

CORRELATION OF EXCESS NATURAL DEATHS WITH OTHER MEASURES OF THE COVID-19 PANDEMIC IN SOUTH AFRICA

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Highlights

- By the first week of February 2021, it was estimated that South Africa had experienced more than 135,000 excess deaths due to natural causes since the start of the COVID-19 pandemic. This number is substantially higher than the 46,473 confirmed COVID-19 deaths reported by the Minister of Health to the same point.
- Review of the excess deaths and official COVID-19 deaths reveals large provincial variations in reporting of confirmed COVID-19 deaths. The Western Cape has the highest ratio of confirmed COVID-19 deaths to excess deaths (68%) followed by Free State (46%). Limpopo and Mpumalanga have the lowest ratio (11-12%) and the national average was 32%.
- **A comparison of the time trends in excess deaths, the confirmed COVID-19 deaths (by date of occurrence), and proportions testing positive for SARS-CoV-2 by province makes it quite clear that these excess deaths are directly related to the COVID-19 pandemic.**
- The ratio of the cumulative number of reported COVID-19 deaths (by date of occurrence) to the cumulative number of excess natural deaths has remained roughly constant with a maximum of approximately 44% over an extended period from late July 2020 to early December 2021, after which the weekly numbers of confirmed COVID-19 deaths start to fall due to late reporting of deaths. This robust relationship suggests that one can produce an estimate of the true number of COVID-19 deaths that is consistent with the magnitude and timing of the excess deaths.
- If we assume that the late reporting of confirmed COVID-19 deaths is confined to a four-week period, the proportion of the excess deaths attributable to COVID-19 is 85%. However, if we assume that late reporting of confirmed COVID-19 deaths extends further back in time and will be the same as in the past, then the estimate of proportion of the excess deaths attributable to COVID-19 is 95%.
- **We estimate that nationally 85-95% of the excess natural deaths are attributable to COVID-19. The remaining 5-15% of the excess deaths are considered to be attributable to collateral causes, probably mainly due to overwhelming of the health services during surges in the pandemic.** These proportions differ by province.

Introduction

The rapid weekly mortality surveillance system established by a collaboration between the SAMRC Burden of Disease Research Unit and UCT Centre for Actuarial Research has provided near real-time estimates of the number of deaths in the country that have been contrasted with the number that could be predicted from historical data. By the beginning of February 2021, it was assessed that South Africa had experienced more than 135,000 excess deaths due to natural causes since the start of the COVID-19 pandemic.¹ While the excess deaths from natural causes obtained from the weekly surveillance of deaths provides compelling insight into the overall impact of the epidemic on mortality in South Africa, cumulatively these numbers have been substantially higher than the numbers of confirmed COVID-19 deaths reported daily by the Minister of Health. On 8 February, the Ministry reported 46,473 confirmed COVID-19 deaths.²

A key challenge that is faced in measuring and understanding of the COVID-19 pandemic is that we do not know the true number of infections or COVID-19 deaths. Since many infected people never get tested, the number of confirmed cases is only a fraction of true infections. Furthermore, we cannot assume that the people who have been tested are representative of the population as there would be numerous factors determining whether an individual gets tested or not.

Furthermore, without detailed information about the underlying cause of death, it is impossible to know what proportion of the excess deaths are attributable to COVID-19 and what proportion are attributable to collateral causes to the pandemic and efforts to contain it. That said, the collateral impact of the pandemic cuts in both directions: some collateral deaths will have occurred as a result of the impact on the healthcare system during surges of COVID-19; yet the non-pharmaceutical interventions associated with the national response to the virus may have reduced other causes of death, for example influenza and respiratory syncytial virus (RSV).

This supplementary report seeks to present evidence supporting the conclusion that the bulk of the excess deaths in South Africa are attributable to COVID-19. We focus on comparisons between the temporal trends in the proportions of tests that are positive for SARS-CoV-2 and the excess and officially reported deaths observed at the national and provincial levels and present a first attempt to estimate the proportion of excess natural deaths that are possibly due to COVID-19.

Proportions testing positive for SARS-CoV-2 and excess mortality

The proportion testing positive (PTP) is simply the ratio of the number of positive SARS-CoV-2 test results divided by the number of tests conducted. Although not without limitations, we consider that this is a better measure of trend in the pandemic than the universally reported absolute number of positive tests (cases), which are critically dependent on the number of people being tested.

