Executive Summary
Following introduction of COVID-19 into South Africa in early March 2020, and the peaking of cases during the week 5-11 July 2020 (over 13,000 cases daily), the daily case load has declined to below 1000 cases per day, with 7% positivity rate. Many countries where COVID was initially contained through public health interventions are now experiencing a ‘second wave’ of COVID infection. The Ministerial Advisory Committee (MAC) was tasked in late August 2020 with responding to the question ‘What does ‘being ready for the ‘COVID-19 second wave’ ‘mean in terms of prevention, detection and response activities? A MAC technical working group (TWG) sought to define a second wave and associated epidemiological features, investigate epidemiological factors associated with a second wave in countries where these have occurred, delineate surveillance activities to support detection and monitoring of a second wave, and finally to make recommendations regarding prevention detection and response activities.

We defined a ‘second wave’ as a new wave lasting one or more days, commencing after the ‘end of wave’ after the previous peak where case load returns to 30% of the previous peak case load. We also defined other parameters to signal a rising case load, namely an uptick, upswing and resurgence.

The group identified 113 countries for analysis that have more than 1 million inhabitants, and a COVID-19 incidence of >10/million cases and described the epidemiology of first and second waves for 49 (first epidemic wave concluded) and 24 (one or more additional wave). Amongst ten countries identified for in-depth case studies, the seroprevalence studies (where available) were all under 10% and the decline in cases leading to the end of the first wave is believed to have been driven by non-pharmaceutical interventions (restrictions imposed to curb the spread of the virus). The TWG also reviewed available serological data on RSA populations and concluded that widespread transmission over a period of more than three months has likely left South Africa with substantial population-level immunity albeit unevenly distributed. In the light of these observations, the TWG concluded that the factors driving the decline in incidence in South Africa differ meaningfully from factors driving the decline in all case study countries and may have been driven by population-level immunity.

Regarding historical data from the 1918 H1N1 influenza pandemic, commentators speculated that the occurrence and nature of a second wave is driven by the level of immunity in the population. If initial
interventions were not severe enough to halt transmission (or if restrictions are lifted slowly enough), immunity accumulated in the population through a longer first wave with a lower peak, leading to herd immunity, such that a subsequent wave was not possible and did not occur.

A number of factors that could be informative to identify ‘at risk’ communities include local (ward-based) data on 1) the number of laboratory-confirmed cases per population to date, 2) the number of tests performed per population to date, 3) the degree to which wards are connected to other wards through population mobility (e.g., as can be measured through mobile phone data), 4) cumulative test positivity to date, 5) population density, and 5) indicators of social vulnerability. Synthesizing data across these parameters may provide sufficient context to help identify areas of relatively high and low risk.

In the light of the above findings, the TWG believes that resurgences are expected and a second wave may occur; however, it is unlikely that a second wave will occur within the next 6-8 months, unless immunity wanes extremely rapidly. If a second wave does occur, it is expected to peak at a lower level than the first wave. Reduced adherence to nonpharmaceutical interventions, waning immunity, and seasonality of transmission could increase the risk of a second wave or a substantial post-wave resurgence as we move into winter of 2021. Beyond the time frame of 6-8 months, it is difficult to assess the likelihood of a second wave.

The TWG summarised the current COVID-19 surveillance methodologies that are currently underway in South Africa, and tabulated their strengths and weaknesses. These include case-detection (current active cases), incidence rate and proportion tested positive (PTP)), notifiable medical conditions surveillance, hospital admissions due to COVID, deaths due to COVID-19, NICD sentinel site surveillance for SARI and ILI, molecular surveillance (NGS-SA), wastewater surveillance (SACCESS) and population-based serosurveys. Lastly, the TWG identified how these surveillance indicators can be meaningfully used at national, provincial and district levels of the health system.

This TWG is of the opinion that a second wave within the next 4-6 months cannot be ruled out, but may not be as large as the first wave (in terms of burden of cases). Strengthened surveillance mechanisms need to be in place to support detection and prevention interventions. In support of this assessment, the TWG has the following recommendations regarding strengthening COVID-19 surveillance.

- That current surveillance activities be continued as described in this TWG’s Appendix, and that slight modifications of indicators contained in the IMT Resurgence Plan be made.
- That daily interpretation of the surveillance indicators (end-of-wave, uptick, upswing, resurgence, new wave etc) as described by this advisory and detailed in the appendix be undertaken by national and provincial epidemiology teams and that these data be used at all levels of the health system to guide preparedness and response activities
- That testing criteria be broadened nationally and implemented provincially to ensure representative testing across at-risk areas
- That a COVID-19 surveillance forum lead by the NICD/NDoH/IMT, including all institutions/stakeholders doing surveillance, provincial DOH and academics, be established and meet as soon as possible to correlate and interpret surveillance data across all modalities.
- That data collection methodology at the point of specimen collection be strengthened to ensure accuracy and improved data quality. This includes the use of electronic data capture at point of specimen collection and inclusion of additional data elements (e.g. origin of specimens such as outbreak investigations in schools, institutions, workplaces and care facilities) to facilitate identification of localised outbreaks.
- That immediate and ongoing investment be made in IT and business intelligence data systems to support national and provincial surveillance and response activities. These should incorporate or
That national, provincial and district teams endorse, support and communicate the benefits of COVIDConnect to the general population and health care workers to ensure uptake, and that contact tracing teams integrate COVIDConnect into contact tracing and responses.

That cause of death data should be strengthened by ensuring rapid capture of death notification forms, and that cause-of-death findings at sub-district level be made available in good time to national and provincial health departments.

That provinces develop resurgence action plans with clear terms of reference. Plans should include a surge response team with named personnel to support COVID-19 containment efforts should a second wave require additional human resources. These surge response teams should include epidemiologists, public health specialists, data analysts, health system analysts, communication specialists, behaviour change experts as well as clinicians, community health workers, contact tracers, and case investigation leads. Response plans should take into account differing urban and rural health systems by accommodating traditional community and religious leaders where appropriate.
General comments

A COVID-19 Surveillance Forum

Application of ‘second wave’ definitions at provincial and district levels to support meaningful interpretation of case-based surveillance data

Integration of surveillance data into provincial outbreak response activities

Case-based surveillance and COVID-10 testing criteria

Strengthening data quality for case-based surveillance

Strengthening mortality surveillance

Conclusion
Background and introduction
The COVID-19 pandemic has swept through South Africa commencing 5 March 2020 with the introduction of the virus through returning travellers from endemic regions and subsequent amplification. A national lockdown implemented from 27 March to 30 April 2020 slowed but did not halt transmission of the virus. Detected cases of COVID peaked around epidemiological week 28, (5-11 July 2020) with a maximum proportion test positivity of just over 30%. Subsequently the daily case load has declined to below 100 cases per day, with 7% positivity rate. Many countries where COVID was initially contained through public health interventions are experiencing a ‘second wave’ of COVID infection – a phenomenon seen with the 1918 ‘Spanish influenza’, and the 2009 H1N1 influenza resurgence. The Ministerial Advisory Committee (MAC) was tasked with responding to the question ‘What does ‘being ready for the ‘second wave’ ‘mean in terms of prevention, detection and response activities?

Terms of reference and scope of this advisory
A technical working group ‘TWG’ of the MAC was convened and met on 24th and 28th August, and 9th September to agree on scope of work and how to structure a response. It was agreed to provide an evidence-based review into epidemiological factors associated with a second wave, identify and recommend surveillance methodologies and indicators, and to provide insightful and critical commentary on the COVID-19 resurgence plan in development by the National Department of Health.

Whilst there was a wish to recommend practical ways to strengthen COVID-19 preparedness and response activities at district and provincial level, and to advise on behavioural interventions, it was recognised that several initiatives were already underway which met this need, namely the WHO ‘Intra-action review’ (IAR) and work being done by the newly constituted COVID-19 Behavioural Interventions Ministerial Advisory Committee.

