THE DAILY COVID-19 EFFECTIVE REPRODUCTIVE NUMBER (R) IN SOUTH AFRICA

NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service

SOUTH AFRICA | WEEK 33 2020

SUMMARY

Overview of report

Disease surveillance is a core function of the National Institute for Communicable Diseases (NICD), a Division of the National Health Laboratory Service (NHLS). This report includes an analysis of data on laboratory-confirmed COVID-19 deaths to estimate the effective reproductive number (R) of SARS-CoV-2 over time in South Africa nationally and in selected provinces where sufficient data are available.

The basic reproductive number (R0) is the average number of secondary infections produced by a typical case of an infection in a population where everyone is susceptible which occurs typically in the first few weeks after introduction of a novel infectious agent into the population. The effective reproduction number (R) is the average number of secondary cases per infectious case in a population composed of both susceptible and non-susceptible hosts (once the infectious agent is circulating). If R>1, the number of new cases per time unit will increase, such as at the start of an epidemic. Where R=1, the number of new cases is stable over time, and where R<1, there will be a decline in the number of new cases per time unit.

This report is based on data collected up to 26 July 2020 (week 30 of 2020). The data were adjusted for the delay from illness onset to death and right censored for 21 days to account for the time lag between onset and reporting of death (R estimated up to 5 July). This analysis updates the report released on 12 June 2020.

The analysis approach used in this report differs from previous versions of the report. In this report R is estimated from the data on laboratory-confirmed COVID-19 deaths, while in previous versions of this report R was estimated using data on laboratory-confirmed COVID-19 cases. The reason for the shift in estimation approach is the changes in laboratory testing practices since June 2020, leading to fluctuations in numbers of tested and confirmed cases which may not accurately reflect the epidemic trajectory. It is felt that laboratory-confirmed COVID-19 deaths are likely a more stable indicator of COVID-19 epidemic progression, albeit with a substantial time lag, which is a disadvantage of this approach. Note: COVID-19 is the name of the disease and SARS-CoV-2 is the name of the virus.

Highlights

- Nationally, the average R during the period of the stage 5 lockdown was 1.33 (95%CI: 1.07-1.65), rising to near 1.5 by the end of April.
- The daily R dropped then dropped steadily throughout stage 4 lockdown, with an average over this period of 1.26 (95%CI: 1.06 – 1.49), continuing to decrease during the stage 3 lockdown, with an average of 1.10 (95%CI: 1.02 – 1.20) from 1 June to 5 July. This indicates ongoing transmission at a steadily slowing rate over this period.
- In the Western Cape Province, the average R during the stage 5 lockdown was 1.45 (95%CI: 1.09-1.92), dropping steadily throughout stage 4 and 3 lockdown. During the stage 3 lockdown, the daily R has been close to the threshold value of 1, with an average of 1.00 (95%CI: 0.95 – 1.05) from 1 June to 5 July. This indicates substantial slowing of transmission towards the end of June and early July.
- In other provinces where estimation was possible (Gauteng, Eastern Cape and KwaZulu-Natal provinces), the R during the stage 5 and 4 lockdown ranged between 1.5 and 1.0. Generally R showed reductions during the stage 3 lockdown indicating slowing of transmission, however in KwaZulu-Natal R remained well above 1 indicating increasing infections in this Province.
- Reasons for the declines in R over the course of the stage 3 lockdown may include good public adherence to physical distancing, mask use and other measures, increasing population-level immunity or other factors, including residual biases in the data.
- This analysis has important limitations. Changes in the ascertainment rate of COVID-19 deaths as well as the delay between symptom onset and reporting of death may change over time, potentially affecting R estimation. The introduction of dexamethasone treatment and use of high flow nasal oxygen since mid-June may lower mortality, making estimation for recent timepoints less reliable. No local data are available from which to calculate the serial interval. Therefore, it is important to interpret these findings together with other sources of data on transmission. Caution should be exercised in interpreting comparisons between different timepoints and provinces as these could be affected by differential testing and reporting practices.