The PTP by province and week since 1 March 2020 based on reports released by the National Institute for Communicable Diseases³ is shown in Figure 1. The graphs for each province are stacked one above the other at the level of 25% testing positive to provide a rapid assessment of the temporal trend. The trends in positivity of tests shown in Figure 1 makes clear the rather different dynamics of the two waves of infections experienced to date, with the first wave being generally more drawn out, particularly in the

¹ <https://www.samrc.ac.za/sites/default/files/files/2021-02-10/weekly6Feb2021.pdf>

² <https://sacoronavirus.co.za/2021/02/08/update-on-covid-19-08th-february-2021/>

³ <https://www.nicd.ac.za/wp-content/uploads/2021/02/COVID-19-Testing-Summary-Week-5-2021.pdf>

Northern Cape and Free State. The second wave, which began in the Eastern Cape in mid-October 2020 and spreading first to the Western Cape and then KwaZulu-Natal, and then more generally to other provinces by early December 2020, appears to have been characterised by somewhat more compressed and intense infection.

For comparison of the excess deaths, data are presented as *p*-scores, a measure of excess mortality as a proportion of the estimated baseline of the mortality that would have been expected in the absence of SARS-CoV-2.⁴ The excess mortality *p*-scores by week and province from the start of epidemiological week 10 of 2020 (week beginning 1 March 2020) through to the end of week 5 of 2021 (week beginning 31 January 2021) are shown in Figure 2. The provincial trends are stacked one above the other at the *p*-score level of 100% (at vertical gaps of 100%). Figure 2 shows that other than in Gauteng, the Free State and the Northern Cape, the peak excess mortality was markedly greater in the second wave than the first – with KwaZulu-Natal showing in excess of 300% (four times) expected mortality for a period of two weeks in early 2021.

Comparison of the two figures suggests a strong temporal lagged correlation between the testing and excess mortality measures. In the period through to early May 2020 (in the Western Cape; and slightly later elsewhere), no substantial excess mortality was observed, with the *p*-scores fluctuating around the expected values, with the fluctuations due to random fluctuations in the number of deaths, or in the estimated baselines. Coinciding with the first wave of COVID-19 mortality, *p*-scores increased in every province, with the notable exceptions of Limpopo (where very limited excess mortality was observed) and then decreased back to close to the estimated baselines, except the Northern Cape and Free State (where the decline in first wave excess mortality was somewhat prolonged). The emergence of the second wave of excess mortality, initially in the Eastern Cape, and then spreading to other provinces also shows a (generally) more intense experience of excess mortality, especially in the provinces that had the mildest experience of excess mortality in the first wave.

⁴ The derivation of this baseline is described in the report on the predicted number of deaths prepared by the SAMRC/UCT team. A *p*-score of 0 indicates that there is no excess mortality relative to the assumed baseline; a *p*-score of 100% indicates that mortality is 100% (that is, two times) higher than the assumed baseline.