Structure of this ‘In-depth appendix’
The ‘in-depth appendix’ accompanies the advisory and recommendations and is structured as follows:

- Part A – Theoretical and evidence-base for recommendations pertaining to a COVID second wave
  - Section 1 - Epidemiological factors associated with a second wave
  - Section 2 - COVID surveillance activities to support detection of a second wave
- Part B Recommendations regarding preparations for a COVID second wave
Part A – Theoretical and evidence-base for recommendations pertaining to a COVID second wave

Section 1- Epidemiological factors associated with a second wave

Outline of Section 1
In this section, we define a ‘second wave’, and terminology that is useful for monitoring epidemiological trends including a ‘resurgence’, ‘uptick’ and an ‘upswing’ and explain the methodology behind reaching these definitions. We examine factors associated with ‘second waves’ in countries where these have occurred, and we look at epidemiological factors that may contribute to a second wave in South Africa. We comment on the likelihood and timing of a possible second wave in South Africa.

Defining the ‘second wave’ and terminology

Methodology regarding thresholds for definitions
The goal of this analysis is to provide a non-mechanistic, case-study based risk assessment for countries which indicates the likelihood within various time periods of ending a current epidemic wave or, if they have ended the current wave but not completely eliminated transmission, of entering a new epidemic wave. We have selected pragmatic operational thresholds, rather than theoretically-based ones.

Wave Peak
We identify peaks retrospectively using the Zig Zag (ZZ) algorithm, which identifies changes in trends by constructing a time series of increases and decreases that smooths over small fluctuations\(^1\). Once the ZZ time series is constructed, peaks are defined as local maxima in the ZZ time series, which are greater than 10 7-day average incidence per million, and for which the trend increases for at least a specified number of days (d) prior to the maximum and decreases for at least the same number of days following the maximum. In this analysis, we use \(d = 14\) days.

End-of-Wave Threshold
Achieving the end-of-wave threshold corresponds to having a time period (E.g. a week or two weeks) where the 7 day moving average of cases is sustained at or lower than a small fraction of recent peak incidence.

We set the end-of-wave threshold as 15\% of the peak incidence or case load, measured in terms of 7-day moving average of case incidence. We specifically use last-7 day average incidence per 1 million capita as reported in Our World In Data\(^2\); for the purposes of this analysis, using the 7-day running average (either absolute or per capita) would be equivalent.

New Wave Threshold
If the epidemic reaches the end-of-wave threshold, it may still return to an incidence level that is a sufficiently high fraction of the previous wave peak incidence to warrant revisiting control efforts. This is defined in the same way as the end-of-wave threshold, though at a different fraction, and it does not reset until 1) the end-of-wave threshold has been met and 2) incidence then rises above the new wave threshold.

For the purposes of our statistical risk assessment, we then need to characterize distinct waves within or between peaks. The prospective operational indicators are upticks, upswings, resurgence, and exceeding the new wave threshold (defined in subsequent sections).

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\(^1\) http://www.investopedia.com/terms/z/zig_zag_indicator.asp
\(^2\) https://ourworldindata.org/coronavirus
Uptick and Upswing

A period is labelled an *uptick* if a target number of consecutive increases in incidence OR test positivity has been observed. An *upswing* is similar, though defined in terms of exceeding a target of net increases (number of periods with increases - number of periods with decreases) over a window; so an upswing window can still include no-change periods or even decreases, depending on the threshold settings. This approach has been followed elsewhere.³

For *upticks*, we use a threshold of 5 days of consecutive increases in last-day average incidence per million (measured in terms of positive tests) OR the proportion of tests that are positive. For *upswings*, we use a threshold of net 6 increases in a window of the previous 8 days (of 7-day average incidence per million or positivity); this means there is at most one decrease in incidence during that period (with all other days having increases) or at most two days of no change (with all other days having increases).

Resurgence

A resurgence occurs when a previously declining or roughly stable level of incidence and test positivity changes to a consistently increasing trend. We operationalize this to mean 1) an *uptick* that occurs within an *upswing* that 2) occurs before the end-of-wave threshold has been reached (a midwave resurgence) OR that exceeds the most recently met end-of-wave threshold (a post-wave resurgence).

Using defined parameters to guide response efforts

To support response efforts, we are generally interested this question: how do observable prospective indicators (such as upticks, upswings, and their combination in resurgences) indicate the likelihood (over a certain time interval) to either fail to meet the end-of-wave threshold or, if a setting has met the end-of-wave threshold, to exceed the new wave threshold.

To calculate this likelihood, we need the correct denominator in our case study series. Once a wave is underway (either the run up to the first wave or after the new wave threshold is exceeded), upticks, upswings, and resurgences are no longer tallied for our analytical purposes, as the target event is occurring. Once the wave peak is reached, however, we resume tallying these indicators to contribute to our estimate of what will happen after such a wave.

Definitions

Throughout this document, we distinguish between the following types of dynamics (see ‘Definitions and methods’ for technical definitions) (Box 1) which are illustrated in Figure 1. Thresholds and precise definitions are listed in Table 1.

**Box 1. Epidemic dynamics related to COVID-19 epidemiology**

- **An epidemic wave** is an increase in cases that reaches some threshold value. The wave is said to have ended when the case incidence* drops below a threshold value defined relative to the maximum case incidence* experienced during the wave.
- **A second wave** is a major increase in case incidence* (above a threshold value defined relative to the maximum case incidence* experienced during the first wave), following the end of the first wave of the epidemic.
- **A resurgence** is a substantial increase in cases before the current wave has ended (midwave resurgence; may occur in the first wave or subsequent waves) or in the inter-wave period (postwave resurgence).
- **An upswing** is an increasing trend in case incidence* or test positivity.
- **An uptick** is continuous increase in case incidence* or test positivity over the course of 5 days or more.

* based on the 7-day moving average

³ [https://www.dph.illinois.gov/regionmetrics?regionID=1].
Figure 1. The French epidemic curve, illustrating epidemic dynamics as defined in Box 1 (data from ‘Our World in Data https://ourworldindata.org/coronavirus)

Table 1. Epidemic dynamics – definitions and thresholds

<table>
<thead>
<tr>
<th>Event</th>
<th>Definition</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave peak</td>
<td>Retrospectively defined as the highest value during which increases were consistently observed for the 14 day period prior to the value, and decreases were consistently observed for the 14 day period after the value, after accounting for small fluctuations in the time series. For a peak to be considered a ‘wave peak’ it must reach at least 10 confirmed cases per million population.</td>
<td>A peak as per definition, which is at least greater than 10 confirmed cases per million population</td>
</tr>
<tr>
<td>End of wave</td>
<td>A period (currently one day) where the case load is (sustained) at or lower than a specific fraction of recent peak incidence</td>
<td>15% of peak incidence or case load</td>
</tr>
<tr>
<td>Uptick</td>
<td>A target number of consecutive increases in incidence OR test positivity have been observed</td>
<td>An increase in cases for 5 consecutive days</td>
</tr>
<tr>
<td>Upswing</td>
<td>A target number of net increases within a defined period; so an upswing window can still include no-change periods or even decreases, depending on the threshold settings</td>
<td>A net of 6 daily increases in case numbers or incidence over the 8 previous days</td>
</tr>
<tr>
<td>Resurgence</td>
<td>A resurgence occurs when a previously declining or roughly stable level of incidence and test positivity changes to a consistently increasing trend. In practical terms a resurgence is identified when an uptick occurs within an upswing either before the end-of-wave threshold has been reached (a midwave resurgence) OR that exceeds the most recently met end-of-wave threshold (a post-wave resurgence).</td>
<td>Co-occurrence of an upswing and an uptick</td>
</tr>
<tr>
<td>New wave</td>
<td>A period (currently 1 day) where case load returns to a specific fraction of the previous peak case load or incidence AFTER the end-of-wave threshold has been met</td>
<td>30% of peak incidence or case load</td>
</tr>
</tbody>
</table>

*all increases/decreases are relative to the 7 day moving average
Epidemiology of a ‘second wave’ (as of 15 October 2020)

Global characterisations of ‘second wave’ epidemiology

Identification of countries for analysis

In this analysis, we included 113 countries that met both the following criteria:

- Has a population of at least 1 million
- Has had a daily incidence of confirmed COVID-19 cases (based on the 7-day moving average) of at least 10 per million population

We additionally excluded countries that met any of the following criteria:

- Did not have incidence data available via Our World in Data
- Had any negative 7-day-average incidence of confirmed cases
- Datasets from ‘Our World in Data’ were downloaded. Data sources are as described at https://ourworldindata.org/coronavirus

Findings of analysis

- To date, 49 countries of the 113 countries selected for analysis have concluded their first epidemic wave and, of these, 24 have experienced additional wave(s) and 5 have seen one of more of those additional waves end.
- For those countries ending the first wave,
  - the median time from the peak to the end of the first wave was 39 days (interquartile range: 24-54), and
  - the median number of cumulative confirmed cases per million population at the end of the first wave was 1282 (IQR: 564-3749; 694, IQR: 345-1910 for only those experiencing a second wave and 1407, IQR: 926-6247 for those not yet experiencing a second wave)
- The median ratio of the magnitude of the wave peak to the size of the post wave trough was 30 (IQR: 13-74).
- The median ratio of test positivity at the peak of the first wave to the end of the first wave was 50 (IQR: 22-inf).
- The median time from the end of the first wave to the beginning of the second wave was 66 days (IQR: 24-84).
- The median number of days in a resurgence within the month preceding the beginning of the second wave was 3 (IQR: 0-7).
- The median number of days in a resurgence within the two weeks preceding the beginning of the second wave was 2 (Range: 0-5).
- 11 of the 25 countries that have experienced a post-wave resurgence entered a second wave within one month of the beginning of the first resurgence after ending the initial wave.
- In 12 of the 24 countries experiencing subsequent waves, the peak of those waves has exceeded the magnitude of the first wave peak.

We examined ten countries experiencing second waves in more detail to gain an understanding of the epidemiological patterns they have experienced: Australia, Belgium, Denmark, France, Israel, Netherlands, Serbia, Slovenia, South Korea, and Spain. Table 2 shows key dates and features of the epidemic dynamics in each of these countries.
In-country experiences of the ‘second wave’ in selected countries

In all of the case study countries, the decline in cases leading to the end of the first wave is believed to have been driven by non-pharmaceutical interventions (restrictions imposed to curb the spread of the virus).

In Australia\(^4\), South Korea\(^5\), and Slovenia\(^6\), a key factor in controlling the first wave was efficient contact tracing, isolation, and quarantine (CTIQ) procedures, implemented while case numbers remained low. Australia and Slovenia combined efficient CTIQ with travel restrictions, border closures, shutdown of non-essential services and stay-at-home orders. These three countries had relatively small first peaks (15.3, 11.9, and 23.0 confirmed cases per million population, respectively) and low total numbers of cases in the first wave (<700 confirmed cases per million population). Denmark\(^7\), Israel, and Serbia also had early responses but lacked efficient CTIQ procedures, relying on strict lockdowns to bring their epidemics under control. These countries had intermediate first wave peaks (56.4-73.1 confirmed cases per million population) and moderate numbers of cases in the first wave (1,661-1,987). Notably, Denmark had a particularly high testing rate (106 cumulative tests per thousand population by the end of the first wave), which may skew the picture of its epidemic, making it appear worse than it was relative to other contexts. Belgium, France, Netherlands, and Spain\(^8\) implemented strict lockdowns only after they had high case numbers, resulting in larger first peaks (65.4-169.0 confirmed cases per million population) and relatively high numbers of cases in the first wave (2,156 - 4,951). For comparison, South Africa concluded the first wave of its epidemic on 8 September with a peak incidence of 212.2 and 10,780 confirmed cases per million population.

Seroprevalence studies have been conducted in some of the case study countries. Specifically, Spain conducted a large, nationally representative serological study toward the end of their first wave (27 April - 11 May)\(^9\). Nationally, the estimated seroprevalence was approximately 5%, but estimates varied substantially in different locations. Madrid and some surrounding regions had the highest estimated seroprevalences at >10% (but <15%). Another study\(^10\), conducted earlier in the epidemic (28 March - 9 April), found that seroprevalence among health care workers in Barcelona was 7.1-12%, suggesting that those at high risk of infection may have had substantially higher seroprevalence by the end of the first wave.

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\(^5\) [https://theconversation.com/4-ways-australias-coronavirus-response-was-a-triumph-and-4-ways-it-fell-short-339845](https://theconversation.com/4-ways-australias-coronavirus-response-was-a-triumph-and-4-ways-it-fell-short-339845)


\(^7\) [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7217796/](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7217796/)

\(^8\) [https://time.com/5871218/spain-coronavirus-cases/](https://time.com/5871218/spain-coronavirus-cases/)

\(^9\) [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31483-5/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31483-5/fulltext)

\(^10\) [https://www.nature.com/articles/s41467-020-17318-x](https://www.nature.com/articles/s41467-020-17318-x)
Factors anecdotally identified as driving the second wave in these countries include

- Australia\textsuperscript{18}: spread from private quarantine facilities (guards), reaching closely connected communities (care homes and public housing)
- Belgium: easing of restrictions, summer vacation activities

\textsuperscript{11} https://www.researchsquare.com/article/rs-25862/v1
\textsuperscript{12} https://www.jpost.com/israel-news/coronavirus-herd-immunity-not-in-israel-according-to-a-serological-study-630059
\textsuperscript{13} https://www.uantwerpen.be/en/research-groups/vaxinfecctio/corona-research/sero-epidemiology-co/
\textsuperscript{14} https://jamanetwork.com/journals/jama/fullarticle/2767382
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\textsuperscript{18} https://files.ssi.dk/Notat_foreløbige_resultater_pilotundersøgelse_seropraevalens_COVID-19_29_6_2020
\textsuperscript{19} https://bloddonor.dk/coronavirus/
\textsuperscript{20} https://datastudio.google.com/embed/reporting/c14a5cf-848c-0369173148ab/page/tpkx
\textsuperscript{21} https://www.connexionfrance.com/French-news/Coronavirus-which-parts-of-France-are-seeing-more-cases-Interactive-map-as-healthauthorities-issue-warnings
\textsuperscript{22} https://www.thelocal.fr/20200717/map-which-areas-of-france-are-of-concern-to-authorities-as-covid-19-cases-rise
\textsuperscript{23} https://www.sciencedirect.com/science/article/pii/S1473309920300078
\textsuperscript{24} https://allecijfers.nl/nieuws/statistieken-over-het-corona-virus-en-covid19
\textsuperscript{25} https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030
\textsuperscript{26} https://cncovid.isciii.es/covid19/#provincias
\textsuperscript{28} https://www.newscientist.com/article/2249150-how-did-australia-lose-its-grip-on-covid-19-and-can-it-get-it-back/#ixzz6WypwpWkmf
• Denmark\textsuperscript{29}: reopening of borders and removal of restrictions
• France\textsuperscript{30}: summer travel and poor adherence to restrictions, especially among younger persons
• Israel: lifting of most restrictions, reopening of schools\textsuperscript{31, 32} poor public support for interventions\textsuperscript{33}
• Netherlands: easing of restrictions from 1 June and more so as of July 1, 2020\textsuperscript{34}
• Serbia: mass gatherings\textsuperscript{35} / lifted curfew\textsuperscript{36}; younger agegroups
• Slovenia: poor adherence to social distancing and non-adherence to quarantine\textsuperscript{37}; outbreaks in care homes
• South Korea\textsuperscript{38}: large gatherings (eg religious) and other superspreading events (eg large office buildings)
• Spain\textsuperscript{39}: return of nightlife / group activities, particularly in younger people

In several countries, there has been a marked demographic shift in the second wave, with the majority of infections in younger populations (e.g., Belgium, Denmark\textsuperscript{40}, France\textsuperscript{41}, Israel\textsuperscript{42}, Netherlands\textsuperscript{43}, Spain\textsuperscript{44}). In addition, disease severity appears to have decreased in the second wave in a number of locations (Belgium\textsuperscript{45}, Denmark\textsuperscript{46}, France\textsuperscript{47}, Israel\textsuperscript{48}, Netherlands\textsuperscript{49}, Spain\textsuperscript{50}), likely due to a combination of factors including younger people getting infected, increased experience of clinicians in treating the disease, better therapeutic options, and (in some locations) broader criteria for testing.

