in KZN showed that hypertension was the fourth most common reason for clinic visits and made up 10% of the total visits in the period from 27 January to 30 June 2020.[106] In contrast to the HSRC's findings, visits for chronic conditions such as hypertension and diabetes remained relatively constant during that period despite level 5 lockdown restrictions.[106]

Medication supplies and delivery

COVID-19 also presented the medicine supply chain with unique challenges. In June 2020, there were reports of medication stock-outs in South Africa for ART, TB medication and psychiatric medication.[112] North West province was the worst affected by the stock-outs.[112] Disruptions in the supply chain due to COVID-19 were multifactorial and included a reduced workforce that affected manufacturing capacity during global lockdowns.[112] In addition, the transport of medicines was affected by both lockdowns and quarantines (if a staff member tested positive for COVID-19 on a ship, for example), and added pressure was placed on the supply chain when countries stockpiled medications in preparation for COVID-19.[112] Poor governance in the form of late payments to suppliers by provinces also played a role in medicine supply issues.[112]

Cape Town Metro Health Services introduced an initiative in which CHWs delivered chronic medications to the homes of patients to decongest facilities and protect these at-risk patients from exposure to SARS-CoV-2.[105] Alternative mechanisms for medication delivery in primary health care (PHC) settings included adherence (support) clubs; alternative pick-up-points (e.g. schools, private practitioners or pharmacies); workplace outreach (to remote farming communities); and, home delivery, all of which require the support of a centralised dispensing and packaging system.[105] Since 2014, the NDoH has been scaling up its CCMDD programme for HIV and NCD treatment.[105,113] In the CCMDD programme dispensing of medication is centralised, after which it is delivered to the patients' choice of collection site (options include alternative pick-up points, adherence clubs and fast-lanes at clinics).[105,113]

Although little evaluation has been done of the cost of these interventions when employed at scale, they have shown improved patient adherence to medications.[105] It is likely that "a mix of options tailored to local context and patient choice" is needed,[105] but the available mechanisms provide options both for future pandemic preparedness and for improving service delivery for other epidemics (HIV, TB and NCDs).

Medical emergencies

One public sector hospital in Johannesburg found that due to patient fears of contracting COVID-19, many people delayed going to hospital for potentially life-threatening conditions such as myocardial infarction, acute stroke and diabetic ketoacidosis.[87]

Trauma

A study from the emergency centre of Mitchells Plain Hospital in the Western Cape investigated the impact of the COVID-19 lockdown and alcohol ban on trauma-related presentations to their ED by comparing the period from 1 March 2020 to 29 September 2020, with the corresponding period in 2019.[114] They found that the total number of trauma presentations was 14.6% lower in 2020 than in 2019, with a mean daily reduction in patient numbers of 2.5.[114] Of particular interest was the statistically significant difference between the number of trauma presentations during lockdown levels that had an alcohol ban compared to those with only alcohol sales restrictions.[114] Trauma presentations increased by a mean of 7.0 patients per day when the alcohol ban changed to restriction on alcohol sales only.[114]

A similar study looked at trauma and non-trauma related presentations to the ED at Pholosong Regional Hospital in Gauteng, comparing data from March and April 2020 with the same period in 2018.[115] Trauma cases decreased by 33.1% in March 2020 and by 57.9% in April 2020 compared to 2018.[115] Non-trauma ED cases decreased as well, but by much smaller margins, with a 2.5% decline in March and a 37.4% decline in April 2020 compared to 2018.[115] When taking into account only the last six days of March – when the hard lockdown was introduced – trauma cases decreased by 67.5% compared to the same period in 2018.[115] This striking difference in trauma cases between the 2020 and 2018 period, is likely attributed to the bans on alcohol sales, gatherings and unnecessary travel that were instituted during lockdown.[115]

Surgical admissions

In preparation for the COVID-19 surge, hospitals curtailed non-essential activities such as elective surgeries.[116] To estimate the backlog of surgeries created by this curtailment, a retrospective study was conducted in six hospitals in the Western Cape (two regional and

four district hospitals) comparing the period 1 April to 31 July 2020 with the same period in 2019.[116] The results showed that total general surgical operations decreased by 44% between 2019 and 2020.[116] Elective surgeries were the most severely affected, with a 74% decrease in operations; followed by trauma with a 42% decrease, and lastly, emergency operations, with a 22% decrease.[116] The backlog of elective surgeries would take an estimated 4 to14 months to clear if one additional surgery could be performed per weekday at each of these hospitals.[116] This estimate was conditional on no further backlogs, yet the authors estimated that with the ongoing pandemic, surgical services would continue to function below capacity well into 2021.[116]

A study conducted at the Klerksdorp-Tshepong Hospital Complex in the North West Province assessed the impact of national lockdown on surgical admissions for urgent and emergency surgical pathologies.[117] The diagnoses included in the analysis for non-trauma cases were as follows: acute abdomen, bowel obstruction, critical and acute limb ischaemia, appendicitis, upper gastrointestinal bleeding, soft-tissue infections, and management of suspected or confirmed malignancies.[117] The study compared surgical admissions incidences pre-lockdown (3 February to 26 March 2020) with those during lockdown (27 March to 30 April 2020) and found a 44% reduction in admissions for non-trauma surgical cases, and a 53% reduction in trauma related cases during lockdown.[117] Reasons for the reduction in non-trauma cases were likely due to fears of contracting COVID-19, restrictions on movement, and financial constraints.[117] Thus, the decrease in admissions raised concerns about the public health consequences of the lockdown and an increase in mortality statistics was anticipated as a result of those who did not seek care for the above conditions.[117] While further research is required on excess deaths during the COVID-19 pandemic, it was noted that excess natural deaths peaked around 21 July 2020; it is possible that a proportion of those not attributed to COVID-19 may have been preventable deaths due to reduced access to healthcare.[117]

General hospital admissions

Much of the South African literature concerning the impact of COVID-19 on the treatment of other conditions has focused on admissions for the surgical disciplines. The Hlabisa Hospital study, from rural KZN found that from 1 January to 20 October 2020 the most common reasons for admission were maternal and neonatal conditions, followed by communicable diseases and NCDs; only 92 of 6,173 patients admitted were diagnosed with COVID-19.[110] The study found that although all-cause daily admissions did not change significantly between lockdown levels, certain subgroups did show notable changes, such as a decrease in admissions for respiratory diagnoses during level 5 lockdown.[110] Another finding was that for those admitted, the odds of death decreased substantially and significantly during level 5 of lockdown.[110] The odds of death increased in the transition from level 5 to 4, and increased again from level 3 to 2 of lockdown.[110] These findings may indicate that those who were most severely ill did not access care during level 5 of lockdown, with the increase in odds of death in subsequent levels indicating improved or delayed access to hospital, as restrictions eased.[110]

A seemingly paradoxical effect of COVID-19 on hospital admissions was the increase in nosocomial infections noted early on in the pandemic at a tertiary hospital in Johannesburg.[87] This was thought to be due to IPC efforts being directed towards COVID-19, empiric antimicrobial treatment for all-cause pneumonia in severely ill patients, and halting of antibiotic stewardship ward rounds.[87]

NOVEL COVID-19 THERAPEUTIC INTERVENTIONS OR SERVICES

Telemedicine and telehealth[iv]

The COVID-19 pandemic created a unique opportunity to accelerate digital solutions in healthcare because there was a need to balance limited in-person contact with access to health services.[119] Telemedicine offers remote clinical services to patients via technologies such as phone calls, video calls and messaging platforms[119] and can take the form of a teleconsultation between a patient and a doctor or between a patient and various other healthcare professionals (such as pharmacists and psychologists).[119] E-prescriptions, with medication delivered to a patient's home, are also possible with telemedicine.[119] This alternative way of treating patients had obvious benefits during the COVID-19 pandemic: virtual consultations limited the risk of disease transmission. In the South African private healthcare sector, virtual consultations for potential COVID-19 cases were encouraged via the DrConnect app.[120] Telemedicine was also an option for patients with other medical conditions, such as HIV or diabetes, who required routine care and chronic medication prescriptions but were anxious about contracting COVID-19.[120]

The Western Cape Department of Health launched a telemedicine service during the COVID-19 pandemic with the aim of identifying high-risk COVID-19 diabetic patients and offering them admission to an intermediate care facility for monitoring.[99,121]

The limitations of telemedicine and telehealth in the South African setting include a lack of access to mobile phones, the high cost of airtime/data, language and cultural barriers, digital literacy, policy frameworks and concerns regarding privacy and confidentiality.119 A systematic review has suggested, however, that by creating a platform for HCWs at rural facilities to access the medical expertise of colleagues and specialists in urban centres, telehealth could improve healthcare delivery in rural settings.[119] In this way, telehealth could increase access to a range of medical expertise previously unavailable in rural areas.