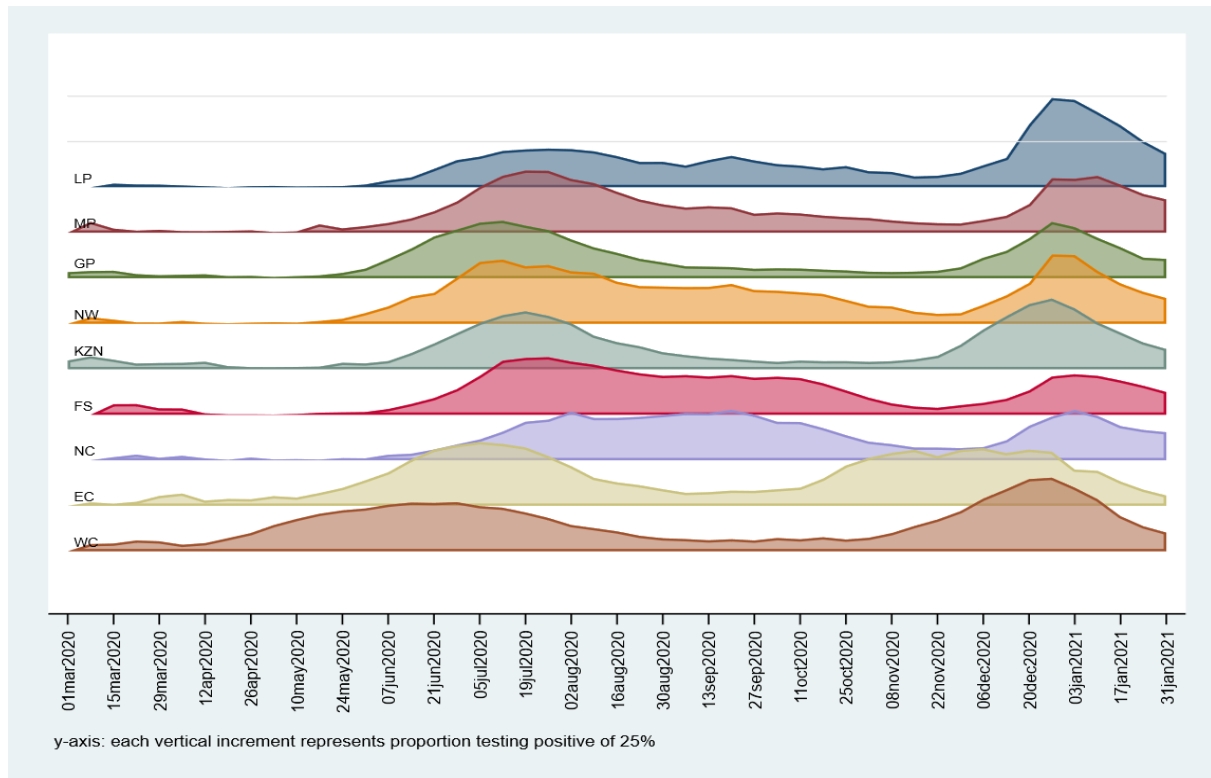


Figure 1: Proportions testing positive for SARS-CoV-2 by week and province, South Africa