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Methods

Daily R estimation

We used data from the first confirmed death in late March until 26 July 2020. The data were adjusted for the delay from illness onset to death and right-censored for 21 days to account for reporting delays (last date of estimation: 5 July 2020). Data on date of symptom onset was 7.5% complete. Missing dates of symptom onset were imputed using chained equations multiple (1000) imputations [i,ii]. The time series is summarized in figures based on the median values for each date. A negative-binomial model was fitted to confirmed COVID-19 cases for which the date of symptom onset was available and used to impute the date of symptoms onset for cases with missing information. The model predictors for imputation were: health sector where death occurred (private, public, outside hospital, or unclassified), age group, month of death, and province.

The daily R was estimated using the method of Thompson et al. (EpiEstim v. 2.2-3) [iii ,iv] for each imputed dataset (1000 time series generated through the multiple imputation process). For the serial interval we used a gamma distribution with mean of 5.3 (s.d. 2.1) and standard deviation 1.8 (s.d. 0.6) to account for the variability (uncertainty) of the selected serial interval values [v]. We report the median and 2.5th-97.5th percentiles of the estimated daily R values obtained from 1000 imputed datasets [i,ii].

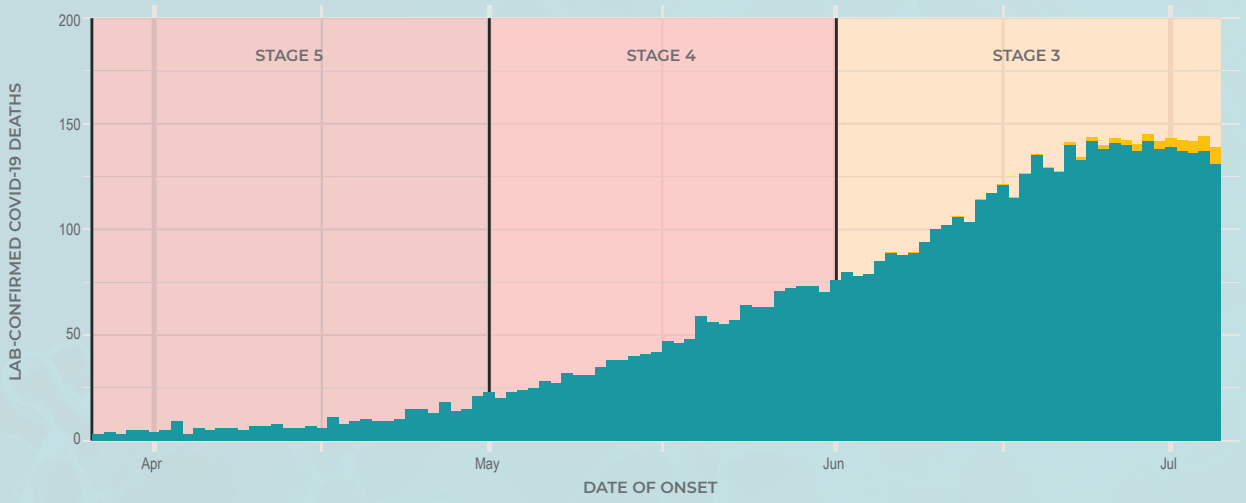
Limitations

The main limitation of this analysis is that changes in the ascertainment rate of COVID-19 deaths may change over time, potentially affecting R estimation. Along with the ascertainment rate, the delay between symptom onset and reporting of death may change over time; cases at the end of the time series will be under-estimated according to the proportion of laboratory-confirmed COVID-19 deaths with delays longer than 21 days between symptom onset and reporting of death. Furthermore, the introduction of dexamethasone treatment in mid-June and use of oxygen administration via high flow nasal cannula may alter mortality outcomes, making estimation for recent timepoints less reliable. In addition, no local data are available from which to calculate the serial interval. The level of variation in the serial interval estimates used here reflects the range of estimates observed in mainland China [vi]. The time series of deaths was based on linelists provided by the National Department of Health (NDoH), linked with the DATCOV hospitalization dataset to ascertain, where possible, the dates of symptom onset for laboratory-confirmed COVID-19 deaths. Lastly, it was not possible to link deaths to the importation status of cases, affecting the reliability of initial R0 estimates, which are therefore not reported here.