Another way telemedicine could benefit rural health settings, beyond COVID-19, is through the use of simple text-message platforms, which are available on all mobile phones, for teleconsultations.[119]

It is possible, however, that because of the limitations mentioned above, telemedicine innovations may actually increase disparities in healthcare access in South Africa, especially in rural areas.[119]

iv Telemedicine refers to remote clinical services whilst telehealth provides a broader spectrum of services, including remote non-clinical services, such as provider training, administrative meetings, and continuing medical education.[118]

Intubox

An innovative prototype of an aerosol box was designed in March 2020 and modified by the ED team at Charlotte Maxeke Hospital to create the Intubox,[87,122] a barrier device intended to protect staff when performing aerosol-generating procedures such as intubating a patient.[87,122] It is similar to the glove boxes used when handling infectious materials in a laboratory.[87,122] Through donor funding, 500 of these boxes were produced and distributed to hospitals around Gauteng.[87] Aside from being used for COVID-19 patients on ventilators and HFNO in the wards, this innovation could be used for multi-drug resistant TB patients and in other infectious disease outbreaks.[122]

While the Intubox is likely to considerably improve HCW safety, its use does not preclude the need for appropriate PPE; it is instead intended as an additional layer of protection.[123] In addition, its use may be limited in certain settings by requirements such as supine positioning of the patient, an experienced laryngoscopist, and the availability of a video laryngoscope.[123]

COVID-19 HEALTH SYSTEMS EXPERIENCES FROM OTHER COUNTRIES

Health system response

Rispel et al. have noted several factors that have affected the success of country-level COVID-19 responses. These include "political leadership, legislative controls, previous experience with respiratory diseases, existing disaster or pandemic management plans, national health systems and technology".[124] China's centralised response to the pandemic, additional healthcare resources, and the use of technology helped to limit the spread of SARS-CoV-2; Emergency Powers legislation, increased critical-care bed capacity and medical personnel, and private sector involvement, contributed to the successful response in Finland.[124] South Korea's experience with previous pandemics (SARS, influenza and MERS) strengthened its response to the COVID-19 pandemic.[7] They also have three times the average number of hospital beds per capita than the Organization of Economic Cooperation and Development (OECD) average, making other health services more resilient when reallocating resources to COVID-19.[7] While Italy, Spain, the United Kingdom (UK) and the United States of America (USA) increased their health resources, suboptimal leadership and poor intergovernmental collaboration hindered their response to the pandemic.[124]

A scoping review of Africa's preparedness for the pandemic identified areas of concern, including a lack of resources and equipment, and inadequate surge capacity.[125] For example, Kenya had a lack of ICU beds and ventilators.[125] The review also showed that there were shortages of resources such as PPE, essential medicines and clinical guidelines for healthcare providers.[125] The review showed that in general Africa had a low level of preparedness to respond to the COVID-19 pandemic.[125]

Impact on treatment of non-COVID-19 conditions and health services

A Harvard study explored the effect of COVID-19 on 31 health services in 10 countries: two LICs (Ethiopia and Haiti), six MICs (Ghana, Lao People's Democratic Republic (LPDR), Nepal, Mexico, South Africa and Thailand) and two HICs (Chile and South Korea) to assess the resilience of their healthcare systems.[7] The findings were as follows:

1. HIV

ART provision was the most resilient of the health services assessed and, in four of the countries studied (Ethiopia, Mexico, South Africa and South Korea), there was effectively no change.[7] The distribution of ART medications from decentralised locations was noted as a possible reason for this.[7]

2. Maternal and child health

Reproductive and maternal health was also found to be one of the more resilient services.[7] Although deliveries and caesarean sections declined in five of the countries, they remained stable in others;[7] Ghana actually showed an increase in caesarean sections and postnatal care, possibly due to concerted efforts to maintain maternal and child healthcare delivery during the pandemic.[7]

Similar to findings for South Africa, visits for children under five years of age with diarrhoea and pneumonia declined for all the countries that reported them.[7] This was attributed to the possible effects of school closures, social distancing, and improved hand hygiene.[7]

3. Non-communicable diseases (NCDs)

The number of healthcare visits among patients with diabetes and hypertension declined by more than 20% in Chile, Haiti, Mexico, Nepal, South Africa and Thailand.[7]

4. Types of healthcare services

There was a decline in both outpatient and hospital service provision in every country that reported on this.[7]

It was hypothesised that the decline in tertiary-care services may have been because of repurposing of facilities for COVID-19 management.[7] Other possible causes include alcohol bans resulting in a reduction in trauma cases (similar to South African findings) and reduced infectious diseases due to measures in place to limit COVID-19 transmission.[7]

Methods of maintaining other health services

Similar to South Africa, countries such as Chile, Mexico and Thailand attempted to maintain drug adherence for people with diabetes and hypertension through alternative medication delivery mechanisms and online prescriptions.[7] Telemedicine was also widely used in the pandemic for continuity of care for NCDs, HIV, and other essential health services.[7,34]

RECOMMENDATIONS

Public health oversight

In an article published by *Daily Maverick* certain experts called for the establishment of a National Public Health Institute (NPHI) to lead the response to future pandemics.[126] They also they suggested that the National Public Health Institute of South Africa (NAPHISA) Act, passed in 2020, may need to be amended in light of lessons learned during the COVID-19 pandemic.[126]

The function of an NPHI would be a similar but expanded version of that performed by the NICD and National Institute for Occupational Health (NIOH) during the COVID-19 pandemic.[126] It would provide the public health oversight to conduct research, training, surveillance and interventions necessary to respond to health challenges in South Africa.[127]

In the event of future pandemics an NPHI would, through disease surveillance and co-ordination of research, advise all levels of government on outbreak responses, coordinate laboratory activity, develop guidelines, provide technical information to HCWs, government and regulatory bodies, and assist in communication strategies to the public.[127]

Through these functions the NPHI would be able to help create practical outbreak guidelines for future pandemic responses that consider human resource and other resource constraints. Furthermore, the NPHI could be involved in the timeous development and dissemination of guidelines (e.g., outbreak and clinical management guidelines), from national and provincial levels to public sector health facilities, in order to allow these facilities to respond more quickly in a crisis. Through provision of technical information to HCWs and governance structures, they would be able to provide support and guidance for issues not addressed in guidelines and adapt the guidelines accordingly.

Furthermore, it is envisioned that NAPHISA will contribute towards population health beyond a pandemic response through surveillance and research related to a range of health and other areas that contribute to South Africa's disease burden, including communicable and non-communicable diseases, occupational health, cancer, injuries and prevention of violence and environmental health.[127] This national level coordination of efforts will assist with both public health and personal health service delivery, resource allocation and evidence-based decision making and policy development.

Health workforce

In November and December 2021, the WHO conducted its third round of a pulse survey to assess global disruptions to essential services as well as health system responses to COVID-19.[128] It was noted that in 61 of 95 participating countries (64%) health workforce challenges were the most commonly reported bottleneck in providing COVID-19 therapeutic services.[128] Similarly, at GSH in Cape Town, South Africa, the availability of ICU-experienced PNs was the greatest limiting factor in increasing the capacity of its critical care services.[93] This was not limited only to hospitals in the central areas of South Africa; staff shortages, particularly of nurses, were also a challenge in a rural hospital in Limpopo[103] and were exacerbated when staff contracted or were exposed to SARS-CoV-2.[103] Fear of contracting SARS-CoV-2 also played a role.[103]

Health workforce challenges are not quickly remedied and contingencies thus need to be put in place now to prepare for future pandemic response,[93] which includes maintaining essential service provision during health crises.[7] This is especially true in light of the central role the health workforce occupies in the response to public health emergencies.[129]

Contingencies should address multiple aspects, including: assessing the need for and education of new HCWs; increasing the knowledge and skill of current HCWs; ensuring safety of HCWs through policy and training; policies and plans for deployment of staff in a health crisis;[129,130] and, addressing the high levels of burnout and mental-health concerns in this group both during and outside of public health emergencies. It is also recommended that managers receive change management training to improve communication and collaboration in crisis situations, where, for example, staff may need to be redeployed.

Okoroafor et al. suggest conducting a workload analysis and health workforce estimations to determine which skills are needed, and where (for example, urban vs. rural settings).[129] The WHO Roadmap for Building the Public Health and Emergency Workforce also advocates for this approach.[130,131] Mapping of the workforce would provide critical information to policy makers with respect to decisions about training and recruitment of new HCWs, and reallocation of existing HCWs.[129]

Another recommendation relates to adequate training in the use of PPE to ensure safety of health workers.[129] This could be conducted as part of in-service training on a regular basis and would ensure appropriate use of PPE in the event of a new pandemic. Educational videos made about this, early in the COVID-19 pandemic in certain South African hospitals,[87] provide an example of the kind of media that can be used for ongoing education at relatively low cost.

It has been reported that even under normal working conditions in South Africa, HCWs have relatively high levels of depression, anxiety, stress and burnout.[132] A scoping review found that HCWs exposed to COVID-19 and other infectious disease outbreaks experienced a wide variety of mental health conditions, including depression, anxiety and post-traumatic stress.[132] The added psychological and emotional stress of a pandemic could exacerbate pre-existing mental health concerns in this vulnerable group. Psychological support is needed to address this issue[132] and was offered using various modalities during the pandemic in South Africa. These included consultations with mental health professionals and counsellors,[93] training on IPC measures, and frequent debriefing sessions.[87] One study conducted in three resource-limited hospitals in the Eastern Cape evaluated a psychological preparedness training programme to support frontline HCWs during the COVID-19 outbreak.[133] The programme was based on interventions used in settings with a high prevalence of natural disasters.[133] The study found that after the intervention HCWs reported improvements in their stress levels and their ability to cope with the pandemic.[133] If they are implemented now, interventions of this kind would not only promote mental health resilience of HCWs during a pandemic they would also help them cope with the work-related stress they experience outside of the pandemic.

Policies and plans to maintain essential health services

While further research is required into the excess deaths reported during the COVID-19 pandemic, it is possible that a proportion of those not attributed to COVID-19 were preventable deaths as a result of reduced access to healthcare.[117] Seeking care for medical emergencies,[87] surgical emergencies[117] and potentially severe childhood illnesses[110] were all adversely affected by the COVID-19 pandemic. Access to care[108] and medication[111] for chronic conditions such as TB and NCDs was also adversely affected. Although addressing issues such as health workforce capacity and facility surge capacity will assist in maintaining other essential health services in a pandemic setting, it is also necessary to have well-thought-out solutions documented in policies and disaster management plans.[126] These policies and plans should be developed with input from multidisciplinary committees (critical care, medical and surgical specialists as well as managers from facilities, district, provincial and national levels) and with public health oversight.

