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

The Daily COVID-19 Effective Reproductive Number (R) in the Public Sector of South Africa

Week 17 of 2022

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 rT-PCR-confirmed COVID-19 cases, hospital admissions, and deaths to estimate the effective reproductive number (R) of SARS-CoV-2 over time in South Africa at the national and provincial levels. The basic reproductive number (R_0) 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 28 April 2022 (week 17 of 2022). The data were adjusted for the delays from illness onset to case report, hospital admission, and death and right censored for 3, 7, and 7 days respectively to account for the time lag between each outcome (test result, admission, or death) and the time of reporting (last date of estimation based on rT-PCR-confirmed cases: 25 April 2022). This analysis updates the report released on 21 December 2021. **In this report, R is estimated from the data on rT-PCR-confirmed COVID-19 cases as well as laboratory-confirmed COVID-19 hospital admissions and hospital-based deaths. In addition, while earlier reports included only primary infections in cases-based analyses, this report, as with the previous report, includes reinfections.** There may be non-overlapping sources of bias for the three data sources, which motivates a comparison of R estimates. Note: COVID-19 is the name of the disease and SARS-CoV-2 is the name of the virus.

Highlights

- R estimates based on cases were above 1 nationally and in all provinces at the end of the estimation period, and R estimates based on admissions were above 1 nationally and in six out of nine provinces at the end of the admissions-based estimation period.
- R estimates decreased both nationally and provincially during December, crossing below one in late December and early January. R increased to close to 1 in late January and remained roughly stable close to 1 until April.
- Admissions- and deaths-based R diverged substantially from cases-based R during December 2021 and early January 2022, to a greater extent than seen in previous waves with the admissions- and deaths-based R generally lower than cases-based R. Admissions- and deaths-based R decreased more gradually than cases-based R during December 2021 and early January 2022.

Methods

Daily R estimation

We used data from 1 December 2021 until 28 April 2022, based on the national DATCOV dataset on hospitalized cases, and the linelist of rT-PCR-confirmed cases, based on datasets maintained by the National Institute for Communicable Diseases (NICD). This report includes both primary infections and suspected reinfections; positive tests were classified as being associated with a suspected reinfection if the time since the most recent positive test for that patient was at least 90 days [iv]. Due to incorrectly entered reference dates for substantial numbers of antigen tests, only cases confirmed via polymerase chain reaction (PCR) testing were used in this analysis. The rT-PCR-confirmed case data was linked with the national DATCOV dataset to obtain dates of symptom onset. Following data linkage, symptom onset data were available for 11% of rT-PCR-confirmed cases, while dates of onset were available for 63% of hospitalized cases, and 70% of fatal cases in the DATCOV dataset. The data were adjusted for the delay from symptom onset to reporting of test result / hospital admission and right censored for 3, 7, and 7 days (for cases, hospital admissions, and deaths respectively) to account for reporting delays (last date of estimation based on rT-PCR-confirmed cases: 25 April 2022). The provincial level DATCOV data have different end-dates, so the provincial time series were individually adjusted for right-censoring; national-level analyses were based on the pooled provincial-level time series, truncated to the earliest end date of provincial time series. Missing dates of symptom onset were imputed using chained equations multiple imputations (50) [i,ii]. 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 dates of symptom onset for cases with missing information. Separate imputations were done for the case and admissions datasets. The hospital-based deaths data set is a subset of admissions, so the same set of

imputations were used. The model predictors for the imputation procedure on the cases dataset were: health sector where sample collection occurred (private or public), age group (in ten-year age bands), month of case report, patient sex, and province. The model predictors for the imputation procedure on the hospital admissions dataset were: health sector where admission occurred (private or public), age group (in ten-year age bands), patient outcome, day of the week of hospital admission, month of hospital admission, and health district in which admission occurred. The daily R was estimated using the method of Thompson *et al*. (EpiEstim v. 2.2-3) [iii,iv] for each imputed dataset. For the serial interval we used a gamma distribution with mean of 6.6 (s.d. 3.3) and standard deviation of 0.5 (s.d. 0.27) to account for the variability (and uncertainty) of the selected serial interval values. Parameters were estimated by fitting a gamma distribution to data from PHIRST-C, a community cohort study of COVID-19 transmission [vii]. We report the medians of the central values and the 2.5^{th}-97.5^{th} percentiles of the estimated daily R values obtained from the imputed datasets [i,ii]. Small numbers of hospital-based deaths in Mpumalanga and Northern Cape led to large fluctuations and wide credible intervals in deaths-based R estimates for these provinces; as a result, this report does not include deaths-based R estimates for Mpumalanga and Northern Cape provinces.

Previous versions of this report have included descriptions of trends in daily R values during lockdown levels 5 through 1, and the adjusted level 3 lockdown, as well as the 2021 lockdown levels 1 through 4. The current report focuses on more recent trends in daily R values, starting on 1 December 2021 (for more details regarding the COVID-19 lockdowns in South Africa, please refer to the South African government website [vi]).

Results

Nationally, R estimates began to decrease in early December, crossing below 1 in the second half of December. R estimates based on cases crossed below 1 first, followed eight days later by R based on hospital admissions, which crossed below 1 nine days earlier than R based on hospital-based deaths. R estimates dropped to approximately 0.7, remaining well below one until late January, when R estimates increased to near 1. R estimates remained close to 1 during February and March, then began to increase in mid-April. R based on cases and admissions reached values above 1 by the end of the estimation period (Figure 1 and Table 1).

Trends at the province level were similar, with R decreasing during the second half of December and in some provinces during early January. R estimates in most provinces remained close to or below 1 until early-to-mid April, when R estimates began to increase, with R estimates based on cases above 1 in all provinces at the end of the estimation period, and R estimates based on admissions were above 1 in six out of nine provinces at the end of the admissions-based estimation period (Table 1).