Results

The daily number of laboratory-confirmed COVID-19 deaths has steadily increased since the first confirmed death in late March 2020 (Figure 1).

Figure 1. Daily number of COVID-19 deaths by date of symptom onset (missing data imputed; median of imputed time series is shown), South Africa (last date included: 5 July 2020). Yellow area shows adjustment for expected future deaths by date of onset.



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Nationally, the average R during the period of the stage 5 lockdown was 1.33 (95%CI: 1.07-1.65), rising to near 1.5 by the end of April (Figure 2). The daily R dropped then dropped steadily throughout stage 4 lockdown, with an average over this period of 1.26 (95%CI: 1.06 – 1.49). During the course of the current stage 3 lockdown, the daily R has varied slightly, with an average of 1.10 (95%CI: 1.02 – 1.20) from 1 June to 5 July.

Figure 2. Upper panel: Estimated daily reproduction number (R), with 95% confidence intervals, South Africa (last date included in the estimation: 5 July 2020). Lower panel: estimated number of laboratory-confirmed COVID-19 deaths by onset date with missing data imputed (orange = adjusted, blue = unadjusted). The median and 95% range for the imputed datasets are shown.

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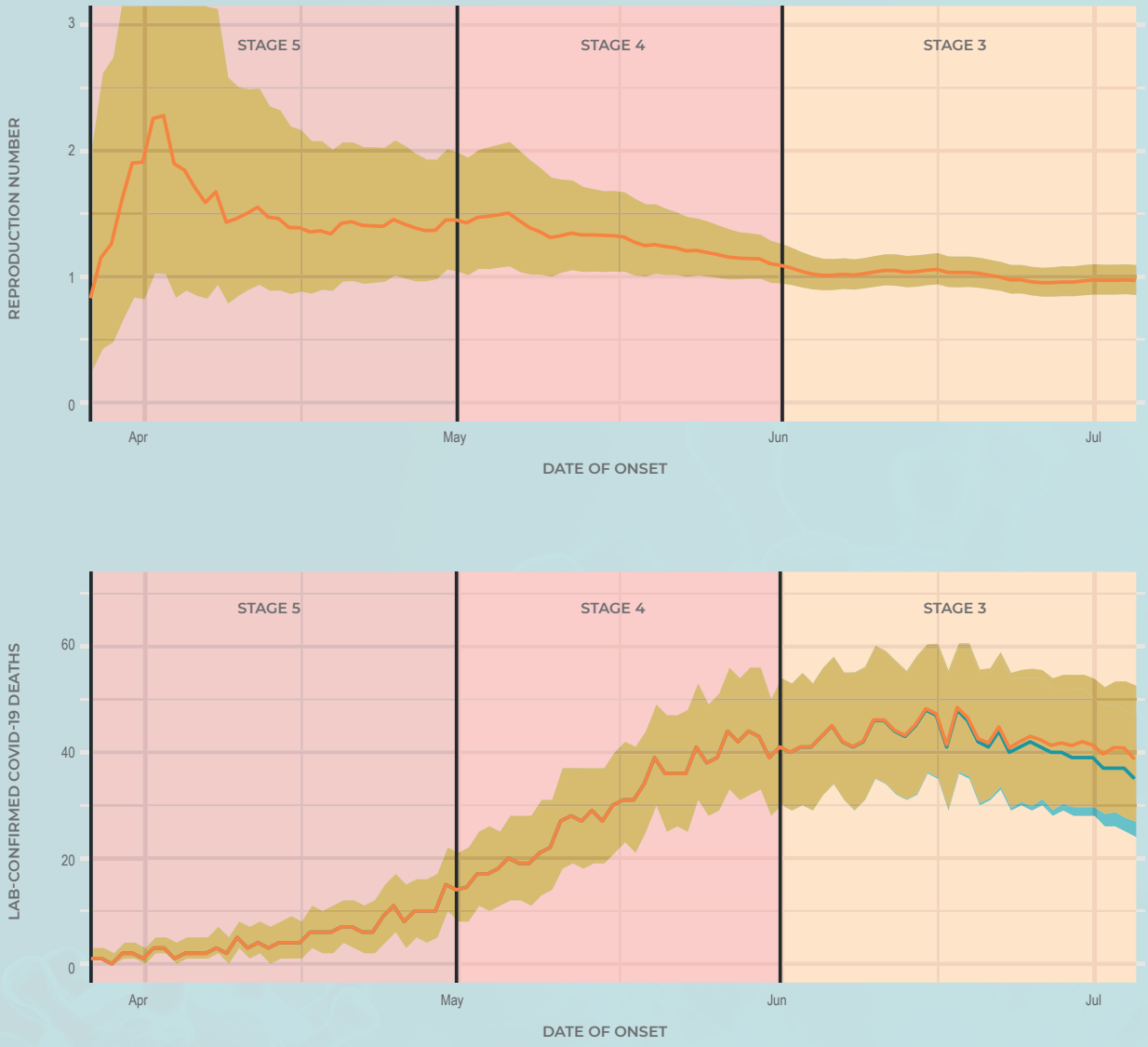
In the Western Cape Province, the average R during the stage 5 lockdown was 1.45 (95%CI: 1.09-1.92), with a value near 1.5 at the end of April (Figure 3). The daily R then dropped steadily throughout stage 4 lockdown, with an average over this period of 1.22 (95%CI: 1.04 – 1.44). During the course of the current stage 3 lockdown, the daily R has been close to the threshold value of 1, with an average of 1.00 (95%CI: 0.95 – 1.05) from 1 June to 5 July.