An important aspect of maintaining routine health services in a crisis are policies and plans for re-escalation of services between waves and post-pandemic, which will free up resources that were diverted to the pandemic response to be used in recovery of routine healthcare.[134] Using lessons learned from the COVID-19 pandemic, South Africa can create a more resilient health system with documented contingencies that can be pivoted to respond to future health crises, while maintaining routine healthcare services.

Alternative delivery mechanisms for medication

The need to decongest facility-based medication collection arose due to the increasing number of HIV patients on ART in South Africa.[105] By decongesting facilities, HCWs are better able to focus on newly diagnosed, unstable or sick patients.[105] Patients using alternative medication delivery systems also save time and money, with reduced waiting times, less time off work and lower travel costs.[105] The CCMDD intervention, already implemented at scale by the NDoH, has a centralised dispensing point and alternative pick-up points for medication (e.g. community halls, private pharmacies and fast-lanes at primary care facilities).[105] While this was initially implemented for HIV patients, it has evolved to include NCDs.[105,135]

The COVID-19 pandemic and resultant lockdowns also necessitated alternative mechanisms of medication delivery, such as home deliveries by CHWs.[105] Other methods piloted in Gauteng include smart lockers (medication lockers that patients can open using their cell phones) and pharmacy dispensing units (an ATM-like interface), although these are relatively new technologies that require further study.[105] While more studies need to be conducted into their cost-effectiveness, these alternative mechanisms for medication delivery present innovative ways to maintain essential healthcare services during a pandemic and improve access and service delivery to patients at all times. They have the potential to increase adherence, retention-in-care and clinical outcomes for chronic conditions.[105] If these systems are implemented at scale in the near future, patients' trust and familiarity with these mechanisms would be in place prior to any future pandemics; and they could thus play an important role in maintaining essential services in pandemic conditions.

Telehealth

Telehealth comprises a variety of services, ranging from teleconsultations, e-prescriptions and access to medical specialist expertise[119] to remote training of HCWs.[118] The benefits of these services in a pandemic setting are obvious considering that in-person contact must be limited to slow transmission, while essential health services need to be maintained. The benefits of telehealth also extend beyond pandemics; telehealth has a potential role in increasing healthcare delivery in rural and remote areas[119,136] and decongesting healthcare facilities.

Despite progress in the implementation of telehealth services in sub-Saharan Africa, sustainability of these programmes after the pilot phase has been a major challenge.[136,137] Since funding for these projects often comes from external sources, plans and resources need to be put in place for the relevant local stakeholders to take over management of the programme once the initial project is complete.[136] The cost to the user in terms of airtime and data,[119] is also an important consideration for sustainability in countries like South Africa. In addition to funding for the technology needed to scale up these programmes,[119] the source of the HCWs needed to operate telehealth services also needs to be considered. Simply reallocating staff from already overburdened facilities will not increase the capacity for service delivery and may adversely affect HCWs by adding to their workload.[136]

The complexity of setting up telehealth services means that successful implementation it requires a comprehensive framework[136,137] that builds on lessons learned from existing frameworks.[137] The framework needs to consider the following factors: technology, organisational structures, change management, economic feasibility, societal impacts, perceptions, user-friendliness, evaluation and evidence, legislation, policy and governance.[137] One of the recommendations for digital health that arose from the seventy-first World Health Assembly, was to improve the digital skills of citizens and thus build trust in this new technology.[138] This could be done by upskilling CHWs to demonstrate the technology to community members and thus increase their comfort with it.

While telemedicine has the potential to bring healthcare to underserved populations, and improve service delivery by reducing travel costs and waiting times,[139] there are many challenges in our setting that would need to be addressed. The steady supply of electricity, cell-phone network coverage and access to the internet are just some of these challenges.[139] One possible solution to address access to the internet is to approach cellular network companies to provide Wi-Fi hotspots for telemedicine services at places such as taxi ranks, shops or primary care facilities. Furthermore, policies would need to be put in place to protect both provider and user in terms of patient safety, medico-legal risk and protection of personal information.[140,141] To overcome some of these challenges, a phased approach to implementation of telehealth services is recommended. This may include short-, medium- and long-term phases, beginning with automated messages to improve adherence to medication or provide appointment reminders, for example.

Another solution is to expand the use of existing platforms. There are many examples in South Africa of public and private sector initiatives that could be scaled or adapted to serve a broader population or increase functionality. One example is the Vula mobile app, which provides rural HCWs (especially nurses in primary care settings) with access to specialist medical advice.[142] In so doing, the Vula app helps to streamline the referral process, as well as providing clinical advice and support, and learning opportunities, to rural HCWs.[142]

Local production

1. Medication

An article written by experts within South Africa has advocated for the establishment of a pandemic preparedness initiative to mitigate the effects of future pandemics on both the health of the population and on the economy.[126] An initiative of this kind would include expansion of South Africa's current capacity for manufacturing generic medication;[126] it would also require South Africa to increase its limited capacity to manufacture active pharmaceutical ingredients.[126,v] Human resources with the skill sets necessary to increase the manufacture of generic medication would also have to be developed.[126]

2. PPE

The fact that South African manufacturers had the capacity to produce good quality PPE at scale during the COVID-19 pandemic is evidenced by the large increase in exported PPE in the first three months of 2020.[144] When the national (level 5) lockdown was instituted, PPE exports were banned but imports were still allowed.[144] In addition, imported PPE was exempt from value added tax (VAT) but locally manufactured PPE was not, which inadvertently placed local manufacturers at a disadvantage.[144] Thus, despite the local capacity to manufacture good quality PPE at lower cost than the imported products, South Africa had difficulty procuring PPE due to competition with the international market and limited transport in the context of global lockdowns.[88]

It is possible that this problem arose, at least in part, as the South African Government was ill-informed about local manufacturing capability.[144] In preparation for future pandemics, as well as to support the local economy, it would be advisable for government to conduct market research about local manufacturing capability for products such as PPE, and do due diligence of the companies identified to ensure access to cost-effective resources.

Governance and leadership

Although CMJAH played an important role in the care of COVID-19 patients it was closed just before South Africa's third wave, due to a fire.[94] It was reported that the fire occurred in the context of multiple fire-safety hazards, despite the hospital having passed a fire-safety audit a few weeks before.[94] This placed additional pressure on other nearby facilities.[95] Fires had occurred in three other Gauteng hospitals in 2015, 2019 and earlier in 2020.[94]

Provincial and district health departments, in conjunction with the Department of Infrastructure Development and facility management structures should ensure that all routine scheduled maintenance procedures as well as health and safety audits are both legitimate and up-to-date, in accordance with the legislated minimum quality standards.[145] Aside from preventing injury, this will ensure that bed capacity and service delivery is not negatively impacted as a result of unsafe facilities or maintenance issues.

v Ingredients in medications that provide health benefits to the patient[143]

Surge capacity facilities

Experts in South Africa have recommended the preparation of plans to adapt facilities to create surge capacity during future pandemics.[126] The Western Cape Department of Health established a large field hospital at the CTICC to provide surge capacity in the form of intermediate care during the first wave of COVID-19 in South Africa.[99] It was decommissioned in August 2020 due to the high cost and the fact that it only operated at approximately a third of its capacity.[99] In subsequent waves of the pandemic the Western Cape adapted other facilities for a similar purpose using the protocols and operational models from the CTICC field hospital.[99] However, the decision was made to put that cost towards sustainable facilities rather than temporary structures.[99] Protocols and operational models such as this one could be used to develop a national policy and standard operating procedure (SOP) for the establishment of such facilities in future crises. In addition, provinces could begin earmarking potential facilities for this purpose, should the need arise. This should include preparation for quarantine facilities in future pandemics. As in the Western Cape, facilities identified should be sustainable options to justify the potential cost involved in modifying them.

Integration of data systems

By mid-2022, DATCOV and EVDS were not yet linked, and thus vaccination data in DATCOV were self-reported.[32] Health surveillance systems need to be integrated[32] to increase the availability of more complete and accurate data. An example of this type of integration of data systems, is the Western Cape Provincial Health Data Centre (PHDC)[146] which integrates data from health facilities (hospitals and primary healthcare clinics), NHLS, pharmacies and specific programme databases (e.g. for HIV and TB).[146] As a result, the PHDC helps to improve clinical service delivery (by improving quality and continuity of care), as well as epidemiological analysis and surveillance (through anonymised patient data) in the province.[146]

This model of integration of health data systems should be implemented at national level for the same reasons, to improve clinical service delivery and enable epidemiological analysis and surveillance. The benefit of the integration of health data and surveillance systems would be evident both within and outside of a pandemic, and would improve data quality and accessibility.


Canzibe Hospital
26 km

South Africa's vaccine strategy has been critically important as vaccines presented the only sustainable measure to prevent severe COVID-19 disease and related deaths, as well as to re-open the economy.

SECTION 3

COVID-19 VACCINES

SOUTH AFRICA'S COVID-19 VACCINE STRATEGY AND ASSOCIATED CHALLENGES

This section describes the history of South Africa's vaccine strategy, the vaccine roll-out experience and various challenges experienced in the process.