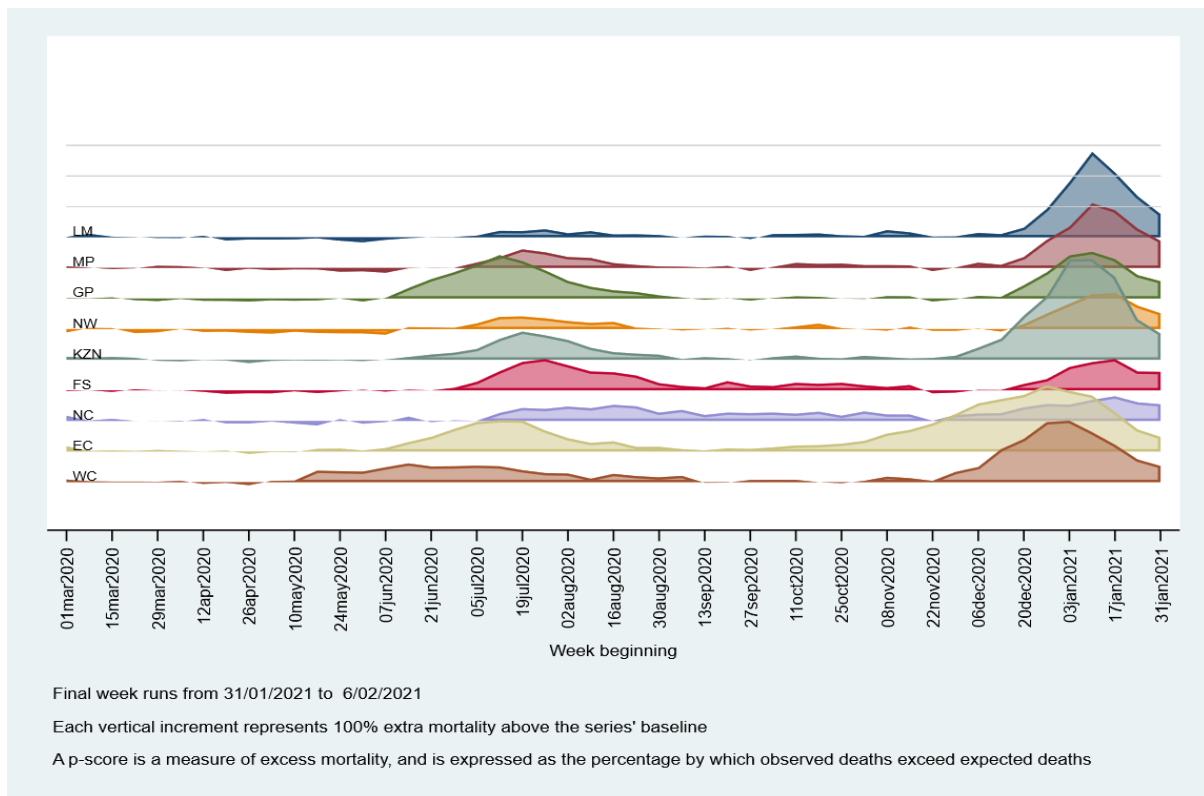


Figure 2: Excess mortality p-scores by week and province, South Africa

As suggested by Figures 1 and 2, there is also a strong association between the measure of excess deaths (the p -score) and the proportion testing positive (PTP). Figure 3 shows this association at a national level of the p -scores (yellow line on left-hand axis) with the PTP (black dashed line on right-hand axis), while Figure 4 shows the same comparison for the nine provinces.

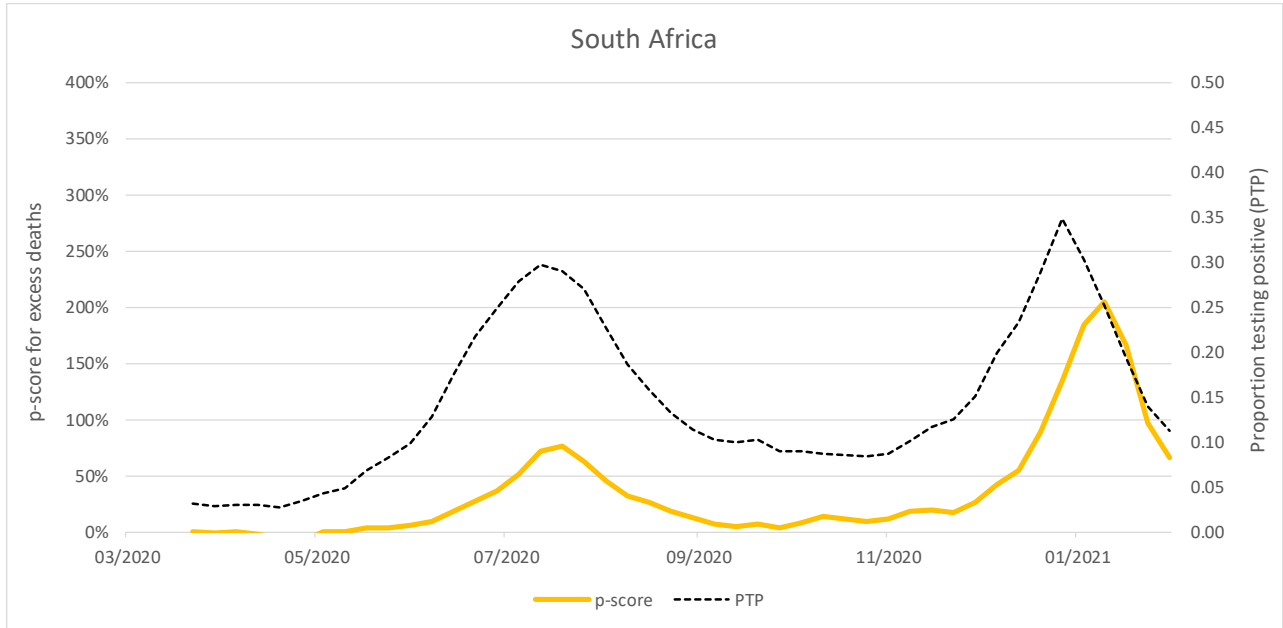


Figure 3: p -scores for excess deaths and proportion testing positive (PTP) by week, South Africa