Figure 3. Western Cape (last date included in the estimation: 5 July 2020). Upper panel: Estimated daily R based on deaths, with 95% confidence intervals. Lower panel: estimated number of laboratory-confirmed COVID-19 deaths by onset date with missing data imputed (orange = adjusted, blue = unadjusted). The median and 95% range for the imputed datasets are shown.



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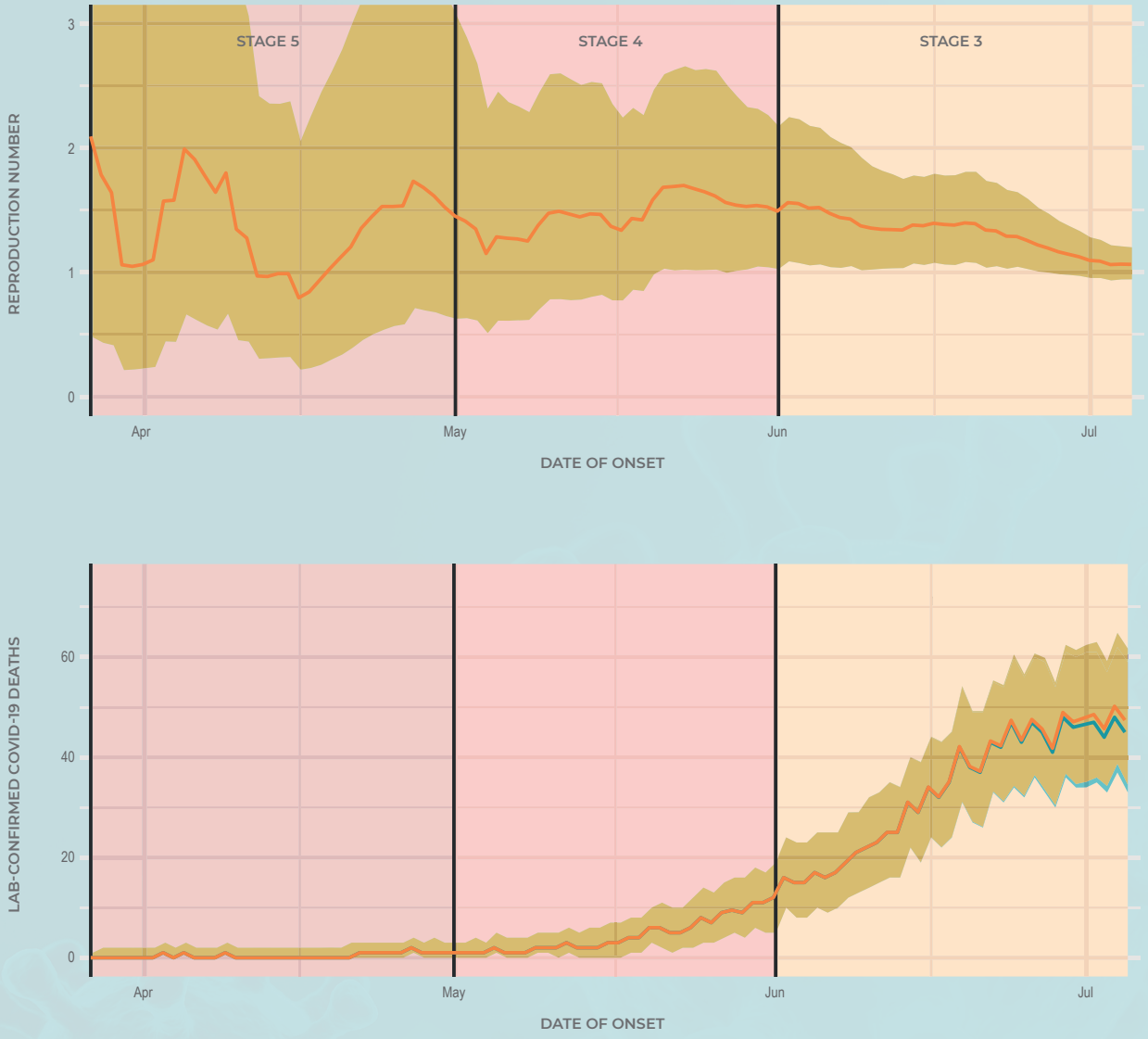
In Gauteng, the average R during the stage 5 lockdown was 1.23 (95%CI: 0.78 – 1.87) , with a value near 1.5 at the end of April (Figure 4). The daily R then increased over the period of the stage 4 lockdown, with an average over this period of 1.51 (95%CI: 1.09 – 2.08). Over the course of the current stage 3 lockdown, the daily R has been declining, with an average of 1.21 (95%CI: 1.05 – 1.43) from 1 June to 5 July.