The origins of a vaccine strategy for South Africa

South Africa's vaccine strategy has been critically important as vaccines presented the only sustainable measure to prevent severe COVID-19 disease and related deaths, as well as to re-open the economy.[86] To this end, a vaccination subgroup of the Ministerial Advisory Committee on COVID-19 (MAC Vac), made up of various professionals, such as virologists, vaccine experts and regulators from the SAHPRA, was created in September 2020.[86] The MAC Vac advised the South African Government to use the COVID-19 Vaccines Global Access (COVAX) facility to acquire vaccines for South Africa.[86] COVAX is a global collaboration, co-led by the Coalition for Epidemic Preparedness Innovations (CEPI), Gavi (the Vaccine Alliance) and the WHO.[147] The aim of COVAX is to provide equitable access to COVID-19 vaccines.[147]

By mid-November 2020, many HICs had already entered into advance market commitments (AMCs) with multiple pharmaceutical companies for numerous vaccine candidates.[148] In fact, these HICs accounted for over half of the AMCs at that time.[148] South Africa decided not to enter into AMCs and opted instead for COVAX, but due to an administrative oversight missed the deadline of 17 November 2020 for first payment of the deposit needed to enter the COVAX facility.[149]

While the delay in procurement of a vaccine was criticised by many, the decision to use the COVAX facility, rather than enter into an agreement directly with pharmaceutical companies, was made ultimately to avoid placing the country at financial risk.[150] The risk of committing millions of rands to a vaccine (such as Johnson & Johnson [J&J]) which may later have proven to be ineffective, was deemed too great.[150] On 22 December 2020, the South African Government announced that the 15% down payment of R283m had been made by the Solidarity Fund to secure entry into the COVAX facility.[151] Delivery of the first batch of vaccines was expected in the second quarter of 2021.[150]

Although COVAX seemed to be a safer option, there were certain pitfalls to its process. Firstly, it was established in April 2020 with the main objective of providing affordable vaccine access to low-income (LIC) and lower-middle-income countries (LMIC), which required upper-middle-income countries (UMIC) and HICs to subsidise funding.[152] As a UMIC, South Africa would be offered the vaccines at the same price as HICs, despite being unable to afford that cost.[152] Many HICs, such as Canada, the UK, the USA, Japan and Europe, had entered into bilateral agreements with pharmaceutical companies and secured 51% of the available vaccine supply at that time for only 13% of the global population.[152] The implications of this are two-fold. Firstly, these HICs, because they had already secured vaccines through bilateral agreements, had less incentive to enter COVAX and subsidise LICs. Secondly, available vaccine supply would have been limited if South Africa had opted to enter bilateral agreements with pharmaceutical

companies at that point.[152] Furthermore, COVAX would provide sufficient vaccines to cover between 5 and 20% of the population of each country, but it was not clear at that time whether the country would have a choice as to which vaccine was provided.[152]

Delays and disagreement in the vaccine strategy

Concerned that there did not appear to be an established vaccine strategy, apart from the arrangement with COVAX, a number of academics drafted a 10-point vaccine strategy proposal in December 2020.[86,152] This strategy addressed a number of issues that would affect vaccine roll-out in South Africa, including expediting registration by the SAHPRA; securing funding; a strategy to target at-risk populations first, in light of likely vaccine supply limitations; outlining the means of vaccine procurement from manufacturers; addressing challenges in delivery systems such as maintaining the cold chain; communication with the public; and, digital technologies to capture data on vaccine uptake.[152] However, with no apparent change in the government response, on 2 January 2021, a group of academics and activists published an Op-Ed in the *Daily Maverick* criticising the lack of vaccine acquisition strategy.[86,153] They raised concerns that without immediate action South Africa would enter the third wave without having vaccinated even vulnerable populations, such as HCWs, thus placing people's lives and the healthcare system at risk.[86,153]

At that point in time, many other countries, including African countries, had negotiated vaccine procurement and had already initiated their vaccine campaigns.[153] The authors of the Op-Ed went on to say that an AMC does not in fact require upfront payment for the vaccine; the assertion by officials that bilateral agreements with pharmaceutical companies presented too great a financial risk was thus unfounded.[153] These agreements would only require payment of a set price for a set quantity once the vaccine was ready to be used.[153] Furthermore, vaccinating would have actually been more cost-effective for South Africa as the cost of vaccinating 20% of the public sector in 2021 with the lowest cost vaccine would come to a ninth of the cost of one day of level 5 lockdown, and even using the most expensive vaccine available would not amount to the cost of one day of lockdown.[152]

In addition, some pharmaceutical companies had promised to make vaccines available at cost and include technology transfer to assist future local production of vaccines,[152] and others had already been producing vaccines locally for trial and evaluation.[86,153,154] Aspen, a local vaccine producer, confirmed on 26 January 2021 that they would have at least 300 million doses of J&J vaccine available for export in that year.[86,153,154]

Purchase decisions and missed opportunities

Following the Op-Ed, the NDoH began bilateral agreement negotiations for AstraZeneca vaccines from the Serum Institute in India on 4 January 2021.[86] SAHPRA provided emergency approval; and the first one million doses of the AstraZeneca vaccine arrived in South Africa on 1 February 2021, with the next 500,000 doses expected by the end of that month.[86,155] SAHPRA then commenced a two-week quarantine and quality assurance check for the vaccines.[155] On 3 January 2021, the three-phase roll-out plan for the vaccine was announced. Phase 1 was to target 1.2 million HCWs in both public and private sectors. Phase 2 was to target other essential workers, persons in congregate settings, persons older than 60 years of age and those 18 years and older with co-morbidities; and finally, Phase 3 was to target all persons 18 years and older.[155,156]

However, just days after the doses had arrived a small clinical study in younger patients showed that the AstraZeneca vaccine was not effective in preventing mild to moderate disease caused by the Beta variant, the dominant variant in the second wave in South Africa at that time (February 2021).[157] This caused the government to put the vaccine roll-out on hold, despite the following: the study had not yet been peer-reviewed; it was a small study in younger patients (median age 31 years) who were not at risk of severe disease; and, many experts were of the opinion that the vaccine would still most likely protect against the severe disease that would otherwise result in hospitalisation and death.[86,157] Later, the decision was taken not to use the AstraZeneca vaccines even though the WHO supported its use and animal model studies corroborated the opinion of various experts that the vaccine would prevent severe disease caused by the Beta variant.[86] These vaccines were subsequently sold to other African Union member states.[158,159] As the AstraZeneca vaccines made up the majority of doses to be delivered by COVAX, the decision not to use it meant that South Africa also missed out on the first COVAX consignment consisting of 237 million doses of AstraZeneca and 1.2 million doses of Pfizer vaccines.[86]

The initial vaccine roll-out

The South African government only began bilateral agreement negotiations with J&J and Pfizer for vaccine procurement in February 2021,[86] whereas many HIC countries already had agreements in place as early as November 2020.[148] When the AstraZeneca vaccine roll-out was placed on hold, attention turned to the results of the Ensemble trial, which showed that the J&J vaccine had 57% efficacy against moderate to severe disease caused by the Beta variant.[85,157] The SAMRC liaised with J&J in Belgium and managed to procure 300,000 doses of the J&J vaccine from spare stock in various clinical trial sites around the world.[158] The South African Health Minister, Dr Zweli Mkhize, along with the SAMRC, negotiated with key officials from the USA to secure an additional 200,000 doses of the J&J vaccine.[158]

It was conceptualised that the vaccines would be provided to HCWs via a trial to study the efficacy of the J&J vaccine, thereby eliminating the immediate need for official SAHPRA approval for the use of the vaccine in a broader population.[85,86,160] Within two-and-a-half weeks, the researchers from the Sisonke trial wrote the study protocol, managed to procure and arrange delivery of vaccine doses, obtained regulatory and ethics approval and began administering doses to HCWs on 17 February 2021.[85] By 15 May 2021, 478,452 HCWs had been vaccinated as part of the Sisonke study.[158]

In parallel to the Sisonke trial process the Electronic Vaccination Data Systems (EVDS) vaccination registration portal was developed and officially launched on 16 April 2021 for registration of persons aged 60 years and older.[161] For those without access to digital technology, teams were sent out equipped with phones sponsored by the business sector and philanthropic organisations, to assist people with registration. Targeted groups included the elderly, the homeless and those in remote rural areas.[161] Other options included going to a vaccination centre to be registered.[161] As early as 3 January 2021, the Minister of Health had authorised the amendments to regulations to make COVID-19 vaccines part of Prescribed Minimum Benefits (PMB).[156] This ensured that medical aids could fund vaccinations for their members and free up government funds for the public sector.[152,156]

The first 325,260 doses of Pfizer vaccines arrived in South Africa on 2 May 2021 and the Minister of Health announced that around 320,000 Pfizer vaccines would arrive weekly until the

end of May.[162] After the 31 May 2021, weekly vaccines delivered would increase to 636,480 until the end of June 2021, which would amount to 4.5 million doses in total.[162] While this arrival was welcomed, its timing meant that aside from the HCWs vaccinated in the Sisonke trial South Africa's most vulnerable populations were not immunised heading into the third wave.[86,162] A further 1,392,300 doses of Pfizer vaccine were delivered by COVAX on 27 June 2021.[163] In addition, it was expected that the locally manufactured J&J vaccines would be ready for distribution by mid-May 2021.[162] Government roll-out of COVID-19 vaccines was thus only officially started in May 2021.[86]