Historical experiences with pandemic waves
The patterns seen in the case study countries described above are consistent with the epidemiology of second waves seen in influenza pandemics. The 1918 flu pandemic has been particularly well studied, with multiple publications demonstrating that the strength, duration, and effectiveness of NPIs

\textsuperscript{29} https://www.themayor.eu/en/denmark-tightens-coronavirus-restrictions
\textsuperscript{34} https://bloddonor.dk/coronavirus/
\textsuperscript{35} https://tass.com/world/1178401
\textsuperscript{36} https://www.zslaw.rs/serbia-lifts-state-of-emergency-and-cancels-curfew/
\textsuperscript{38} https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030&act=view&list_no=368031&tag=&nPage=6
\textsuperscript{40} https://www.ssi.dk/sygdomme-beredskab-og-forskning/sygdomsovervaagning/c/covid19-overvaagning
\textsuperscript{42} https://www.science.co.il/medical/coronavirus/Distribution-age.php
\textsuperscript{43} https://allejifiers.nl/nieuws/statistieken-over-het-corona-virus-en-covid19/
\textsuperscript{44} https://www.issi.eu/QueHacemos/Servicios/VigilanciaSaludPublicaRENAVE/EnfermedadesTransmisibles/Paginas/-COVID-19.-Informes-previos.aspx
\textsuperscript{46} https://covid19.who.int/region/euro/country/dk
\textsuperscript{47} https://covid19.who.int/region/euro/country/fr
\textsuperscript{48} https://www.science.co.il/medical/coronavirus/Statistics.php
\textsuperscript{49} https://covid19.who.int/region/euro/country/nl
\textsuperscript{50} https://www.issi.eu/QueHacemos/Servicios/VigilanciaSaludPublicaRENAVE/EnfermedadesTransmisibles/Paginas/-COVID-19.-Informes-previos.aspx
determine, at the scale of a city, whether a second wave occurs and its relative magnitude\textsuperscript{51,52,53}. Markel \textit{et al}.\textsuperscript{53} observed: “Overall, cities that implemented nonpharmaceutical interventions earlier experienced delays in the time to peak mortality, reductions in the magnitude of the peak mortality, and decreases in the total mortality burden.” This is consistent with the patterns for the first wave of the COVID-19 epidemic in the case study countries, as described above. Both Markel\textsuperscript{53} and Hatchett\textsuperscript{51} observed that no cities saw a second wave so long as NPIs remained in place; second waves only occurred after relaxation of interventions. Bootsma and Ferguson\textsuperscript{52} contend that the occurrence and nature of a second wave is driven by the level of immunity in the population. Essentially, they argue, second waves occur when the initial intervention is ‘too’ effective, driving down transmission so severely that little immunity is accumulated in the population. When such interventions are rapidly lifted, transmission rebounds causing a second wave; in contrast, if interventions are not severe enough to halt transmission (or if restrictions are lifted slowly enough), immunity accumulates in the population through a longer first wave with a lower peak, which may result in herd immunity, such that a subsequent wave is not possible. They demonstrate these dynamics by fitting a model to the mortality data from 47 United States cities.

\textit{Will a ‘second wave’ occur in RSA?}

Epidemiological factors associated with the current decline in case load in South Africa

Based on our definitions, South Africa reached the end of its first wave on 8 September, and cases have been declining steadily since the epidemic peaked on 20 July. Despite an early and extensive lockdown from 27 March to 30 April 2020, the South African epidemic was not brought under control, and the effective reproduction number remained above 1 throughout the Stage 5 lockdown. This is in contradistinction to European countries where the lockdown appears to have contained transmission. Despite the apparent ineffectiveness of containing transmission in South Africa, a decline in incidence has occurred as restrictions have been lifted. These observations suggest that the factors driving the decline in incidence in South Africa differ meaningfully from factors driving the decline in all case study countries. This begs the question as to whether or not increasing population-level immunity may be contributing to a reduction in transmission.

Interpreting current serological evidence

There are few available seroprevalence studies in South Africa. Marvin Hsiao and colleagues (personal communication) from UCT/NHLS reported on SARS-CoV-2 seroprevalence in antenatal women and people living with HIV in samples collected between 17 July and 17 August 2020. Overall, a seroprevalence of 37\% in the Cape Metro subdistricts, ranging from ~30\% in CT Southern and Eastern subdistricts to ~45\% in Klipfontein and Khayelitsha was reported. Higher seroprevalence was seen in PLWHIV (relative to antenatal samples), more densely populated subdistricts, and women (relative to men). Age-specific seroprevalence ranged from 30.3\% (>55 years) to 48.7\% (45-49 years), though some age categories had small sample sizes.

The seroprevalence estimates from these convenience samples may overestimate the true population seroprevalence (as these persons attended clinic during this time period and were therefore relatively mobile), though biases in both directions are likely (serology assays may be falsely negative in persons more recently infected, and test validation panels likely over represent severe cases\textsuperscript{54,55}). The observed


\textsuperscript{54} https://academic.oup.com/aje/advance-article/doi/10.1093/aje/kwaa188/5900104

\textsuperscript{55} https://academic.oup.com/jid/advance-article/doi/10.1093/infdis/jiaa523/5898481
differences between subsamples indicates that cautious interpretation is warranted. Nevertheless, seroprevalence is high enough to indicate that active immunity is likely playing an important role in the current epidemic decline, and is consistent with the infection fatality ratio being within the bounds of expectation. The findings of this study are consistent with recent serological results from Kenya\textsuperscript{56}, which is at a similar stage of its epidemic to South Africa. In general, studies from LMIC settings have found substantially higher seroprevalences than seen in developed countries. These include seroprevalences of 38\% in adult male blood donors in Karachi, Pakistan\textsuperscript{57}, 40\% in a population-based survey in Maranhao, Brazil\textsuperscript{58}, 57\% in slums and 16\% in non-slum areas in Mumbai, India\textsuperscript{59}, 45\% in a population-based survey in Atahualpa, Ecuador\textsuperscript{60}, and 71\% in a population based survey in Iquitos, Peru\textsuperscript{61}.

Identifying communities ‘at-risk’ for a second wave

Due to widespread transmission over a period of more than three months, and as indicated by preliminary serological results, South Africa is likely to have ended its first epidemic wave with substantial population-level immunity; however, this immunity is not likely to be evenly distributed, and substantial pockets of susceptibility may remain.

Nationally representative serological studies will be invaluable to determine which communities remain at risk; however, such results will not be available for some time. In the meantime, there are a number of factors that could be informative when thinking about communities that are ‘at-risk’ for a second wave, which can be assessed at the ward level. These include information on

1. the number of laboratory-confirmed cases per population to date,
2. the number of tests performed per population to date,
3. the degree to which wards are connected to other wards through population mobility (e.g., as can be measured through mobile phone data),
4. cumulative test positivity to date,
5. population density, and
6. indicators of social vulnerability.

While none of these factors alone will give a clear picture of future transmission risk, synthesizing across this information may provide sufficient context to help identify areas of relatively high and low risk. For example, wards with low numbers of confirmed cases per population may be areas that have not yet experienced significant transmission or areas with particularly low testing levels. By combining this information with data on testing patterns to date and test positivity, we should be able to identify which wards have seen low transmission to date, or have an unknown transmission history.

Population density and social vulnerability serve as proxies for crowded living conditions and the extent to which the population has the ability to reduce contact and prevent onward transmission. Population mobility serves as a proxy for the risk of seeding infection from outside areas. Thus, among those wards having seen low transmission to date or with unknown transmission history, those with high population density, high social vulnerability, and/or high mobility are likely to constitute the highest risk areas for future spread.

Although this assessment does not give a precise quantitative indicator for which areas are most at risk, it does provide us information about which areas are highest priority for timely collection of serological

\textsuperscript{56} \url{https://www.medrxiv.org/content/10.1101/2020.09.02.20186817v1}
\textsuperscript{57} \url{https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7444608/}
\textsuperscript{58} \url{https://www.medrxiv.org/content/10.1101/2020.08.28.20180463v1}
\textsuperscript{59} \url{https://www.tifr.res.in/TSN/article/Mumbai-Serosurvey%20Technical%20Report-NITI.pdf}
\textsuperscript{60} \url{https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa1055/5876901}
\textsuperscript{61} \url{https://www.researchgate.net/publication/343414173_Seroprevalence_of_anti-SARS-CoV-2_antibodies_in_the_city_of_Iquitos_Loreto_Peru}
data (those with unknown transmission history), and can be used to develop a relative scaling for areas where potential new hotspots might emerge.