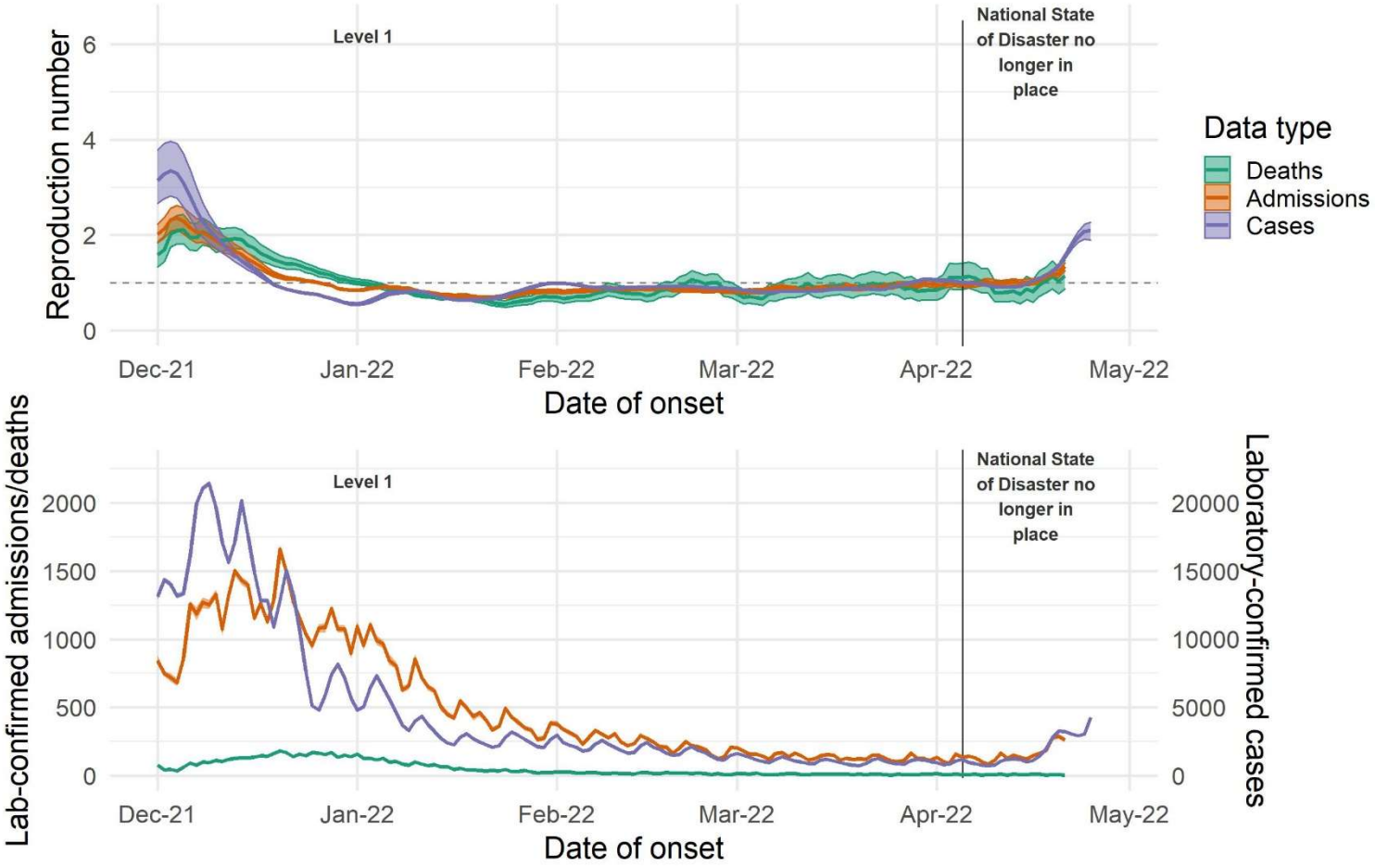

Figure 1. Upper panel: Estimated daily reproduction number (R), with 95% credible intervals, South Africa (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

Table 1: Daily R estimates by province for R based on rT-PCR-confirmed cases and laboratory-confirmed hospital admissions from healthcare and laboratory service providers. Each cell contains median values with 95% credible intervals.

	Cases	Cases	Admissions
	25 April 2022	21 April 2022	21 April 2022
National	2.09 (1.89,2.27)	1.55 (1.50,1.60)	1.34 (1.26,1.42)
Eastern Cape	1.87 (1.68,2.05)	1.42 (1.28,1.56)	1.25 (0.93,1.61)
Free State	2.41 (2.09,2.75)	1.87 (1.66,2.12)	1.59 (1.22,2.03)
Gauteng	2.12 (1.92,2.32)	1.64 (1.56,1.71)	1.40 (1.27,1.53)
KwaZulu-Natal	2.31 (2.05,2.60)	1.79 (1.70,1.89)	1.57 (1.39,1.75)
Limpopo	2.09 (1.72,2.48)	1.56 (1.27,1.89)	1.98 (1.33,2.77)
Mpumalanga	2.09 (1.84,2.35)	1.35 (1.20,1.52)	1.09 (0.73,1.48)
Northern Cape	2.71 (2.26,3.20)	1.87 (1.51,2.25)	2.03 (1.07,3.52)
North West	2.14 (1.86,2.42)	1.65 (1.43,1.89)	1.46 (1.07,1.90)
Western Cape	1.61 (1.52,1.70)	1.06 (1.01,1.12)	0.90 (0.75,1.04)