Approximately 750,000 HCWs not vaccinated as part of the Sisonke trial were to be vaccinated as part of Phase 1b of the vaccine strategy, which was rolled out on 17 May 2021, simultaneously with Phase 2.[163] Phase 2 was expanded to include people over 50 years of age and people over 40 years of age.[163] However, scaling up of the programme was hindered when 2 million J&J vaccines earmarked for South Africa were destroyed in mid-June 2021 after being assessed as contaminated by the Federal Drug Administration in the USA.[86,163] The replacement J&J vaccines were delivered at a later date.[86]

By 28 June 2021, the Pfizer vaccine second doses were initiated and on 3 July 2021 SAHPRA gave emergency use approval, with conditions, to the Chinese Sinovac vaccine.[163] This was in keeping with a suggestion made by experts in December 2020 in a proposed 10-point vaccine strategy that identified bilateral agreements with other countries as an additional procurement option so as not to "put all eggs in one basket".[152]

On 15 October 2021, South Africa passed the milestone of 20 million vaccinations administered, which meant that over 35% of the country's adult population had been at least partially vaccinated.[164] Furthermore, 10.7 million people were fully vaccinated at that time and had received either the two Pfizer doses or one J&J dose.[164] From 20 October 2021, persons aged 12 years and older could be vaccinated.[164]

Sustaining the vaccine momentum and demand-side roll-out challenges

By 12 January 2022, well into the Omicron-dominated fourth wave, only 27% of the population had been fully vaccinated, i.e., they had received at least one J&J or two Pfizer doses.[165] With the high transmissibility of this variant, booster doses for both Pfizer and J&J were approved by SAHPRA to improve immunity and prevent severe disease and death.[165] In addition, even with sufficient supply, vaccine delivery to rural townships and villages had proved "to be a challenge beyond what was expected" and required innovative solutions such as mobile vaccination campaigns.[165] The percentage of the adult population (persons aged 18 years and older) at least partially vaccinated between the 17 February 2021 and the 25 June 2022 was 51%.[16]

Vaccine demand

A major challenge in the South African vaccination campaign was vaccine hesitancy; a study published in November 2021 showed that only 55% of South Africans accepted the vaccine, with a further 16% showing moderate acceptance.[166] South African COVID-19 vaccine hesitancy was estimated to be as high as 29.2%.[166] The government released a communication strategy for the COVID-19 vaccines in early May 2021 which included addressing issues related to vaccine hesitancy (such as safety and efficacy of the vaccine, as well as debunking

myths).[167] However, one study conducted in South Africa in September 2021, in which 60% of respondents had not been vaccinated, found that the three reasons most commonly given for not having the COVID-19 vaccine were concern about side effects (26.1%); concern that development and approval of the vaccine had happened too quickly (12,6%); and, mistrust of the government (11.8%).[168]

Race, vaccine literacy and level of trust in the government's ability to roll-out the COVID-19 vaccination programme, were predictors of both non-uptake of the vaccine and vaccine hesitancy.[168] In addition, those who felt they could not trust the government's ability to roll out the COVID-19 vaccination programme, were 13 times more likely to be vaccine-hesitant and 5 times more likely not to have the vaccine.[168] These findings illustrate the importance of making clear and easily understandable information available to the public on vaccine development and safety.[168]

Transparency and clear communication by the government regarding the processes involved in the vaccine programme roll-out, as well as swift action where corruption is uncovered were cited as paramount in building trust and decreasing vaccine hesitancy.[168] A rural study in Mpumalanga between August and October 2021 (with 49.6% of participants unvaccinated), identified lack of information regarding location of vaccine sites (13.0%) and eligibility for vaccination (12.3%), concerns about side effects (12.5%) and inconvenience (hours and location of vaccination sites) (11.0%) as the most common barriers to getting vaccinated.[169] In addition to clear messaging on safety and efficacy of the vaccine, these findings highlighted the importance of factors such as availability of information regarding the logistics of getting the vaccine as well as factors related to access, such as vaccination sites that operate outside of working hours, mobile sites, or sites at workplaces.[169]

One successful method of reaching the rural elderly for COVID-19 vaccinations involved taking vaccination services to social grant queues where they were assisted with registration on the EVDS and vaccinations were provided by mobile vaccine trucks.[170]

DATA ANALYSIS

3. Total number of vaccines administered

For the period 17 February 2021 to 25 June 2022, the total number of people over the age of 18 years who were at least partially vaccinated (having received at least one dose of J&J or Pfizer vaccines) was 20.2 million, according to the SVD. The total number of vaccines administered (including booster doses) in the same period was 36.8 million, according to the provincial vaccination dataset (PVD). As the latter does not specify age ranges, the higher number could be due to the fact that all ages are included or due to the fact that it includes booster doses and thus is an overestimation.

4. Proportion per period

Over half of the individuals vaccinated (over 18 years of age), were vaccinated in the third wave (56.1%). The next highest proportion was in the period between the third and fourth waves (23.3%), followed by the fourth wave (10.3%). After the fourth wave the proportion drops to 8.4%.

The PVD shows a similar pattern to the above, except for a much higher proportion in the period after the fourth wave, which may be accounted for by inclusion either of booster doses or of younger age groups (Table 8).

Table 8: Proportion of vaccinations per period

Waves	Total no. of individuals vaccinated*	Proportion of individuals vaccinated*	Total no. of vaccines administered**	Proportion of all vaccines administered**
2><3	386,207	1.9%	386,243	1.0%
3	11,347,861	56.1%	15,840,537	43.0%
3><4	4,706,257	23.3%	8,659,253	23.5%
4	2,091,000	10.3%	4,616,537	12.5%
>4	1,696,650	8.4%	7,330,538	19.9%
Total	20,227,975	100.0%	36,833,108	100.0%

**only includes 18 years and older (SVD)*
***all vaccines administered including booster doses (PVD)*

5. Provincial vaccinations

The highest provincial proportion of COVID-19 vaccinations was in Gauteng, which accounted for 26.9% of individuals over 18 years of age at least partially vaccinated (SVD) and 27.9% of vaccinations administered (PVD). This was followed by KwaZulu-Natal with 15.9% and 15.7% respectively, and the Western Cape with 14.2% and 15.0% respectively. The Free State vaccinated a slightly higher proportion than its proportional population size: 5.7% and 6.0% respectively, while it accounts for only 4.8% of the South African population. Limpopo showed a similar trend (Table 9). The provincial vaccination patterns were reflective of their population sizes.

Table 9: Proportions vaccinated per province and provincial population size

Province	EC	FS	GP	KZN	LP	MP	NC	NW	WC
Proportion of individuals vaccinated*	11.1%	5.7%	26.9%	15.9%	10.5%	6.9%	2.2%	6.6%	14.2%
Proportion of vaccines administered**	11.1%	6.0%	27.9%	15.7%	10.0%	6.1%	2.0%	6.2%	15.0%
Population size[12]	11.0%	4.8%	26.6%	19.0%	9.8%	7.8%	2.2%	6.9%	11.9%

**only includes 18 years and older (SVD)*
***all vaccines administered including booster doses (PVD)*

6. Vaccinations per age group

Only the SVD contained data regarding age groups. The proportion of individuals at least partially vaccinated per age group is as follows: 18-34 years made up 32.9%; 35-49 years made up 31.6%; 50-59 years made up 15.9% and over 60 years made up 19.6% (Table 10).

The highest proportion of individuals at least partially vaccinated was found in different periods for different age groups.

The 18-34 year-olds had the highest proportion of individuals vaccinated for that age group during the period after the fourth wave (62.1%) and during the fourth wave (55.9%), whereas the highest proportion for the 35-49 year-olds was in the period between the second and third waves (44.8%) followed by the period between the third and fourth waves (33.4%). The highest proportion of individuals vaccinated among the 50-59 year-olds was in the period between

the second and third waves (21.7%) followed by the third wave (20.2%). Finally, the highest proportion of over 60 years-olds was vaccinated in the third wave (30.3%), and then in the period between the second and third waves (9.6%) (Table 10).

Findings may reflect the phases of the vaccine roll-out in South Africa in the following way: Phase 1 involved vaccinating HCWs[155] and began in the period between the second and third waves[85] which may explain the high numbers of 35-49 year olds in that period. Phase 2 of vaccine roll-out was for other essential workers and people over 60 years of age[155] and began around the time of the beginning of the third wave;[86] which reflects the high proportion of over-60-year-olds vaccinated in the third wave. The roll-out for younger age groups (18-34 year olds) which began near the end of the third wave[171] may account for the high proportion of individuals vaccinated in the fourth wave and after the fourth wave.

Table 10: Proportions of individuals vaccinated per age group per period

Waves	18-34	35-49	50-59	60+
2><3	23.9%	44.8%	21.7%	9.6%
3	17.8%	31.7%	20.2%	30.3%
3><4	49.2%	33.4%	11.1%	6.3%
4	55.9%	29.0%	9.5%	5.6%
>4	62.1%	25.5%	7.6%	4.8%
Entire period	32.9%	31.6%	15.9%	19.6%

**only includes 18 years and older (SVD)*

7. Vaccinations per birth sex

For the entire period, females accounted for 56.2% and males for 43.8% of individuals over 18 who were at least partially vaccinated. In the breakdown of female to male individuals, at least partially vaccinated per period, males initially made up a small percentage (24.4% in the period between the second and third waves). Over subsequent periods the proportion of males increased and eventually accounted for 46.8% in the fourth wave and 47.6% in the period after the fourth wave (Figure 7). The trend of fewer men than women getting vaccinated was widely recognised. To address this, Gauteng made plans in August 2021 for mobile clinics and workplace outreach to increase the uptake of vaccinations by men.[172] The usage of social grant queues described earlier also appeared to increase reach to men.[170] This kind of targeted response may explain the improvement in vaccination uptake by men.