To this end, the South African COVID-19 Modelling Consortium (SACMC) is developing a dashboard to combine data sources to identify communities that may be at risk of a second wave. This dashboard will include graphical and numerical output to allow the user to assess spatial patterns (in the form of maps) and identify wards that meet user-specified criteria thought to be associated with risk of further transmission. Some example output is illustrated in Figure 2. Once available, seroprevalence data can be added as a map layer in the dashboard to provide a more robust risk assessment.

Likely scenarios for South Africa.
In the light of the above findings, the TWG believes that resurgences are expected and a second wave may occur; however, it is unlikely that a second wave will occur within the next 4-6 months, unless immunity wanes extremely rapidly or if population behavioural characteristics change significantly. The latter may take place, if for example, during December travel, SARS-CoV-2 is introduced into naïve populations and social distancing and other NPIs are not adhered to. If a second wave does occur, it is expected to peak at a lower level than the first wave. Health services are unlikely to be overwhelmed. Beyond this time frame, it is difficult to assess the likelihood of a second wave. Reduced adherence to nonpharmaceutical interventions, waning immunity, and seasonality of transmission could increase the risk of a second wave or a substantial post-wave resurgence as we move into winter of 2021.

![Figure 2. Left: Cases per one million population per ward in South Africa (as at 8 September 2020) Data source: National Institute for Communicable Diseases. Right: Level 2 Mobility per ward in Gauteng, defined as proportion of individuals with significant movement outside ward. Data Source: Vodacom Mobility Data (Period: 18-27 August). (NB: This app should be ready for demonstration purposes as of 15 September. A link can be provided but will require login, as some of the data cannot be shared publicly)](image)

Key uncertainties in predicting a second wave in South Africa
There are at least five mechanisms that can drive second pandemic waves:

- a change in viral transmissibility (e.g., due to seasonality),
- behavioural changes in a population,
- spread among weakly connected subpopulations,
- viral evolution, and
• **waning immunity**

When applied to COVID-19, there is substantial uncertainty about the details of each potential mechanism, so we will take them in turn. Viral transmissibility mainly changes in one of two ways – either through a substantial shift in population-level contact patterns (such as resulting from school terms, which is thought to drive seasonality of many childhood infections, including measles⁶³) or through seasonal effects on viral stability in the environment. Both are possible for COVID-19 in South Africa, and the former is strongly linked to the second mechanism of behavioural changes. Seasonality is known to be important for the transmission of endemic human coronaviruses; however, this is an effect that emerges with the long-term circulation of a pathogen. Early in a pathogen’s spread, the small seasonal differences in transmissibility that later come to define transmission seasons are effectively irrelevant early on in a pandemic, when the availability of a large susceptible population provides near unlimited opportunity for transmission⁶⁴.

There are a number of anticipated behavioural changes that may affect the possibility of a second wave in South Africa. These include the reopening of schools, loosening of other restrictions as the economy opens, reduced adherence to NPIs as restrictions are loosened, and travel during the upcoming summer holidays. Each of these anticipated changes is likely to cause a relative increase in transmission; however, the question remains whether that increase is sufficient to bring the effective reproduction number above 1 in the context of the current existing population immunity. The fact that the epidemic has declined as restrictions have eased to date is promising, but this remains one of the key areas of uncertainty with regard to the possibility of resurgences and even a potential second wave.

Based on the data available so far, there is substantial geographic heterogeneity in seroprevalence. This is likely an indicator that the South African population can be considered to form a set of weakly connected subpopulations. Overall, it appears that the areas with the highest attack rates in South Africa’s first wave have been densely crowded urban areas and informal settlements. In one study of the 1918 influenza pandemic in Norway⁶⁵, it was observed that “the first wave hits the poor; the second wave hits the rich.” South Africa could be in a similar situation currently, with little immunity among the affluent populations who were able to substantially reduce contacts through effective NPIs. Rural areas may also constitute weakly connected subpopulations with low or varying levels of immunity. Thus, introductions into these subpopulations are likely to cause outbreaks over the coming months, but there remains substantial uncertainty regarding the numbers of people who will be infected as these pockets of susceptibility are hit.

Viral evolution plays a large role in the epidemiology of influenza but is thought to play less of a role with coronaviruses, which tend to be relatively genetically stable.

Waning of immunity to SARS-CoV-2 is one of the biggest sources of uncertainty that will determine the likelihood, timing, and magnitude of potential subsequent waves of transmission. While it is evident that there is some level of protective immunity conferred by SARS-CoV-2 infection, the extent and duration of protective immunity – particularly for those who had mild or asymptomatic cases – is uncertain. The duration of immunity for related coronaviruses is estimated to be between about 8 months⁶⁶ and 4 years⁶⁴, with reinfections commonly occurring 12 months after a previous infection⁶⁷. These findings

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⁶³ [https://science.sciencemag.org/content/287/5453/667.full](https://science.sciencemag.org/content/287/5453/667.full)

⁶⁴ [https://science.sciencemag.org/content/369/6501/315.full](https://science.sciencemag.org/content/369/6501/315.full)

⁶⁵ [https://europepmc.org/article/med/29356350](https://europepmc.org/article/med/29356350)

⁶⁶ [https://science.sciencemag.org/content/368/6493/860](https://science.sciencemag.org/content/368/6493/860)

⁶⁷ [https://www.medrxiv.org/content/10.1101/2020.05.11.20086439v2.full.pdf](https://www.medrxiv.org/content/10.1101/2020.05.11.20086439v2.full.pdf)
suggest that the apparently high level of immunity (or at least previous exposure) currently found in the South African population may not persist, suggesting substantial potential for a second wave in winter 2021 if a vaccine is not available.

Section 2 - COVID surveillance activities to support detection of a second wave

Structure of Section 2
In Section 2 we define surveillance and outline the aim and objectives of COVID surveillance. We identify COVID surveillance activities that are currently taking place, and tabulate how these data are potentially useful at different levels of the health system.

Definition of surveillance
Epidemiological surveillance is the systematic collection, analysis and dissemination of health data (in this case data on COVID-19) for the planning, implementation and evaluation of public health programmes.

Aim and objectives of surveillance
The WHO interim guidance on surveillance strategies for COVID-19 (7 August 2020) states that, the aim of surveillance for COVID-19 is to enable public health authorities to reduce transmission, thereby limiting associated morbidity and mortality.

Key objectives of COVID-19 surveillance include:
- enabling rapid detection, isolation, testing, and management of cases.
- guiding implementation and adjustment of targeted control measures, while enabling safe resumption of economic and social activities.
- detecting and containing outbreaks among vulnerable populations. (Note: this could include settings with people at high risk of severe COVID-19 outcomes or closed/semi-closed setting with high risk of transmission such as long-term care facilities, prisons, health facilities, workplaces and schools.)
- evaluating the impact of the pandemic on health-care systems and society.
- contributing to the understanding of the co-circulation of SARS-CoV-2 virus, influenza and other respiratory viruses, and other pathogens.

In the current period while the number of cases and deaths are decreasing across the South Africa, the first three objectives will be critical to timeous detection and location of any uptick in cases to identify and respond to areas of new or increased transmission.

Approaches to COVID-19 surveillance and surveillance methodologies
A key underlying principle of the approach to COVID-19 surveillance in South Africa, and particularly in relation to detecting a ‘second wave’ is the need to use, adapt and strengthen existing surveillance and data systems, whilst building surveillance capacity in the long-term. While there may be dedicated COVID-19 surveillance in the short to medium term (e.g. for the next year) this should ultimately be integrated with surveillance for all notifiable medical conditions in the long term. Adapting systems developed for COVID-19 surveillance (e.g. the DATCOV hospital admissions surveillance) to be used for surveillance of other conditions should be considered.