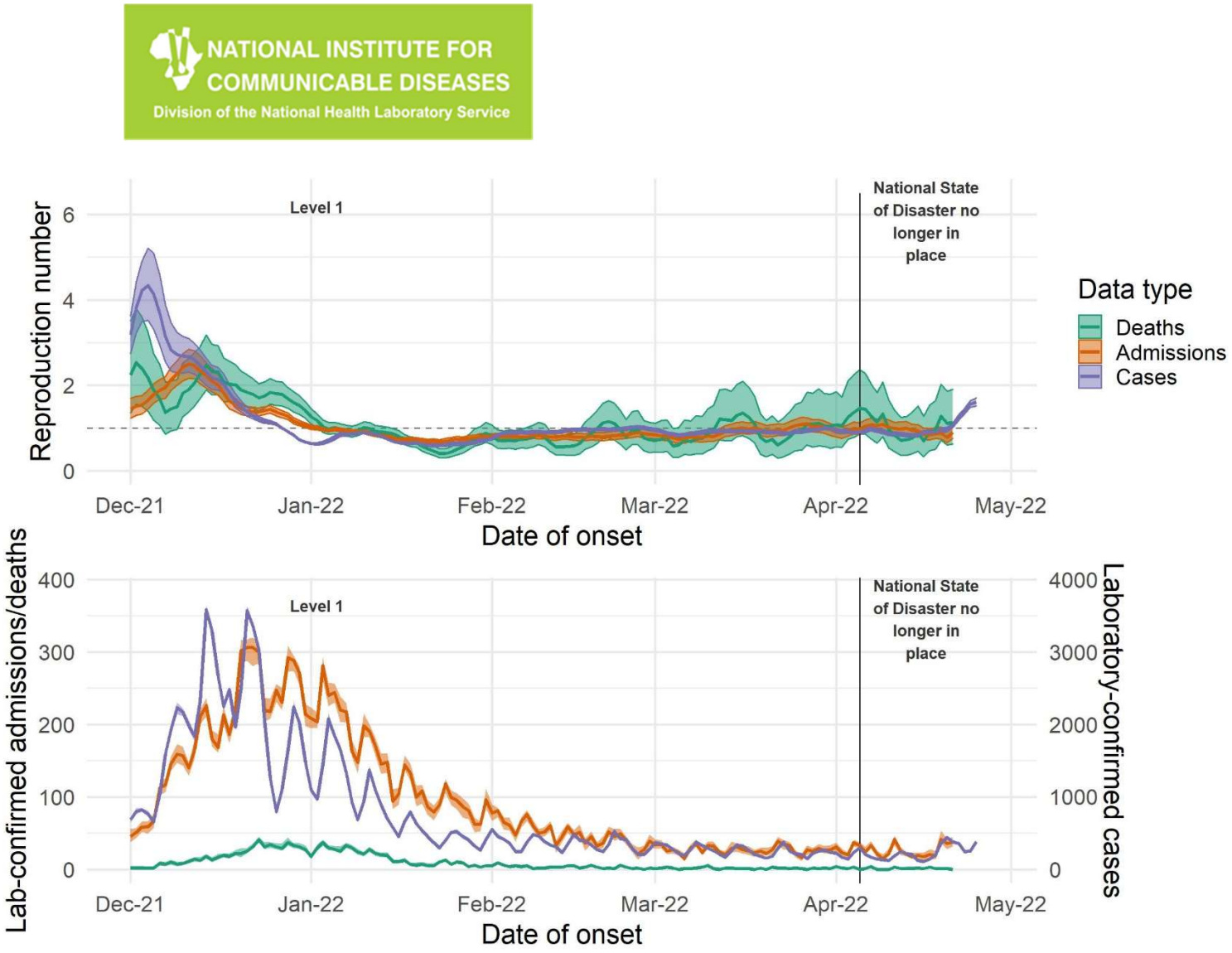

Figure 2. Upper panel: Estimated daily reproduction number (R), with 95% credible intervals, Western Cape (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