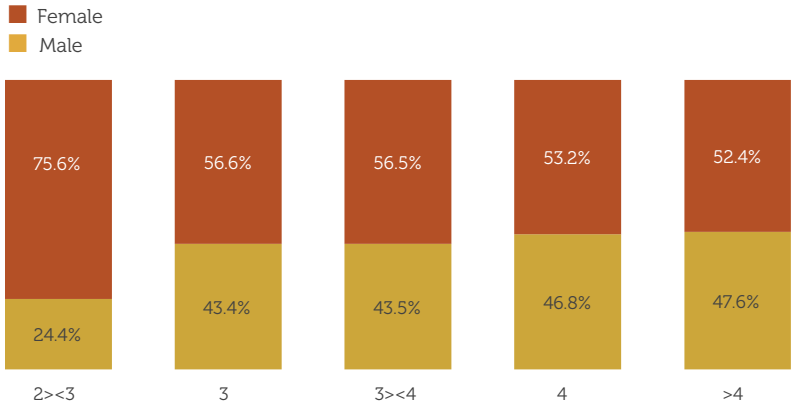

FIGURE 7: Proportion of individuals vaccinated by birth sex, per period (J&J or Pfizer first dose)
Source: NDoH EVDS. Available on: https://github.com/ndoh-evds/evds-data-analytics

IMPACT ON NON-COVID-19 CONDITIONS AND HEALTH SERVICES

Impact on childhood immunisation programmes

A study that used routine DHIS data to assess the impact of the COVID-19 response on PHC services in South Africa, assessed immunisation coverage in children and found that seven of nine provinces experienced a decline in the number of fully immunised children under a year in the period March to December 2020, as compared to the same period in 2019.[35] The overall decline in fully immunised children for this age group was 4.3%, with the largest declines in the Northern Cape, Eastern Cape and Mpumalanga, and the periods in which these declines were the greatest, coincided with lockdown periods.[35] This is in keeping with other findings which suggest that movement restrictions during lockdowns had more of an impact on childhood immunisations than on other services.[173]

Other factors that affected this service included fear of contracting COVID-19 at health facilities, repurposing of health resources to COVID-19 and the COVID-19 vaccination drive.[173] Negative sentiment and vaccine hesitancy around the COVID-19 vaccine may have affected childhood immunisations as well, although more research is needed to assess this.[173] While the COVID-19 pandemic has exacerbated the problem, childhood immunisation coverage in South Africa was suboptimal even before the pandemic.[173] An analysis of 2016 data showed that 40.8% of South African children were not fully immunised.[173] In addition, vaccine hesitancy was noted to be a major factor in suboptimal childhood immunisation coverage as early as 2009.[168]

HIV vaccine research

While it is true that many HIV resources were diverted to fight the COVID-19 pandemic, COVID-19 vaccine technology may in fact help in the development of an HIV vaccine.[174] The mRNA technology used successfully by Pfizer and Moderna to produce COVID-19 vaccines proved that mRNA vaccines could be safe and effective and have thus boosted HIV vaccine development.[174,175]

International scientists and authors have also noted that the research and development that has gone into the HIV vaccine informed the development of COVID-19 vaccines.[176,177] The large investment of resources and expertise into development of the COVID-19 vaccines, enabled their rapid development and evaluation;[177] lessons learned will help to inform development of an HIV vaccine.[176,177]

NOVEL COVID-19 VACCINATION INTERVENTIONS OR SERVICES

Reaching rural areas

Right to Care, a non-governmental organisation (NGO), vaccinated 43,000 HCWs in rural Eastern Cape and Northern Cape during the Sisonke trial.[178] In June 2021 Right to Care was set to assist the NDoH in rolling out vaccinations in rural and hard-to-reach areas in the Eastern Cape, Northern Cape, Free State and Mpumalanga using this experience as well as that from their extensive HIV programmes.[178] They hoped to share their innovations to benefit other provinces. These innovations included creating mobile vaccination teams and mobile pharmacies; using geographic information system (GIS) technology to plan routes and storage points for the vaccine; ensuring internet connectivity; cold-chain planning for vaccine storage; and setting up a call centre staffed by doctors and nurses to assist patients reporting adverse events.[178]

Efforts by the Eastern Cape Provincial Department of Health (DoH) and the Bulungula Incubator in Xhora Mouth on the Wild Coast[179] proved successful and their vaccination drive yielded solutions to many of the challenges faced when trying to roll-out COVID-19 vaccinations in rural areas. These included:

- **The value of local knowledge in increasing access to communities:** By utilising the help of local NGOs with context-specific knowledge of the area, the people and the roads,[179] a variety of fixed vaccination sites, one-day mobile sites for hard-to-reach areas, or district hospitals supporting satellite clinics can be set up to address the community's specific needs.[179] Other methods of community-based intervention in South Africa included vaccination drives at social grant queues,170 taxi ranks, taverns and sporting events.[179] One strategy employed to increase convenience was weekend vaccination campaigns, such as Vooma Vaccination Weekends.[180]
- **Advance community sensitisation:** CHWs are employed to undertake door-to-door visits to provide information on vaccines to the people as well as to increase awareness of the vaccination sites and their service delivery dates and times.[179] Another communication method used was loud-hailing of vaccine information from branded vehicles within communities.[179]
- **Involve local trusted and influential individuals:** Community and traditional leaders are engaged in the vaccination campaign to build trust and create buy-in with the local communities.[179]
- **Careful logistics planning and supply-side flexibility:** This ensures that potential logistical pitfalls and supply-side constraints are addressed by, for example, planning the availability of the correct equipment and vehicle; asking district pharmacies to open earlier to dispense doses thereby decreasing delay in departure to the vaccine site; and, using CHWs to pre-register people on EVDS to reduce administration time on the vaccination day.[179] In addition, for very remote areas, planning vaccine storage sites and maintenance of the cold chain is important.[178] When planning for weekend vaccination campaigns, considerations should include nurses working flexi-hours instead of overtime, and the extension of pharmacy hours, both of which may require negotiation with the unions.

- **Eliminate the need for multiple-dose vaccinations:** The migrant nature of rural communities creates difficulty in administering a second dose. The single-dose vaccine should thus be used whenever possible.[179]

Learning points from another rural vaccine roll-out included:

- **The use of telemedicine:** A toll-free call-centre manned by doctors and nurses to assist in the event of an adverse reaction to the vaccine.[178]
- **Mobile vaccination teams and mobile pharmacies:** These can be used as another way to take the vaccine campaign to the people.[178]

Drive-through vaccinations

The Gauteng DoH drive-through site at a church in Bonaero Park, Ekurhuleni was established in July 2021 and supported by the Aurum Institute.[181] Drive-through sites offered quick and convenient vaccine services in a socially distanced manner, complete with registration, information sharing, vaccination and monitoring for adverse events for 15 minutes post-vaccine administration.[181] Other drive-through sites in Gauteng, including at a Mosque in Houghton and at the Zwartkops Raceway in Tshwane, were open on weekdays and Saturdays which further bolstered vaccination roll-out.[182] One limitation of the drive-through model is that it is limited to those with their own vehicles. A survey conducted by the Centre for Social Change, the University of Johannesburg and the HSRC showed that car ownership increased the likelihood of being vaccinated.[183] The increase in access appears to be more related to the location of vaccination sites and the cost of transport to get there.[183] Athlone Vaccination Centre of Hope, a drive-through site in the Western Cape was set up to offer vaccinations to public transport users as well as private motorists,[184] although it is not clear if this did in fact happen.

Expansion of African vaccine manufacturing

The WHO launched a technology transfer hub in South Africa in June 2021, to support scale-up of African production of vaccines from 1% to 60% (of all vaccines administered on the continent) by 2040.[185,186] At the end of January 2022, of the 10 billion doses of COVID-19 vaccine that had been administered globally, only 346 million were in African countries.[185] The WHO requested that Moderna, Pfizer and BioNTech help African researchers develop a COVID-19 vaccine for local production but the companies did not agree to assist due to concerns it would negatively affect current vaccine production.[185] It is speculated that as a result a process that would have taken a year will now more likely take three years.[185] During the pandemic these same companies sent more than 70% of their vaccines to HICs.[187] Moderna announced that they would not enforce their vaccine patents during the pandemic and South African researchers from the University of the Witwatersrand and Afrigen have used publicly available information to reproduce the Moderna vaccine.[185,187] Despite likely challenges in scaling up production, they hope to begin clinical trials in November 2022.[185,187] Scientists are currently trying to produce an mRNA vaccine that is cheaper than mainstream alternatives and does not require the ultra-cold storage that other vaccines need, thus making it easier to distribute on the African continent.[185,187] This initiative is likely to help empower Africa to produce their own vaccines in the near future, and thereby address health inequities.[187]

COVID-19 HEALTH SYSTEMS EXPERIENCES FROM OTHER COUNTRIES

Vaccine strategy and access

In contrast to South Africa (where SAPHRA first approved the AstraZeneca vaccine in late January 2021),[188] countries like the UK and the USA had already gained regulatory body approval for COVID-19 vaccines in December 2020 in order to roll these out to high-risk populations and HCWs.[152] As mentioned, many countries, including African countries, had already begun negotiations for vaccine procurement in 2020; and some 40 countries had already initiated mass vaccination campaigns by early January 2021.[153]