Surveillance for COVID-19 can also broadly be framed as either identifying current infections (which requires testing for the presence of SARS-CoV-2), identifying past infection (i.e. testing for antibodies to SARS-CoV-2) and monitoring changes in viral genetic sequences and antigenic properties so as to understand the impact of these data on future disease burden.

With particular reference to the current stage of the COVID-19 outbreak in South Africa, the surveillance approach may be grouped into three broad strategies (Figure 3).

- Firstly, seroprevalence studies may indicate the extent of the first wave, including the incident fatality rate, and the extent of current population vulnerability.
- Secondly, surveillance for incident cases, deaths and hospitalisations, sentinel site surveillance to detect seasonal and geographic trends, surveillance amongst vulnerable populations and molecular characterisation of new cases may inform early identification of a resurgence, and/or emerging new strains.
- Lastly, new case detection will facilitate rapid containment of infection and prevent an upswing/resurgence from becoming a second wave.

These approaches can be applied at the level of a population or to particular groups or settings either at high risk of transmission or high risk of poor outcomes, such as long-term care facilities, prisons, health facilities, workplaces and schools.

Current surveillance activities for COVID-19 including data sources, and a description of how data is utilised for surveillance purposes are described in Table x below.

**Figure 3: Surveillance strategies in order to detect and respond to a ‘COVID-19’ second wave**
Serological surveillance to understand population vulnerability

Serology (antibody) surveys identify patterns of COVID-19 infection amongst persons from whom samples originate. Where samples are representative, inferences may be made regarding the epidemiology of SARS-CoV-2 in particular geographical areas.

Preliminary serological data is available in two epidemiological settings, as referred to above, namely 1) residual sera from persons in the Western Cape Province undergoing HIV viral load testing, and HIV ELISA testing from persons attending ante-natal clinic in the last week of July 2020, and 2) persons enrolling in a vaccine trial in Gauteng Province July –August 2020.

Two population-representative household sero-surveys are planned in South Africa, namely the HSRC national survey, and a survey planned by the NICD in Cape Town, Pietermaritzburg and Klerksdorp

Detection of new infections and interpretation of the significance of these

Case-based surveillance (acute cases, admissions and hospitalisations)

Case-based surveillance has been in place since the outset of the COVID-19 epidemic in South Africa and includes reporting on the number and characteristics of diagnosed COVID-19 cases, hospital admissions and deaths and thus currently relies on diagnostic SARS-CoV-2 PCR testing in persons who present to health services and are deemed by the attending clinician to meet the suspected case definition.

Sentinel site surveillance of severe acute respiratory illness (SARI) and influenza-like illness (ILI)

The NICD has included testing for SARS-CoV-2 amongst persons enrolled at sentinel sites with severe acute respiratory illness (SARI), influenza-like illness (ILI programme) and the viral watch programme. These data provide the relative proportion of clinical cases where viral pathogens are isolated. In the past these data have allowed the NICD to interpret temporal and seasonal trends in the etiology of specific viral pathogens including influenza and respiratory syncytial virus. Results from these surveillance programmes are reported monthly on the NICD website.

Molecular epidemiological surveillance

The Network for Genomic Surveillance in South African (NGS-SA) is a consortium (including of members from the NHLS, NICD, UCT, UKZN, Stellenbosch, SANBI, H3ABionet and others) established in June 2020 to perform genomic surveillance of SARS-CoV-2 across South Africa. Any specimen on which RT-PCR has yielded a positive result for SARS-CoV-2 at a Ct value of less than 30 is suitable for performing whole genome sequencing. Conducting ongoing regular genome sequencing of SARS-CoV-2 virus in representative samples of COVID-19 patients across South Africa will provide information on whether lineages causing infection reflect ongoing infections within a local cluster, or re-introductions from further afield. These data may also inform contact tracing efforts by identification of chains of transmission, and support outbreak investigations in health care institutions. This will inform the types of measures used to limit transmission e.g. travel restrictions vs. local outbreak response. The NGS-SA is working towards ensuring that genome sequences are available in real-time in order to support outbreak response activities and policy making.

71. https://nextstrain.org/groups/ngs-sa
Environmental surveillance: waste-water surveillance

The South African Collaborative COVID-19 Environmental Surveillance System (SACCESS) is a network of >10 institutions and >25 scientists, researchers and government officials at local, provincial and national levels, co-ordinated by NICD, which is developing surveillance methods for the detection of SARS-CoV-2 RNA in wastewater. This can be applied in sewage systems across the country to provide additional surveillance information to detect early outbreaks, track the density of infections, and identify hotspots for intensive intervention. The SACCESS team is highly multidisciplinary and will combine laboratory findings with epidemiological, clinical and public health insights to assist intersectoral responses to COVID-19.

Broadly speaking, the network will

- Develop and fine tune the methods needed for this surveillance;
- Focus on large municipalities to provide data for assessing trends and for planning;
- Identify municipalities in provinces currently experiencing low rates of infection to help identify early hotspots for intervention.

The network will also monitor sewage from selected institutions (e.g. prisons, care homes) to assist in identifying hidden infections and thus prevent major outbreaks and provide data to track effectiveness of interventions. The anticipated work will continue for the duration of the epidemic, at least 18 months if not longer. Mapping of sewage catchment areas and linking to particular suburbs (Figure 6) or health sub-districts will facilitate triangulation of data. Regular measurements from different areas can be visualized on a dashboard such as the prototype developed by NICD (Figure 7).