Figure 4. Gauteng (last date included in the estimation: 5 July 2020). Upper panel: Estimated daily R based on deaths, with 95% confidence intervals. Lower panel: estimated number of laboratory-confirmed COVID-19 deaths by onset date with missing data imputed (orange = adjusted, blue = unadjusted). The median and 95% range for the imputed datasets are shown.



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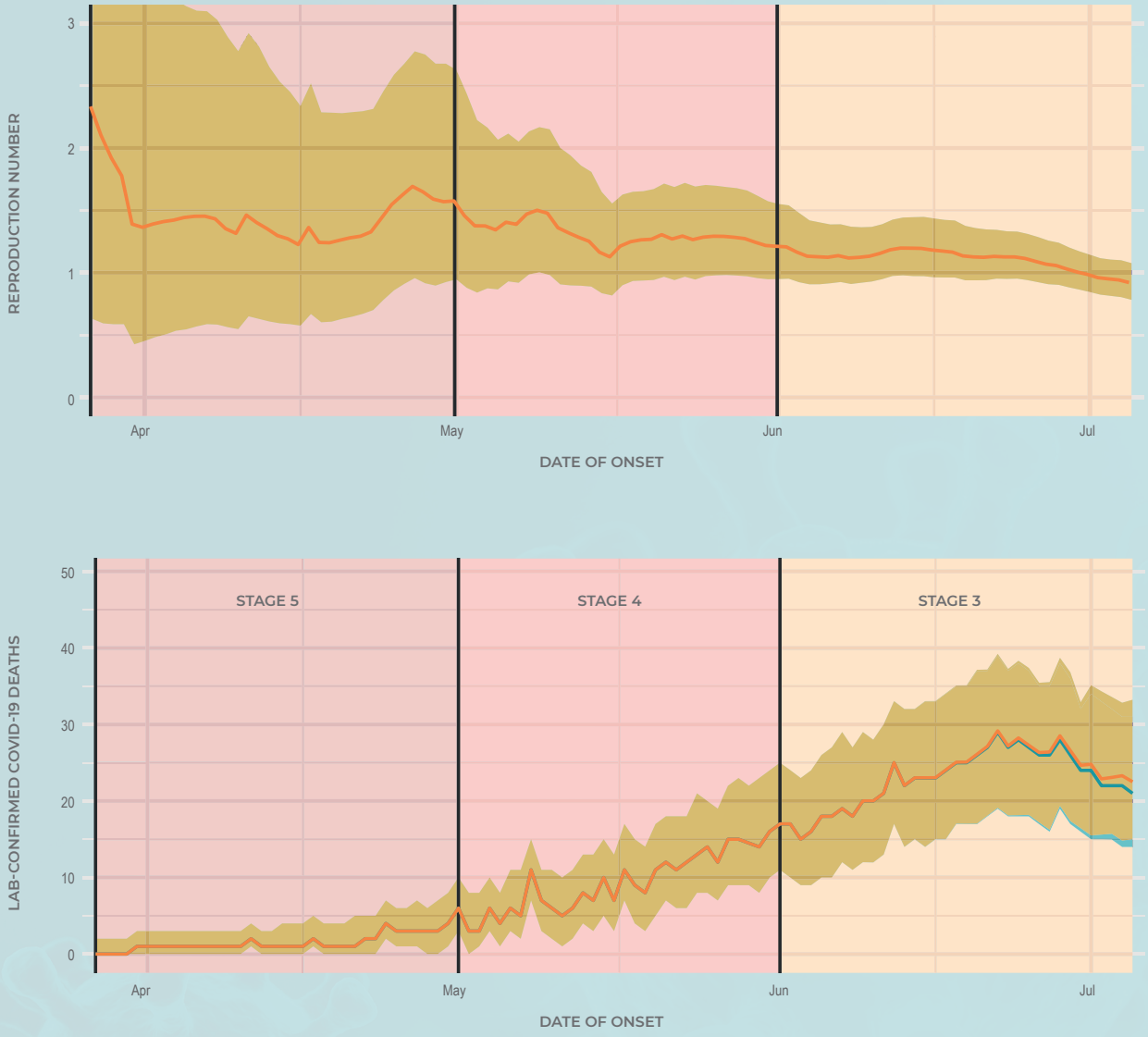