However, vaccine access has not been equitable. An example, is that by February 2022, 70% of the available mRNA vaccines had been sent to HICs.[187] Poorer countries were reliant on the COVAX facility to ensure adequate vaccine supplies, which were only likely to be received many months after wealthier countries had initiated their vaccine campaigns.[153] Africa has vaccinated comparatively small numbers; in stark contrast to HIC countries, only 10% of people in Africa were fully vaccinated by mid-February 2022.[187]

Demand-side constraints have also played a major role in low vaccination uptake in Africa. A review of literature on COVID-19 vaccine hesitancy in Africa showed that vaccine acceptance ranged from 6.9% to 97.9% on the continent.[189] In keeping with these findings, a survey conducted in June 2021 in 23 countries around the world, ranging from high- to low-income countries, found that in comparison to other countries in the sample, countries in Africa had a lower vaccine uptake and higher vaccine hesitancy.[190] Reasons for the vaccine hesitancy in Africa included concerns about the safety of the vaccine and potential side effects, mistrust of pharmaceutical companies and misinformation from the media.[189] The survey found that vaccine acceptance for all 23 countries was on average 75.2%.[190] As was seen in both African and South African findings, common reasons for hesitancy include vaccine safety and efficacy, mistrust of the science in vaccine development and mistrust of the government.[190] In light of these findings, clear communication to the public on vaccine development, safety and benefits are of the utmost importance.[190]

Impact on childhood immunisations

One study by Harvard researchers looked at the effect of COVID-19 on 31 health services in 10 countries: two LICs (Ethiopia and Haiti), six MICs (Ghana, Lao People's Democratic Republic (LPDR), Nepal, Mexico, South Africa and Thailand) and two HICs (Chile and South Korea) to assess the resilience of their healthcare systems.[7]

It was found that childhood immunisations declined by more than 10% in all countries reporting them, except Ethiopia and Ghana, after the pandemic was declared.[7] In fact, childhood immunisations were among the most affected services and although several countries' immunisation rates improved by the end of 2020, not all missed doses were caught up.[7] There are thus clear missed opportunities with regards to full immunisation of children.

It was expected that 2021 would be a year in which the childhood immunisation rates recovered after the lockdowns of 2020. However, WHO and United Nations Children Fund (UNICEF) reports indicate that immunisation coverage has declined even further.[191] This has resulted in millions more children, across all regions of the globe, missing vital doses of diphtheria, tetanus and pertussis (DTP), measles, polio and human papillomavirus (HPV) vaccines.[191]

These declines are thought to be due to the effects of the COVID-19 pandemic (decreased access to health services, repurposing of resources and supply-chain issues), but also due to an increase in the number of children in settings that limit vaccine access (e.g. conflict zones) and increased misinformation leading to lack of trust in vaccines.[191] The potential dire consequences of these missed immunisations highlights the need to make concerted efforts to:

- Recover missed vaccines
- Increase immunisation coverage through resource allocation by governments
- Address misinformation with evidence-based and people-centred communication strategies
- Increase health system resilience for future pandemics.[191]

RECOMMENDATIONS

Vaccines

1. Procurement strategies

A lesson learned from South Africa's COVID-19 vaccine response is that, in the face of global demand, it is important to have a procurement strategy that can be rapidly implemented. As part of the Scientist's Collective 10-point COVID-19 vaccine strategy, it was suggested that in a global pandemic multiple procurement options are preferable.[152] Furthermore, having bilateral agreements in place with both pharmaceutical companies and other countries would allow for negotiation of fair pricing and, with the former, the possibility of technology transfer.[152] AMCs create an incentive for pharmaceutical companies to develop vaccines by entering into agreements to purchase large, specified quantities of a vaccine at a set price once it has proven effective and is licensed.[153,192] If an effective vaccine is not produced there is no obligation to pay.[152,193] This mechanism was successfully used by GAVI to purchase pneumococcal vaccines for low-income countries in 2009.[192] In addition to being a good option for future pandemic preparedness, this mechanism could help with the cost-effective development and purchase of vaccines for diseases such as HIV, malaria and TB.[193]

2. Locally manufactured vaccines

During the COVID-19 pandemic, Aspen Pharmacare was manufacturing the J&J vaccine in South Africa but the 300 million doses to be ready in 2021 were intended for export.[86] For future pandemic planning it would be prudent to investigate the early use of options in which vaccines are manufactured and undergo clinical trials within South Africa. The government could negotiate an agreement for vaccine procurement with the pharmaceutical companies involved in the local manufacture of vaccines, to ensure that a proportion of those produced remain in South Africa.

In addition, South African scientists have managed to reverse engineer the Moderna mRNA COVID-19 vaccine and are set to begin clinical trials in November 2022.[185,187] Having the capability to produce mRNA vaccines in South Africa will assist in vaccine manufacturing for future and current pandemics. This will also decrease the need for South Africa (and likely Africa) to compete with the international community for vaccines and thus increase equity in access.

Increasing access to rural populations

The aforementioned Eastern Cape experience of COVID-19 vaccinations has yielded some important learning points for vaccine roll-out in rural areas. Supply-side interventions could include involvement of local stakeholders for context-specific planning, as well as ensuring that the necessary logistic arrangements are in place with suitable flexibility and innovation where possible. Furthermore, access could be increased through the use of a variety of fixed and mobile service delivery points as well as campaigns delivered at convenient and frequently venues such as workplaces, grant queues, etc. Demand-side interventions could include community sensitisation and appropriate and context-specific communication campaigns.

Improving health data quality

Quality public health data is essential to an effective health system response as it informs decision-making (at policy and individual levels), is the backbone of evaluating the effectiveness of interventions and helps create a sense of trust with the public.[33]

One data-quality framework evaluates data in terms of completeness, consistency, conformity, accuracy and timeliness.[194] The evaluation asks, in other words, whether all the relevant data is collected correctly and is measuring what it should at the right time.[194] A data-quality improvement intervention in certain facilities providing PMTCT services, implemented by a study in KwaZulu-Natal, included training on data collection; monthly reviews of data; and, performing of data audits.[195] The study found that after the intervention data completeness improved from 26% to 64% and data accuracy improved from 37% to 65%.[195]

Other factors essential to the usefulness of health data include making data accessible to the wider scientific community to enable independent evaluation and improve transparency and assessment of the effect of an event or intervention on specific populations or communities through the analysis of raw disaggregated data.[33]

Finally, the way in which data is represented to the public is important in both a pandemic context and for appropriate evidence-based decision making for other health conditions. Thus, presenting figures to the public in terms of percentages and proportions, rather than just whole numbers, as well as providing data in context (for instance comparing COVID-19 wave peaks) makes information more accessible to the public.[33]

Implementing interventions (such as the data-quality improvement intervention) at scale in health facilities, as well as improving data accessibility will improve both the preparedness for future pandemics and other health services in the immediate term.

Communication with the public

To build trust and confidence in any vaccination programme, it is important that government engages the public through detailed and transparent communication.[152] Communication strategies should address the following: the process of procurement; the plans to ensure equitable vaccine distribution to the public; and, factors related to vaccine hesitancy.[152] To address vaccine hesitancy, science-based education programmes using multimedia platforms can create awareness, debunk myths and demonstrate the public health benefits of vaccines to the population.[152] The weekly social listening report for COVID-19, generated by the South African Government, allowed for the formulation of evidence-based responses to address rumours and misinformation collected through social listening mechanisms.[75]

Using the same type of education programme and social listening mechanisms for the expanded programme of immunisation (EPI) to address deficits created by the COVID-19 response could encourage recovery of missed vaccine doses. It could also help to create greater uptake and resilience within the EPI programme. Furthermore, ongoing communication and transparency around vaccines to the public outside of pandemic situations can create a comfort and familiarity with the processes involved in developing and procuring vaccines in general, as well as addressing vaccine hesitancy at every possible opportunity. Thus, when the next health crisis hits South Africa, there will be a baseline knowledge of vaccination programmes for the public to draw on.

Maintaining childhood vaccination services

A Harvard study found that most countries included in the study had declines in childhood immunisations as a result of COVID-19 lockdowns, with incomplete recovery of missed vaccine doses.[7] Ghana was an exception to this, as it showed an increase in child health services and pentavalent vaccines, in that period,[7] which is thought to be due to a specific effort to maintain maternal and child health in that period.

COVID-19 lockdown resulted in a 50% decline in childhood immunisation visits that could be further negatively affected by vaccine hesitancy surrounding the COVID-19 vaccine.[173] South Africa's EPI programme had suboptimal coverage even prior to the COVID-19 pandemic, with the latter exacerbating existing deficits even further.[173] One possible reason for this would be missed opportunities for vaccination (MOVs), which include healthcare providers missing the opportunity to check for and offer vaccinations at visits to health facilities for childhood preventative services, curative services and when a child is accompanying a family member to a health facility, in addition to visits specifically for immunisation.[173] It has been suggested that implementation studies might be an appropriate way to address MOVs, by using Quality Improvement methodology at facilities and caregiver engagement to improve vaccine coverage.[173] This, in conjunction with the communication strategies in the preceding section, would help to improve EPI coverage now and promote resilience in this service for future pandemics.

TABLE OF RECOMMENDATIONS

The recommendations in this section were informed by a combination of findings from the literature reviews and key informant insights, and were synthesised across the various topic areas into sets of recommendations aligned to the various WHO Building Blocks.