Surveillance in high-risk / vulnerable groups and HCW

WHO recommends dedicated enhanced surveillance for incident cases using SARS-CoV-2 PCR (or appropriate diagnostics) for some high-risk groups (e.g. prisons, schools, workplaces, long term care facilities and health care settings) to ensure the prompt detection of cases and clusters. Surveillance for these groups will include active case finding through daily screening for signs and symptoms, and referral for SARS-CoV-2 PCR testing if indicated. If a confirmed case is identified in a vulnerable population and testing capacity allows, consideration can be given to widespread testing of all contacts of a case depending on the number of cases, the effectiveness of infection control practices and the likelihood of transmission within the facility based on its physical structure, living arrangements and the degree of social mixing.
<table>
<thead>
<tr>
<th>Surveillance methodology</th>
<th>Data collection methodology</th>
<th>Collation and distribution of data</th>
<th>Strengths</th>
<th>Limitations and weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Case-detection</strong> (current active cases, incidence rate and proportion tested positive (PTP))</td>
<td>SARS-CoV-2 PCR testing on symptomatic or asymptomatic persons presenting to primary health care or hospital facilities who meet case definition for testing (passive case detection) at private or public facilities</td>
<td>Testing data (positive and negative tests) are submitted electronically to the NICD, de-duplicated and then reported to NDoH data lake. Geocoding is done by NICD and NDoH. Incidence rate and PTP are calculated by NICD. Data are available to provinces via on-line interface. Reports are available on line <a href="https://www.nicd.ac.za">www.nicd.ac.za</a> and are updated daily.</td>
<td>Real-time (with a lag of up to 24 hours) reporting of case load PTP, allowing determination of epidemiological trends.</td>
<td>Data quality (especially geolocation and patient contact details) are dependent upon data collection processes at point of specimen collection. Case load is influenced by testing criteria.</td>
</tr>
<tr>
<td><strong>Notifiable medical conditions surveillance</strong></td>
<td>Laboratory-based case identification and electronic submission into NMC database WITH clinician-based notification (clinical details)</td>
<td>Case-level data is available to all users on NMC system</td>
<td>Line lists of all laboratory-confirmed cases are available through NMC.</td>
<td>Incomplete clinical data Summary reports sent by email to nominated recipients only. Clinical data not analysed/reported. Backlog of paper-based notifications as manual data entry is required.</td>
</tr>
<tr>
<td><strong>Hospital admissions due to COVID</strong></td>
<td>Persons admitted to all private and most public facilities with a diagnosis of SARS-CoV-2 are reported into the DATCOV surveillance database via an electronic portal</td>
<td>Data are reported to NDoH, provinces and private sector and reported online at <a href="https://www.nicd.ac.za">www.nicd.ac.za</a>. Facility-based reports are accessible via the interface.</td>
<td>Real time data on burden of admissions including severity, clinical management and outcomes are available with a 24-48 hour lag period</td>
<td>Not all public hospitals submit data into DATCOV, but coverage is increasing daily. Case load is influenced by testing criteria.</td>
</tr>
<tr>
<td><strong>Deaths due to COVID-19</strong></td>
<td>All persons dying from COVID-19 are reported by facilities to provincial health authorities and</td>
<td>Deaths are reported to provinces and then to the NDOH by manual collation of data which is included in provincial daily situation reports.</td>
<td>Data represent a minimal estimate of deaths deemed due to COVID</td>
<td>Significant under-reporting occurs because of delays in collation of data at a provincial level, and the use of a manual system.</td>
</tr>
<tr>
<td><strong>NICD sentinel site surveillance for SARI and ILI</strong></td>
<td>COVID testing all persons meeting a specified clinical case definition (severe acute respiratory illness (SARI), or influenza like illness (ILI))</td>
<td>Data summarised nationally and reported on the NICD website quarterly</td>
<td>Data are useful for syndromic management at provincial level</td>
<td>Not all provinces are represented</td>
</tr>
<tr>
<td><strong>Molecular surveillance (NGS-SA)</strong></td>
<td>Whole genome sequencing of SARS-CoV-2 in diagnostic samples from sentinel sites across South Africa</td>
<td>Data are reported nationally at <a href="https://www.krisp.org.za/ngs-sa/">https://www.krisp.org.za/ngs-sa/</a></td>
<td>A powerful tool for determining chains of transmission, viral dynamics and emergence of new strains.</td>
<td>Data are not yet integrated into national, provincial or district level responses</td>
</tr>
<tr>
<td><strong>Wastewater surveillance (SUCCESS)</strong></td>
<td>Detection of SARS-CoV-2 RNA in wastewater to detect early outbreaks, track the density of infections, and identify hotspots for intensive intervention</td>
<td>Not yet available</td>
<td>Will provide population-level exposure data</td>
<td>Findings may not be traceable to specific geographic areas. Data need to be integrated into district level responses.</td>
</tr>
<tr>
<td><strong>Population-based serosurveys</strong></td>
<td>Representative sampling of households or other surveillance units in specific geographical areas to detect presence of antibodies to SARS-CoV-2. In preparation by HSRC and NICD</td>
<td>Not yet available</td>
<td>Will give a reasonably accurate picture of population-level exposure to SARS-CoV-2 in the recent past</td>
<td>Findings will be an under-estimate of disease burden, as seropositivity rate is affected by sensitivity of serological test, and the recent incidence of disease in each geographical area. The duration of immunity is currently unknown. The generalizability of data may differ depending on site and sampling techniques.</td>
</tr>
</tbody>
</table>
Using surveillance data to detect and respond to a resurgence / second wave

Surveillance data from the sources described above needs to be triangulated and interpreted so that meaningful inferences regarding the stage of the pandemic and appropriate responses can be made. These data need also to be adapted to district level in order that district-level containment and response interventions can be implemented. Table 3 below illustrates how the ECDC determines the risk of resurgence based on surveillance indicators.

Table 3. The European Centre for Disease Prevention and Control has classified the risk of resurgence using data from case-based surveillance as follows:\n
<table>
<thead>
<tr>
<th>Risk of resurgence</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (very high if also no physical distancing and no contact tracing)</td>
<td>Increase in cases and hospitalizations OR Increase in cases and proportion positive (if sufficient testing capacity and intensity of testing has remained stable)</td>
</tr>
<tr>
<td>Moderate to high</td>
<td>Increase in cases but no increase in hospitalizations or proportion positive (if sufficient testing capacity and intensity of testing has remained stable)</td>
</tr>
<tr>
<td>Moderate</td>
<td>No increase in cases and continue to implement control measures such as physical distancing</td>
</tr>
</tbody>
</table>

Conclusion

A number of factors have emerged from the review of data available to the TWG pertaining to the likelihood of a second wave, and potential responses to it.

Firstly, countries that have experienced a second wave by and large contained their initial epidemic through implementation of non-pharmaceutical interventions, leaving a sizeable proportion of the population susceptible to COVID-19.

Secondly, historical evidence from the 1918 flu pandemic suggested that that the occurrence and nature of a second wave is driven by the level of immunity in the population. If initial interventions were not severe enough to halt transmission (or if restrictions are lifted slowly enough), immunity accumulated in the population through a longer first wave with a lower peak, leading to herd immunity, such that a subsequent wave was not possible and did not occur.

Thirdly, available serological data on RSA populations and suggests that the South African population has substantial population-level immunity albeit unevenly distributed.

Surveillance indicators and activities need to be geared to identify these ‘at risk’ communities through collation of local (ward-based) data on 1) the number of laboratory-confirmed cases per population to date, 2) the number of tests performed per population to date, 3) the degree to which wards are connected to other wards through population mobility (e.g., as can be measured through mobile phone data), 4) cumulative test positivity to date, 5) population density, and 5) indicators of social vulnerability.

To this end, the current surveillance methodologies, complemented by findings from those still to be implemented, will support prevention and detection efforts regarding a second wave. These surveillance indicators should be meaningfully used at national, provincial and district levels of the health system.

Part B Recommendations regarding preparations for a COVID second wave

Introduction
In the light of the observations made above, recommendations can be made to support surveillance, preparedness and response activities

Recommendations regarding COVID-19 surveillance in South Africa.

General comments
The MAC TWG believes that the current surveillance modalities in the country are adequate and should be continued and where appropriate strengthened.

A COVID-19 Surveillance Forum
In order to share and triangulate surveillance data across modalities, and so as to ensure a coherent understanding of COVID-19 epidemiology across South Africa, it will be helpful to establish a COVID-19 surveillance forum. This forum will bring together stakeholders including academics, environmental health professions, public health and infectious disease specialists from public and private sector institutions and government, including provincial and metro health departments. The implications of surveillance results and required responses can be discussed. Surveillance thresholds for action should be determined and adapted through the surveillance forum and in discussion with other stakeholders. The role and cost-effectiveness of different surveillance approaches at different stages of the outbreak should also be addressed by this forum. The representation of provinces and metros on the surveillance forum will support an integrated use of surveillance data at all levels of the health system.

Application of ‘second wave’ definitions at provincial and district levels to support meaningful interpretation of case-based surveillance data
The MAC TWG advises the application of the standard definitions and thresholds as defined in this document, and that these be applied and calculated at provincial and district level daily. The TWG also recommends transparency with sharing of these indicators at all levels of the health system, and with regard to resurgences and new waves, possibly even transparency at the level of reporting in the public domain.

Integration of surveillance data into provincial outbreak response activities
Table 4 and 5 describe how national, provincial and district structures can use data from the various surveillance activities to support alert and response activities. The TWG recommends that the suggestions be incorporated into the NDoH resurgence plan, and that provinces report on and interpret indicators, and how the surveillance data is being used to guide surveillance and response activities.

Case-based surveillance and COVID-10 testing criteria
Case-based surveillance is perhaps the most critical surveillance modality, but it is highly dependent on testing criteria, test availability and test methodology. The MAC advises that testing criteria be broadened nationally and implemented at facility level. Further, the MAC advises the inclusion of results of rapid antigen testing into national surveillance data systems when antigen testing becomes available.

Strengthening data quality for case-based surveillance
Consideration should be given to enhancing variables captured at the time of testing of cases to include name of school in learners, workplace in employed people, long term care facility or correctional service facility to facilitate containment of clusters. This should be applied not only to
COVID-19 surveillance, but surveillance for other conditions as well (e.g. measles) to strengthen systems for communicable disease response.