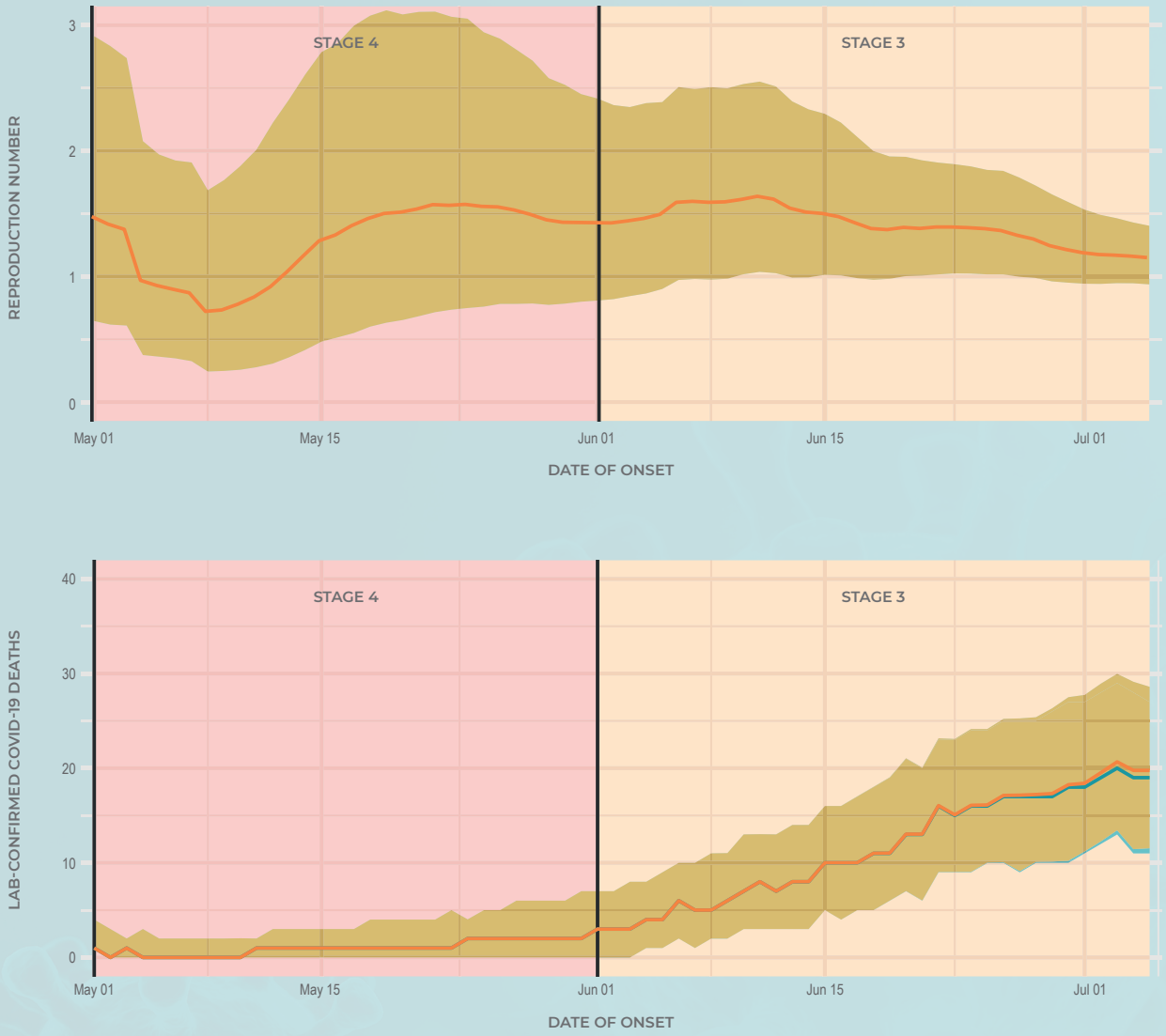
In the Eastern Cape, the average R during the stage 5 lockdown was 1.37 (95%CI: 0.97 – 1.95) , with a value near 1.5 at the end of April (Figure 5). The daily R fluctuated during stage 4 lockdown, with an average over this period of 1.27 (95%CI: 1.04 – 1.55). Over the course of the current stage 3 lockdown, the daily R has remained relatively steady, with an average of 1.07 (95%CI: 0.98 – 1.17) from 1 June to 5 July.