Health system building blocks and principles	Recommendations
Leadership and governance	**Agile and adaptive governance** • Develop a variety of response strategies prior to a public health emergency to allow for greater adaptability in emergency response. This will also minimise the risk of overemphasising some issues while negating others. • Plan for contingencies based on the lessons learnt from COVID-19 to ensure pandemic preparedness and a resilient health system. • Institute explicit priority-setting mechanisms and frameworks that can both guide resource allocation and decision-making in stable periods and can be adapted to guide efforts during public health emergencies. **Implications for the rural context:** Context-specific lessons from the rural experience of COVID-19 should be used to prepare contingencies and decision frameworks to ensure that rural and underserved communities are better served during periods of stability and when future health crises emerge.
	Public health oversight • Establish and operationalise the National Public Health Institute of South Africa (NAPHISA) to provide coordinated public health oversight for research, training, surveillance and interventions necessary to address the burden of diseases in South Africa. • Facilitate pandemic preparedness and response through NAPHISA's enhanced ability to engage with government and other key stakeholders with respect to outbreak responses, laboratory coordination, guideline development and technical support for HCWs, government and regulatory bodies, and formulation of communication strategies. • Provide reliable, evidence-based information through NAPHISA to assist government with both public health and personal health service delivery, resource allocation and evidence-based decision making and policy development. **Implications for the rural context**: Although NAPHISA is a national-level body and its activities may not specifically benefit rural areas alone, the availability of robust information on the rural context will allow for context-specific decision making and resource allocation.
	Public and private sector collaboration • Institute new or strengthen current public-private partnerships and collaboration to improve service delivery in accordance with need and regardless of ability to pay. • Establish regulations for governance and oversight of private sector activities during public health emergencies to ensure that inequities and access challenges are not further exacerbated.
	Facility management • Facilitate collaboration between provincial and district health departments, the Department of Infrastructure Development and facility management structures to ensure that all routine scheduled maintenance procedures, as well as health and safety audits, are legitimate and up-to-date in accordance with legislated minimum quality standards. **Implications for the rural context:** Given that access to maintenance services and the option of directing patients to other facilities may be more of a challenge in rural areas, efforts to ensure ongoing and timeous maintenance must account for these potential challenges.

Health system building blocks and principles	Recommendations
Medical products and technologies	**Local production and supply capacity** • Adapt existing local testing technology from COVID-19 for novel pathogen detection as well as for testing for other health conditions such as HIV and TB to decrease dependence on foreign supply chains, reduce costs and facilitate access. • Facilitate access to locally produced technology such as PPE through robust supply chain mechanisms, due diligence and corporate governance to realise the benefits highlighted in the previous point as well as for more agile access in times of increased need. • Explore the possibility of agreements with pharmaceutical companies that manufacture vaccines and medications locally to enhance access to locally produced technology, bolster local capabilities and potentially impact local production of vaccines for other preventable conditions. • Leverage current local expertise to develop technology that is context-specific and allows for usage in resource and access-constrained environments. **Implications for the rural context:** Although the health system as a whole will benefit from lowered costs and increased access, rural facilities, which are usually resource constrained and under-served would greatly benefit from cost-containment and reliable supply-chain mechanisms as well as from technologies that take into account the unique resource and access constraints present in rural areas.
	Procurement strategies • Increase procurement options through bilateral agreements with pharmaceutical companies and other countries. • Utilise advance market commitments to create an incentive for companies to develop vaccines and other technologies with little risk to the country. • Develop a procurement strategy for public health emergencies to facilitate rapid, ethical and trustworthy decision-making to ensure supply of the necessary resources.
Health workforce	**Community health workers** • Further define the scope of CHWs to include screening, point-of-care testing, health education, assisting the public with health-related interventions such as self-testing and the use of health-related technology (e.g., registering for a service such as vaccines or linkage to care after self-testing). • Develop a strategy for the effective and efficient use of CHWs during a public health emergency, including active case-finding, contact-tracing and health-education campaigns. • Elevate the status of CHWs as key resources in the health system to build trust within communities and ensure they are well utilised. **Implications for the rural context:** Given the human resource and access constraints in rural areas, CHWs could play a vital role not only in delivering health interventions but also use their local knowledge and the trust they have built to relay reliable health information and improve health literacy, especially during public health emergencies where much uncertainty exits.
	Capacity development • Conduct workload analysis and health workforce estimations to map the current workforce and determine the extent of training, development and recruitment needed to fill the current gaps. • Include pandemic preparedness in human resource planning to ensure adequate staffing and skill during a public health emergency and to guide reallocation of HCWs while maintaining essential health services. **Implications for the rural context:** Quantifying the workforce and understanding the trends in distribution would assist with human resource planning for rural areas and facilitate innovative ways to increase access to skilled HCWs.
	Occupational health and safety • Institute ongoing training on infection prevention and control (IPC) practices in order to prepare and protect staff, as well as patients. • Establish psychological support services including in-person and telehealth counselling services, support groups and departmental debriefings to address work-related stress and mental health concerns, and improve HCW resiliency and ability to cope during periods of heightened uncertainty and workload. **Implications for the rural context:** Availability of occupational health and safety interventions and increasing access to these resources, particularly those that can be delivered remotely, will benefit HCWs in rural settings who are more isolated and have less access to clinical and psychological support structures.

Health system building blocks and principles	Recommendations
Information	**Health data quality** • Implement data quality improvement interventions such as training on data collection, monthly reviews of data and data audits to improve the data available for decision-making. • Increase accessibility of data to the wider scientific community to allow for independent evaluation and analysis. • Improve accessibility of data to communities by ensuring that it is presented in an easily understandable manner. **Implications for the rural context:** The availability of quality data that is easily accessible to scientists and communities will allow for evaluation of the impact of interventions on specific communities and will improve context-specific decision-making.
	Integration of data systems • Establish a national-level health data system that integrates data from health facilities, laboratories, pharmacies and specific programme databases (e.g., for HIV and TB programme data) with the aim of improving clinical service delivery and enabling epidemiological surveillance and analysis. **Implications for the rural context:** An integrated data system that allows patients to be tracked across the health system is of particular importance to those in rural areas who often need to access higher levels of care in other geographic areas.
	Communication with the public • Employ social listening mechanisms to better understand population needs and concerns. • Develop context-specific communication strategies that address key concerns and misinformation. • Ensure detailed and transparent communication with the public to create trust in health services. **Implications for the rural context:** Specific campaigns that consider the rural context and challenges with access to information are needed and should be created in conjunction with trusted local leaders.

Health system building blocks and principles	Recommendations
Service delivery	**Integration of health services** • Scale up the integrated service delivery interventions introduced during COVID-19 to improve access and efficiency. • Ensure that integration is robust enough to withstand disruptions due to public health emergencies. • Utilise all health interactions to provide opportunistic screening and preventative treatment, especially in the wake of disrupted services of public health importance, such as childhood vaccinations. **Implications for the rural context:** Integrated and opportunistic service delivery is essential to ensuring access for rural communities where services are geographically distant. The usage of community-based integrated services such as mobile vans and CHWs will increase access, especially for those with multi-morbidities.
	Maintenance of essential health services • Develop public health emergency and disaster management plans to bolster efforts to maintain essential health services during public health emergencies. • Engage multi-disciplinary committees from clinical and public health disciplines as well as health management to create contingency plans for essential health service delivery at all levels of the health system. **Implications for the rural context:**: Specific plans that take into account the challenges to service delivery in rural areas are needed to ensure that essential service delivery during crises are not further impacted by failure to consider contextual factors.
	Surge capacity facilities • Create a national policy and protocols for establishment of surge capacity facilities, including quarantine, during public health emergencies. • Develop a framework to guide decisions on when and whether to repurpose or build surge capacity facilities. • Identify potential facilities that could be repurposed or adapted to address need.
	Integration with technology • Develop a framework to guide the use of technology across the health system, taking into consideration factors related to the technology itself, organisational structures, change management, cost and societal impacts, user perceptions and friendliness, and governance (including clinical governance). • Implement and scale-up state-of-the-art technological tools to enhance disease surveillance, screening tools, health communication, linkage to care and HCW training and development. • Address barriers to uptake of technology such as lack of trust in, and access to, data and technology. • Redesign service packages to include telehealth interventions such as teleconsultations, e-prescriptions, and referral services. **Implications for the rural context:** and telehealth have the potential to increase access to and for rural populations if barriers to access, such as cost, network coverage, and technology and health literacy, are addressed.

Health system building blocks and principles	Recommendations
Access	**Self-testing, self-screening and self-assessment** • Explore patient-directed health interventions across various health conditions in order to improve access, and enhance the agency patients possess with regard to their health. • Ensure robust linkage to care mechanisms to ensure that self-detected health concerns receive appropriate intervention. **Implications for the rural context:** These interventions have the potential to increase the access to health services of rural populations but geographic challenges and lack of health resources in general pose a threat to linkage to care. To overcome these hurdles, strategies such as CHW assistance may be needed.
	Mobile units • Invest in mobile units that can be repurposed for a variety of health system functions such as clinical prevention, testing and treatment, and laboratory and dispensary services. • Utilise point-of-care or rapid turnaround health technology to decrease potential for lack of follow-up care. **Implications for the rural context:** Mobile units allow for healthcare to be taken to remote and hard-to-reach places with the potential to increase access to a variety of health interventions but this must be accompanied by strategies to ensure follow up and linkage to care.
	Alternative delivery mechanisms for medication • Implement or scale up existing decentralised or alternative delivery mechanisms such as community halls, private pharmacies, fast-lanes and CHWs to decongest facilities and improve access and adherence to medication. • Institute strategies to bolster medication access during public health emergencies when restrictions on movement, fear of contracting disease or downscaling of essential health services may impact access to medication. **Implications for the rural context:** Decentralising and increasing the available avenues for medication collection and delivery will increase access, provided that the avenues selected consider contextual factors and challenges that may impede efficiency.

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