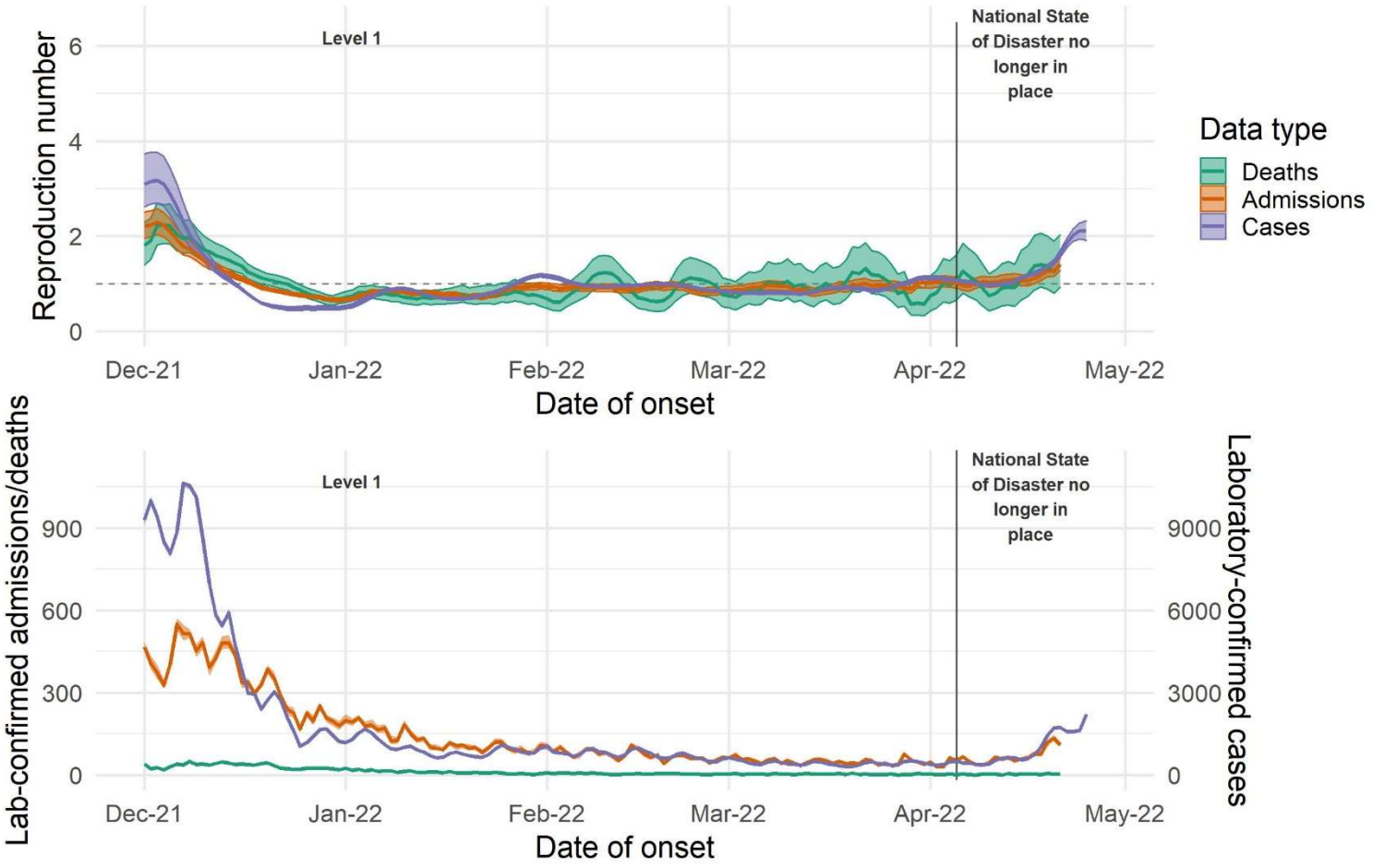

Figure 3. Upper panel: Estimated daily reproduction number (R), with 95% credible intervals Gauteng (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

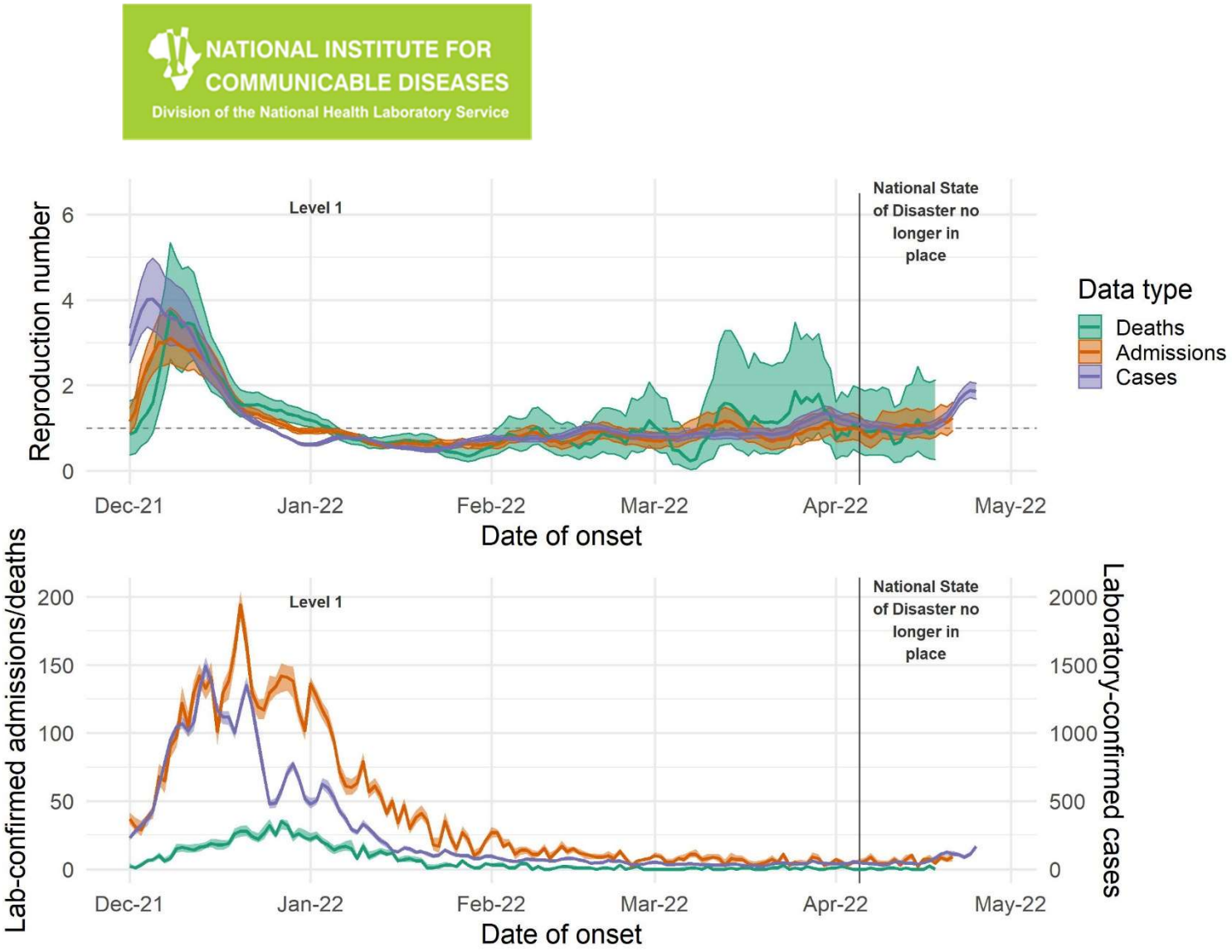

Figure 4. Upper panel: Estimated daily reproduction number (R), with 95% credible intervals, Eastern Cape (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