Figure 5. Eastern Cape (last date included in the estimation: 5 July 2020). Upper panel: Estimated daily R based on deaths, with 95% confidence intervals. Lower panel: estimated number of laboratory-confirmed COVID-19 deaths by onset date with missing data imputed (orange = adjusted, blue = unadjusted).. The median and 95% range for the imputed datasets are shown.



In KwaZulu-Natal, the average R during the stage 5 lockdown was 1.04 (95%CI: 0.75 – 1.40), with a value near 1.5 at the end of April (Figure 6). The daily R fluctuated during the current stage 4 lockdown, with an average over this period of 1.26 (95%CI: 0.88 – 1.75). Over the course of the current stage 3 lockdown, the daily R has remained well above 1, with an average of 1.29 (95%CI: 1.05 – 1.60) from 1 June to 5 July.

Figure 6. KwaZulu-Natal (last date included in the estimation: 5 July 2020). Upper panel: Estimated daily R based on deaths, with 95% confidence intervals. Lower panel: estimated number of laboratory-confirmed COVID-19 deaths by onset date with missing data imputed (orange = adjusted, blue = unadjusted). The median and 95% range for the imputed datasets are shown. Plots show estimates from 1 May, as daily R estimates are unstable early in the time series due to small numbers of deaths.



This report was jointly prepared by the National Institute for Communicable Disease (NICD) and the DST-NRF Centre of Excellence in Epidemiological Modelling and Analysis (SACEMA). Inquiries should be referred to Prof Cheryl Cohen (cherylc@nicd.ac.za).

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