**Strengthening mortality surveillance**
Data on deaths should be strengthened as a matter of urgency. Data capture and coding of the cause of death should be strengthened to ensure rapid availability of results. Cause of death findings should be made available to provincial Departments of Health for triangulation with patient data and recorded death data. This will allow for monitoring of deaths due to non-specific respiratory causes (e.g. unspecified pneumonia), which may represent undiagnosed COVID-19, as well as changes in rates of death due to different causes, as per WHO recommendations.
<table>
<thead>
<tr>
<th>Surveillance Activity</th>
<th>Data element / indicator</th>
<th>Threshold or trend indicative of a resurgence / second wave</th>
<th>How can data elements (especially those indicative of a resurgence) be used at this level?</th>
</tr>
</thead>
</table>
| **Case-based surveillance** | Number of cases and clusters in community and the incidence rate | Application of criteria for uptick, upswing, resurgence and second wave | National: Provision of technical, epidemiological, clinical, financial support for provincial case detection and containment, increase national messaging re NPIs,  
Provincial: Conduct provincial/district incidence rate calculations. Provide resources to affected districts to support epidemiological, clinical, financial service delivery, strengthen hospital services, increase provincial messaging re NPIs.  
District: Detection, isolation and management of cases and contact tracing. Strengthen case finding. |
| Testing rate / unit population | N/A | Use to interpret proportion test positivity. Stratify by geographical area or other risk group. Alter testing policy as appropriate | National:  
Provincial: Use to interpret proportion test positivity. Stratify by geographical area or other risk group. Alter testing policy and/or support district to increase testing rate when appropriate  
District: Increase testing when appropriate. |
| Proportion test positive | An increase suggests a risk of resurgence. | Encourage provinces to emphasise case-finding activities. Increase testing | National:  
Provincial: Conduct provincial/district level proportion-test-positive calculations Support district efforts to find cases, whilst providing clinical care and treatment and supporting districts with epidemiological and clinical capacity  
District: Increase testing, whilst providing ongoing detection, isolation and management of cases. |
| Incidence risk in different risk groups | Compare incident risk over time between different groups – an increase in a particular group suggests a resurgence | Provide epidemiological analysis to identify risk groups. Inform provinces and support provincial responses accordingly | National:  
Provincial: Conduct provincial/district level incidence risk calculations. Focus case findings and containment efforts on specific risk groups, whilst providing health promotion messaging  
District: Focus case findings and containment efforts on specific risk groups, whilst providing targeted health promotion messaging. |
| Geographic distribution (incidence risk / population in a defined area) | Compare incident risk across time and place - an increase in a particular group suggests a resurgence | Provide epidemiological analysis to identify risk groups. Inform provinces and support provincial responses accordingly | National:  
Provincial: Conduct provincial/district level geographical analysis. Focus case findings and containment efforts on specific risk groups, whilst providing health promotion messaging  
District: Focus case findings and containment efforts on specific risk groups, whilst providing health promotion messaging. |
| Admissions (total and currently admitted, and rate) | An increase suggests a risk of resurgence | Correlate with case numbers and associated indicators, support provinces to strengthen case finding, conduct whole genome sequencing | National:  
Provincial: Conduct province/district level admissions analysis and correlate with case numbers. Identify affected clusters. Support districts to strengthen case finding and containment efforts. Provide strengthened clinical care  
District: Focus case findings and containment efforts on specific risk groups/identified clusters, whilst providing targeted health promotion messaging. |
| Deaths (COVID and all-cause) | An increase suggests a risk of resurgence, emergence of a new strain, or decline in quality of in-patient care, or undetected cases | Correlate with case numbers, admissions and associated indicators, support provinces to strengthen case findings and quality of clinical care | National:  
Provincial: Conduct province/district level death analysis and correlate with case numbers. Support districts to strengthen case finding and containment efforts. Strengthen death notification systems. Provide strengthened quality clinical care  
District: Focus case findings and containment efforts on specific risk groups, whilst providing targeted health promotion messaging. |
Table 5 Surveillance activities and appropriate responses to surveillance indicators and the threat of resurgence at national, provincial and district levels

<table>
<thead>
<tr>
<th>Surveillance Activity</th>
<th>Data element / indicator</th>
<th>Threshold or trend indicative of a resurgence / second wave</th>
<th>How can data elements (especially those indicative of a resurgence) be used at this level?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>National</td>
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<td>District</td>
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<tr>
<td><strong>Sero-surveys</strong></td>
<td>HSRC and NICD serosurveys (planned)</td>
<td>Identification of localised and historical prevalence</td>
<td>Identify vulnerable areas, determine risk of resurgence and support provinces to provide appropriate NPI messaging where necessary.</td>
</tr>
<tr>
<td>Interval sero-surveys of residual ANC / HIV viral load sera</td>
<td>Monitor trends over time to infer changing population vulnerabilities</td>
<td>Co-ordinate serological testing across the country. Identify vulnerable areas, determine risk of resurgence and support provinces to provide appropriate NPI messaging where necessary.</td>
<td>Conduct province-wide analysis of vulnerable areas to determine risk of resurgence. Prepare clinical services accordingly. Provide appropriate health promotions messaging. Support districts to find and contain cases</td>
</tr>
<tr>
<td><strong>Sentinel surveillance for clinical syndromes</strong></td>
<td>Severe acute respiratory illness (amongst admitted persons)</td>
<td>Monitor trends in prevalence of COVID-19 amongst persons admitted with pneumonia</td>
<td>Develop and refine testing and case management protocols. Infer adequacy of case-based surveillance and testing strategy. Assist provinces to strengthen case-finding</td>
</tr>
<tr>
<td></td>
<td>Influenza-like illness / Viral watch</td>
<td>Monitor trends in prevalence of COVID-19 amongst outpatients with influenza like illness</td>
<td>Infer adequacy of case-based surveillance and testing strategy. Assist provinces to strengthen case-finding</td>
</tr>
<tr>
<td><strong>Molecular surveillance</strong></td>
<td>Whole genome sequencing and genetic lineages</td>
<td>Changes in RNA sequences over time</td>
<td>Interpret case finding data in the light of genomic findings. Should a new strain emerge, adapt surveillance and case definitions accordingly</td>
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<tr>
<td></td>
<td>Environmental surveillance of wastewater for SARS-CoV-2</td>
<td>An increasing signal or a new detection in an area previously COVID-19 free</td>
<td>Co-ordinate waste-water surveillance across the country. Interpret trends over time. Support provinces to strengthen case finding in response to new or increasing signals</td>
</tr>
</tbody>
</table>
Conclusion

The TWG makes the following recommendations:

- That current surveillance activities be continued as described in this TWG’s Appendix, and that slight modifications of indicators contained in the IMT Resurgence Plan be made.
- That daily interpretation of the surveillance indicators (end-of-wave, uptick, upswing, resurgence, new wave etc) as described by this advisory and detailed in the appendix be undertaken by national and provincial epidemiology teams and that these data be used at all levels of the health system to guide preparedness and response activities.
- That testing criteria be broadened nationally and implemented provincially to ensure representative testing across at-risk areas.
- That a COVID-19 surveillance forum lead by the NICD/NDoH/IMT, including all institutions/stakeholders doing surveillance, provincial DOH and academics, be established and meet as soon as possible to correlate and interpret surveillance data across all modalities.
- That data collection methodology at the point of specimen collection be strengthened to ensure accuracy and improved data quality. This includes the use of electronic data capture at point of specimen collection and inclusion of additional data elements (e.g. origin of specimens such as outbreak investigations in schools, institutions, workplaces and care facilities) to facilitate identification of localised outbreaks.
- That immediate and ongoing investment be made in IT and business intelligence data systems to support national and provincial surveillance and response activities. These should incorporate or expand on existing systems including COVIDConnect, NICD’s Notifiable Medical Conditions Surveillance System (NMC-SS).
- That national, provincial and district teams endorse, support and communicate the benefits of COVIDConnect to the general population and health care workers to ensure uptake, and that contact tracing teams integrate COVIDConnect into contact tracing and responses.
- That cause of death data should be strengthened by ensuring rapid capture of death notification forms, and that cause-of-death findings at sub-district level be made available in good time to national and provincial health departments.
- That provinces develop resurgence action plans with clear terms of reference. Plans should include a surge response team with named personnel to support COVID-19 containment efforts should a second wave require additional human resources. These surge response teams should include epidemiologists, public health specialists, data analysts, health system analysts, communication specialists, behaviour change experts as well as clinicians, community health workers, contact tracers, and case investigation leads. Response plans should take into account differing urban and rural health systems by accommodating traditional community and religious leaders where appropriate.