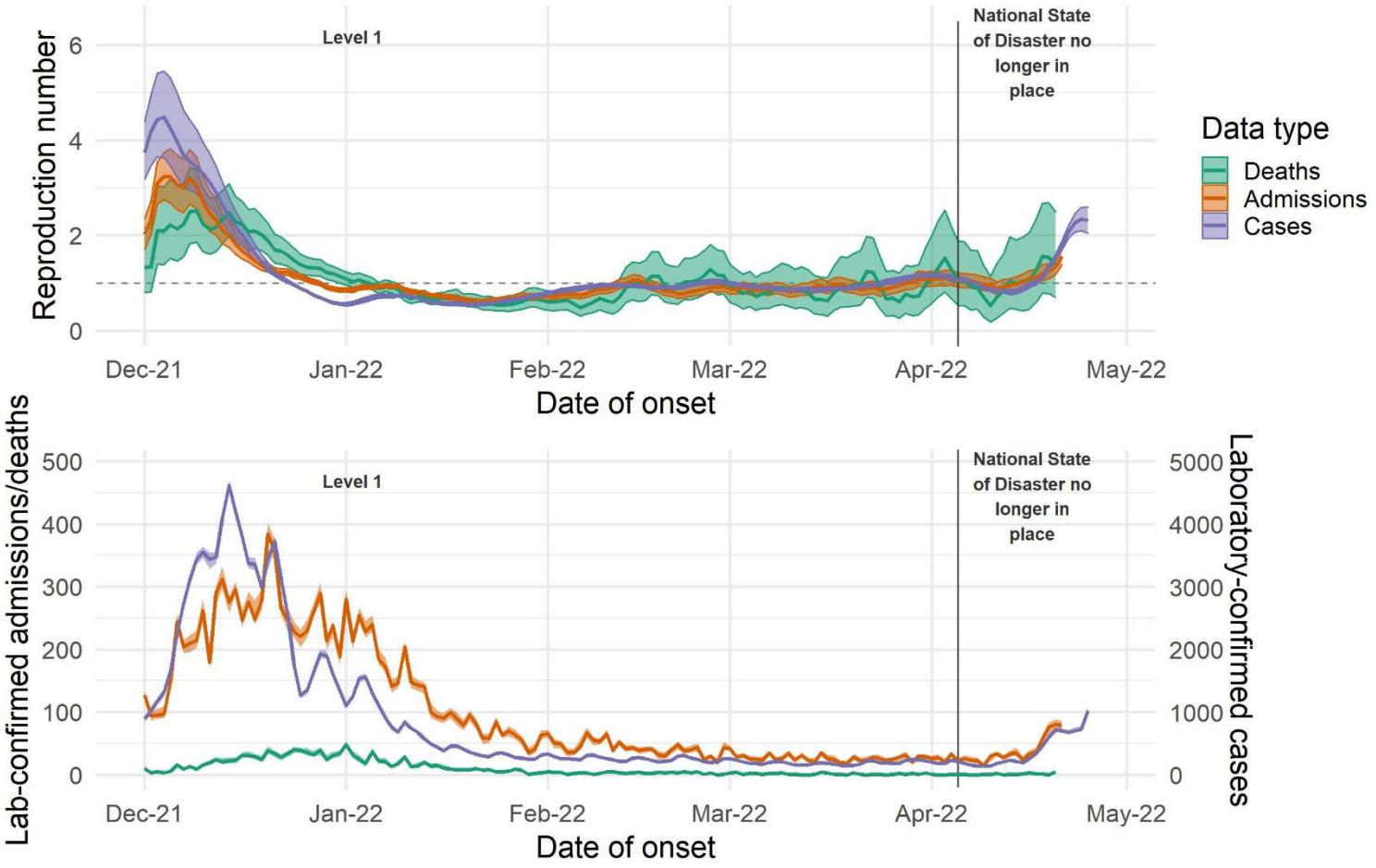

Figure 5. Upper panel: Estimated daily reproduction number (R), with 95% credible intervals, KwaZulu-Natal (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

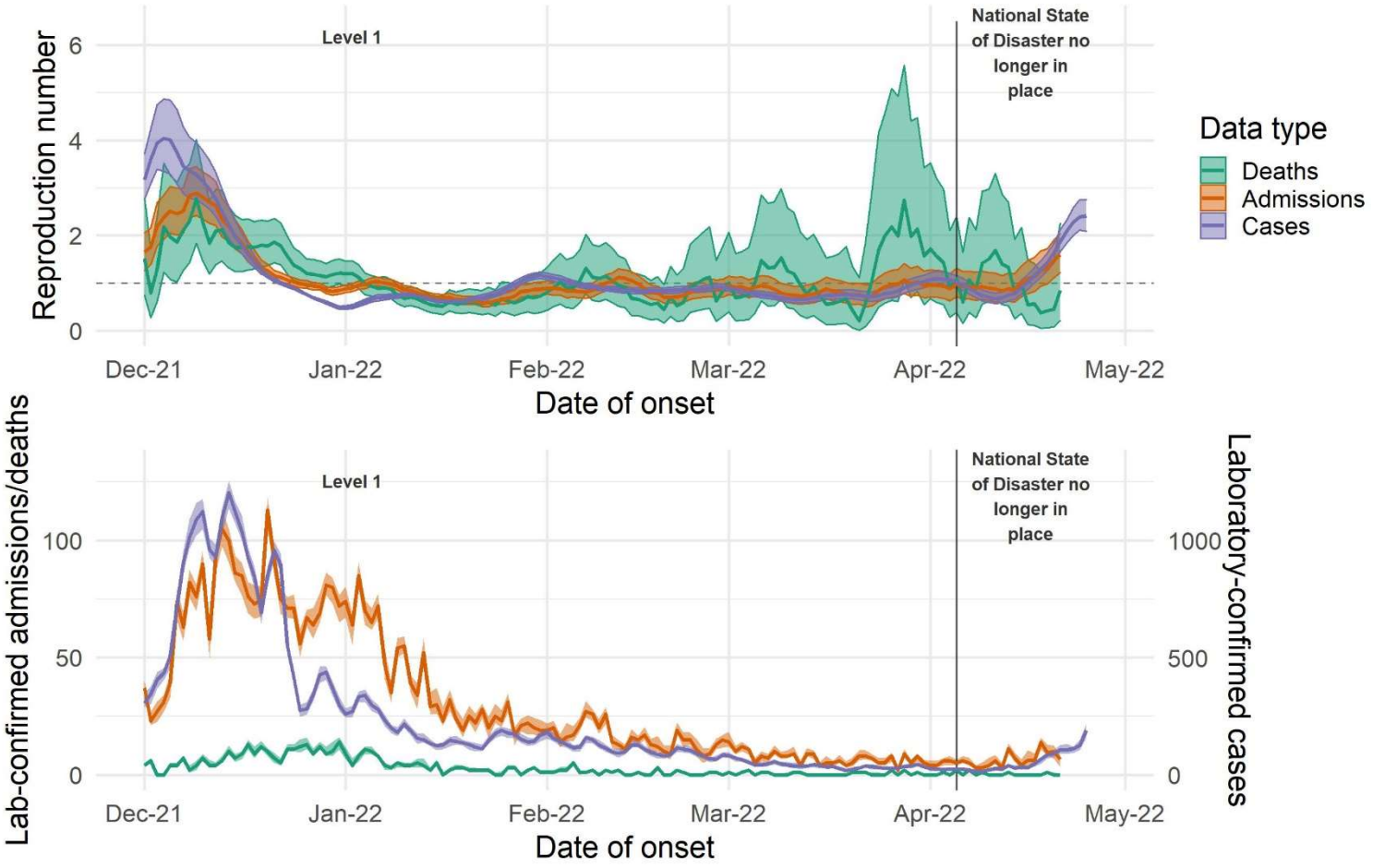

Figure 6. Upper panel: Estimated daily reproduction number (R), with 95% credible intervals, Free State (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases. hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

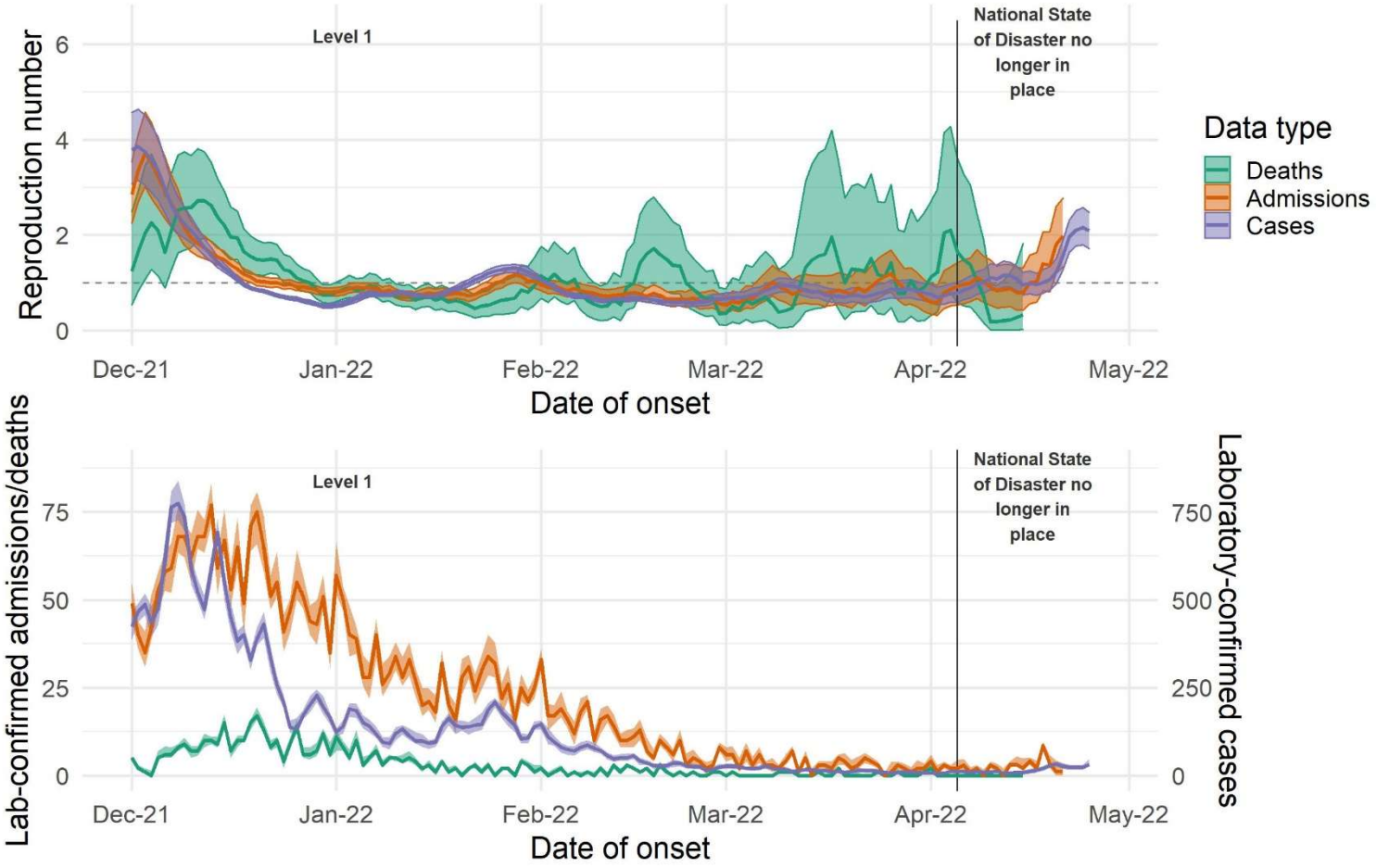

Figure 7. Upper panel: Estimated daily reproduction number ®, with 95% credible intervals, Limpopo (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases. Hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

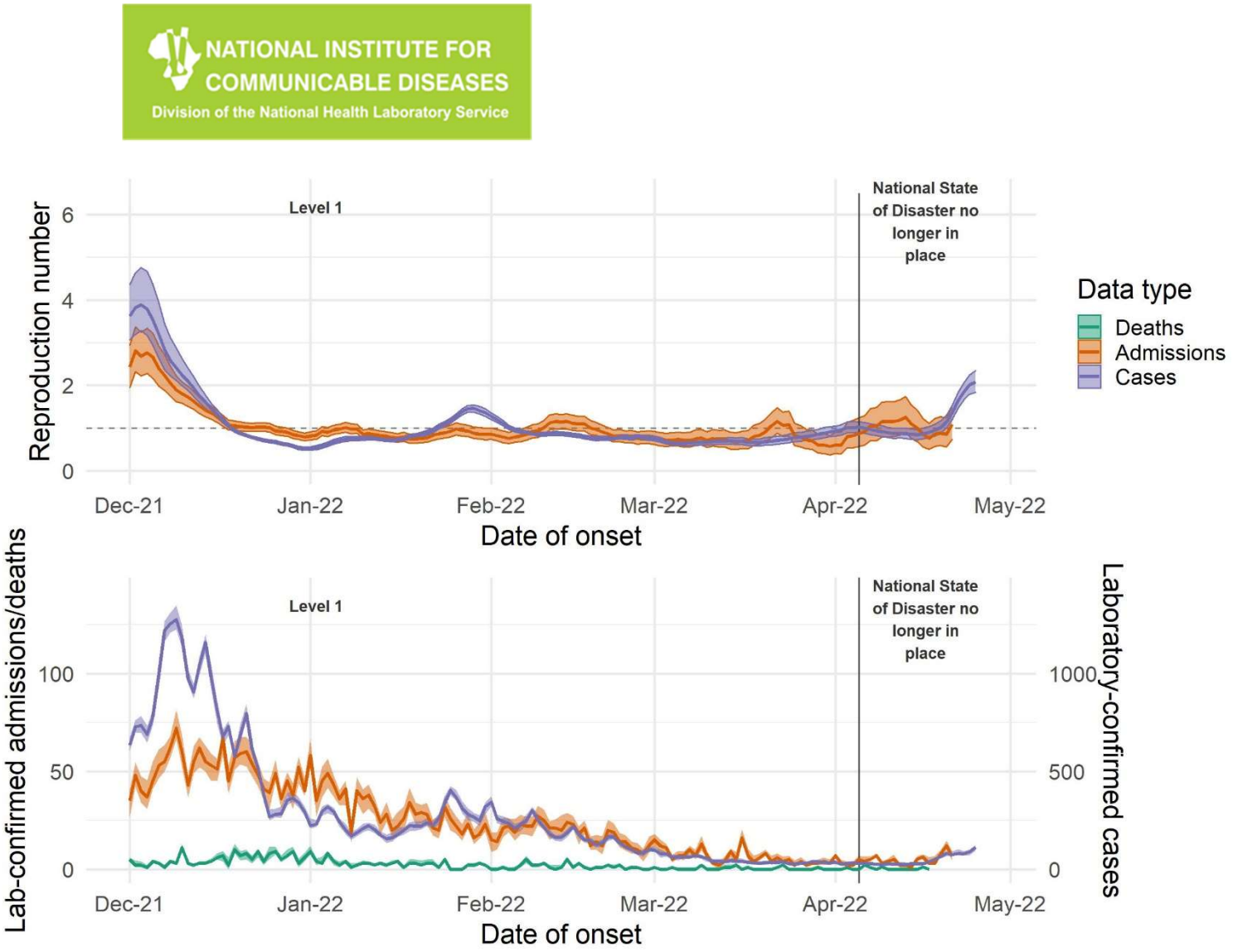

Figure 8. Upper panel: Estimated daily reproduction number ®, with 95% credible intervals, Mpumalanga (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

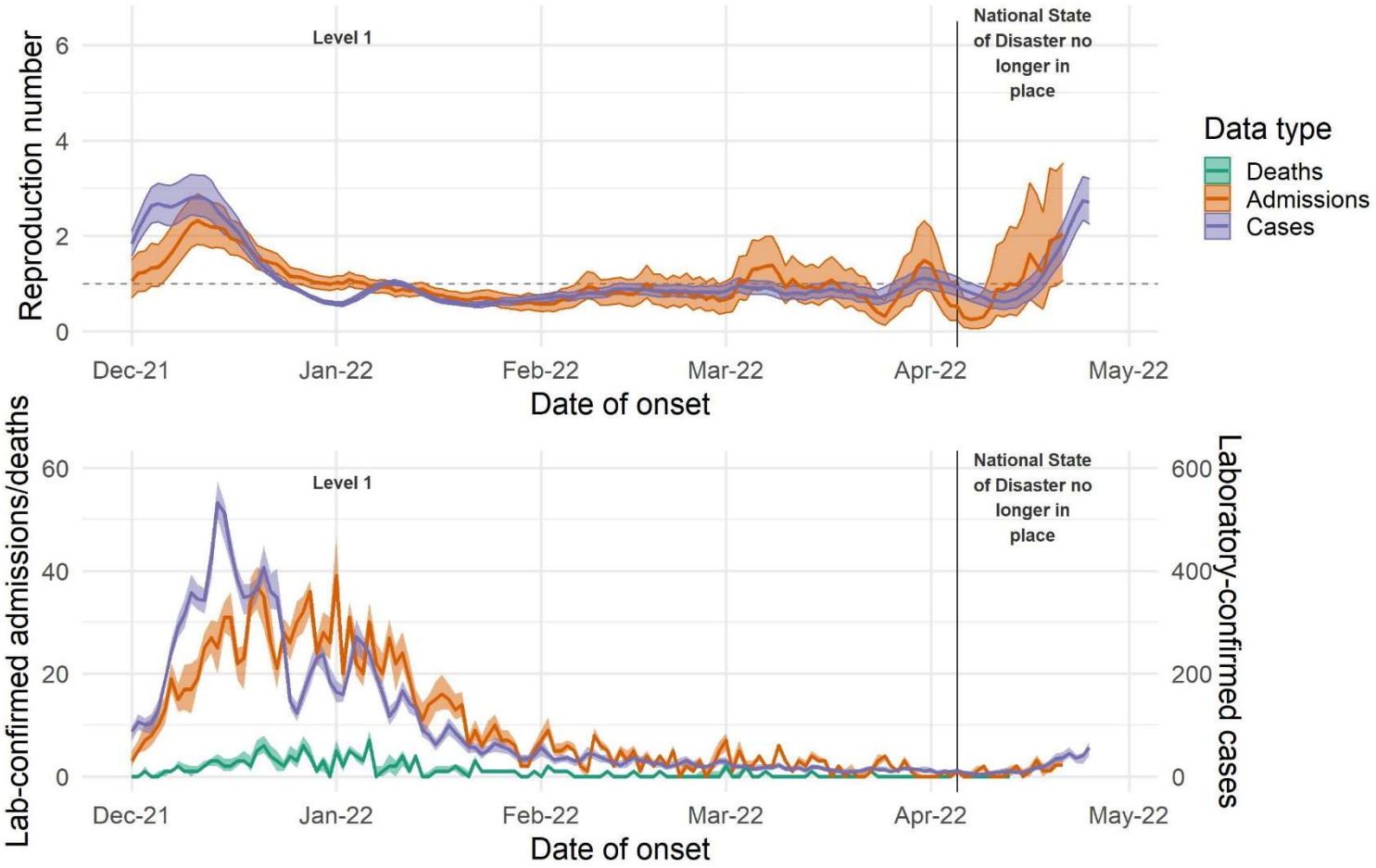

Figure 9. Upper panel: Estimated daily reproduction number ®, with 95% credible intervals, Northern Cape (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

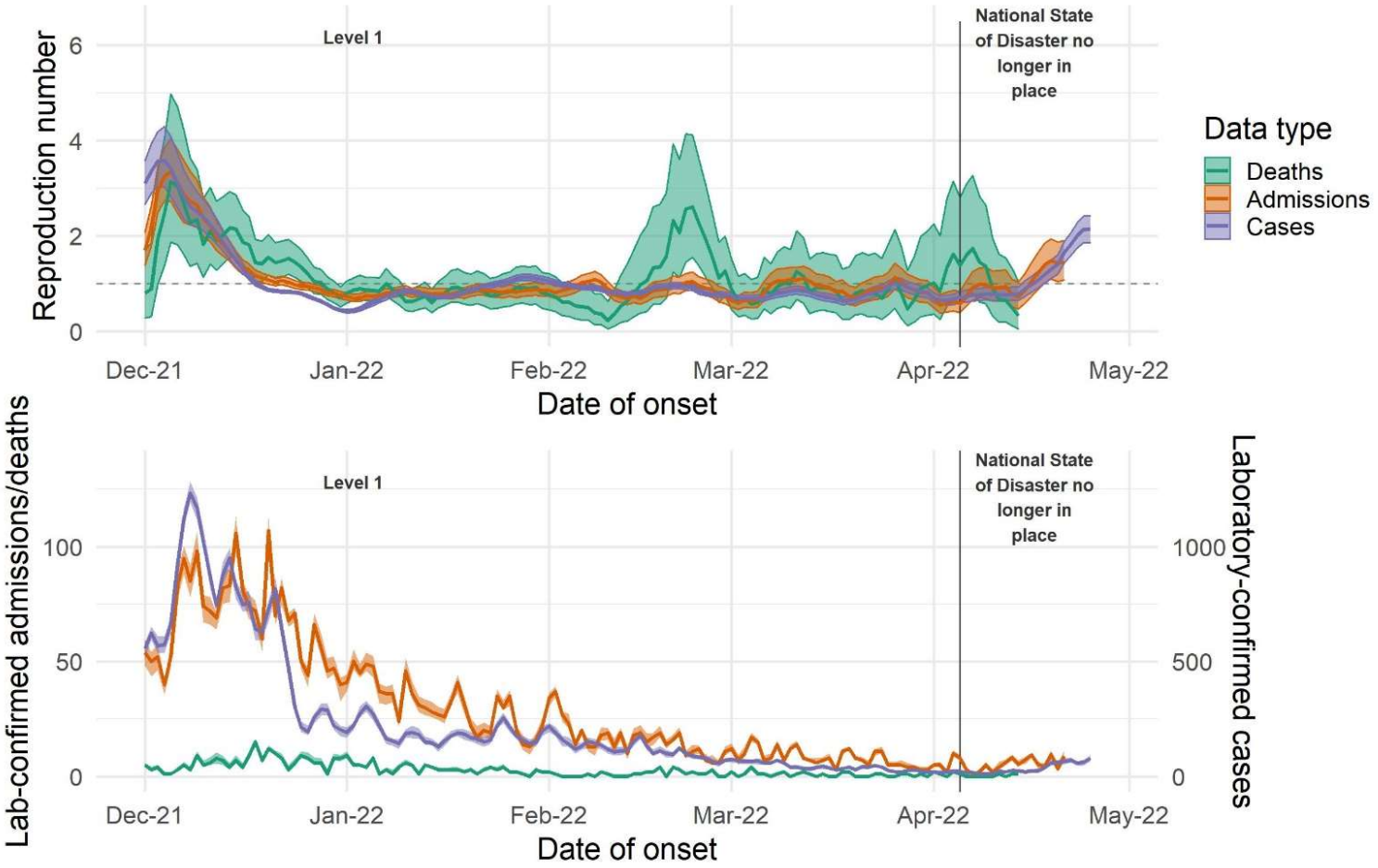

Figure 10. Upper panel: Estimated daily reproduction number (R), with 95% credible intervals, North West (last date included in the estimation: 25 April 2022). Lower panel: estimated number of rT-PCR-confirmed COVID-19 cases, hospital admissions, and hospital-associated deaths by onset date with missing data imputed. The medians and 95% ranges for the imputed datasets are shown. Daily numbers of rT-PCR-confirmed COVID-19 cases in the bottom panel are shown on the right-hand y axis.

Limitations

The main limitation of this analysis is that the ascertainment rate of COVID-19 cases and deaths, along with the proportion of cases which are admitted to hospital, may change over time, potentially affecting R estimation. These effects are likely driven in part by changes in the criteria for testing and hospital admission, by shifting care seeking behavior during the epidemic, by increasing vaccination coverage, and by differences in severity e.g. by variant. In addition, small numbers of deaths in province-level analyses lead to large credible intervals.

Along with the ascertainment rate, the delay between symptom onset and reporting of case/admission/death may change over time, which would affect the accuracy of the adjustment for right-censoring the end of the time series. Furthermore, a number of factors may have altered severity outcomes over time, including increasing vaccination coverage, changes in quality of healthcare provided if health systems are overwhelmed, and potential differences between earlier circulating viruses, the Beta (501Y.V2 / B.1.351) variant that dominated the second wave, the Delta (B.1.617.2) variant which was dominant during the third wave, and the Omicron (B.1.1.529) variant which is currently dominant [viii]. Combined, these factors may lead to perturbations in the time series data that are unrelated to transmission. Comparing R estimates from the three data endpoints may help in assessing the severity of some of these biases, as indicated by inconsistent results across analyses of the three data endpoints. In addition to limitations in the ability of the available time series data to reflect underlying transmission, the serial interval distribution is estimated based on a relatively small data set.

This report was jointly prepared by the National Institute for Communicable Disease (NICD) and the DSI-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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