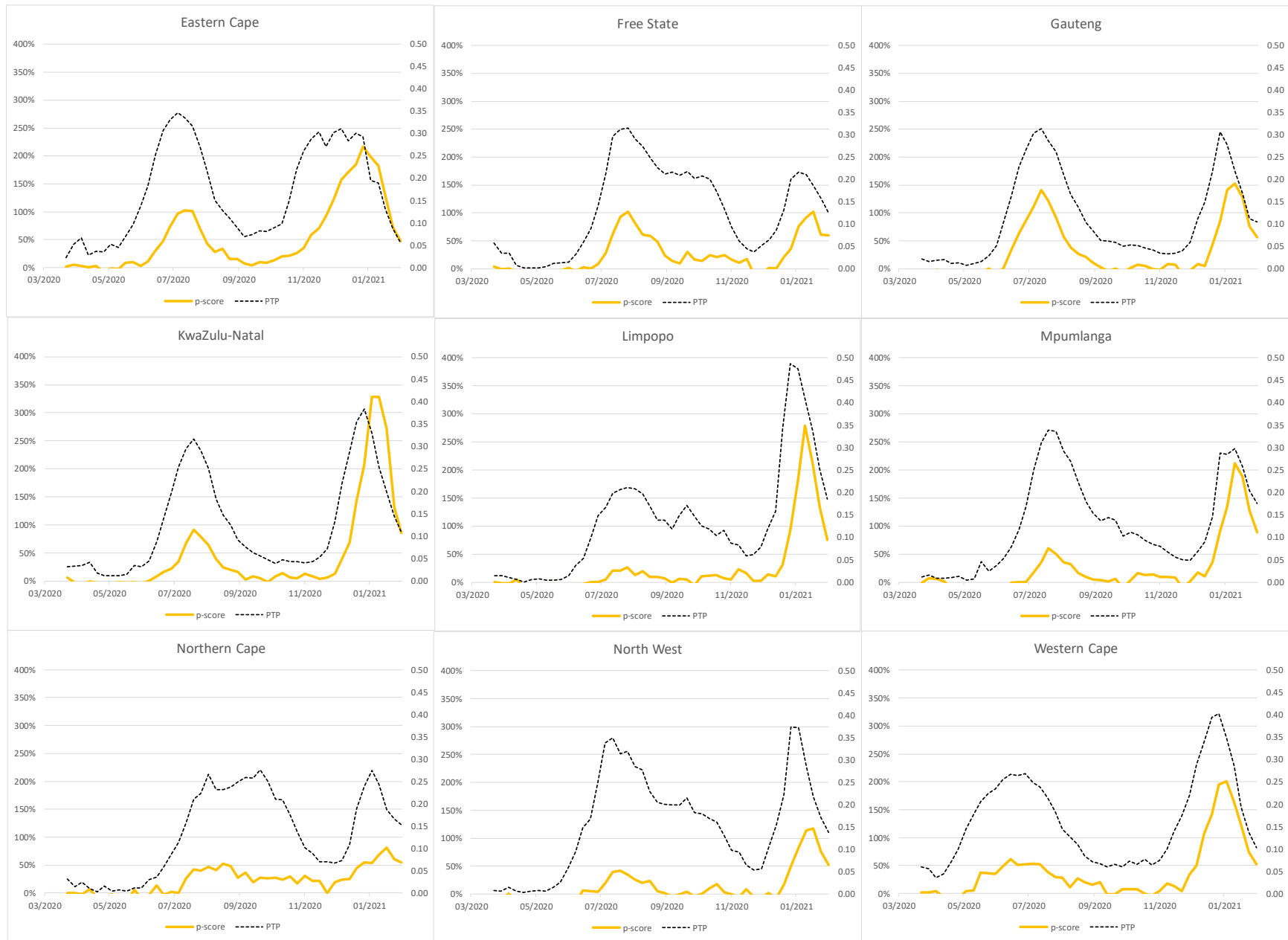


Figure 4: p-scores for excess deaths and proportion testing positive (PTP) by week and province

Reported COVID-19 deaths and excess mortality

The information released nightly by the Minister of Health records the known COVID-19 deaths notified to the National Department of Health by provincial health departments in the preceding 24-hour period. These reported deaths include only those known to have died from COVID-19 and suffer from two limitations. First, the data, by definition, is skewed towards COVID-19 deaths occurring within health facilities. Second, the data are subject to lags (at times in the past quite long lags) between the date of death, and the date of reporting to the national department.

At a national level, we can see this in Figure 5, which shows the number of known COVID-19 deaths (classified by week of death – the blue line; and classified by week of reporting – the dashed red line); and the excess deaths.

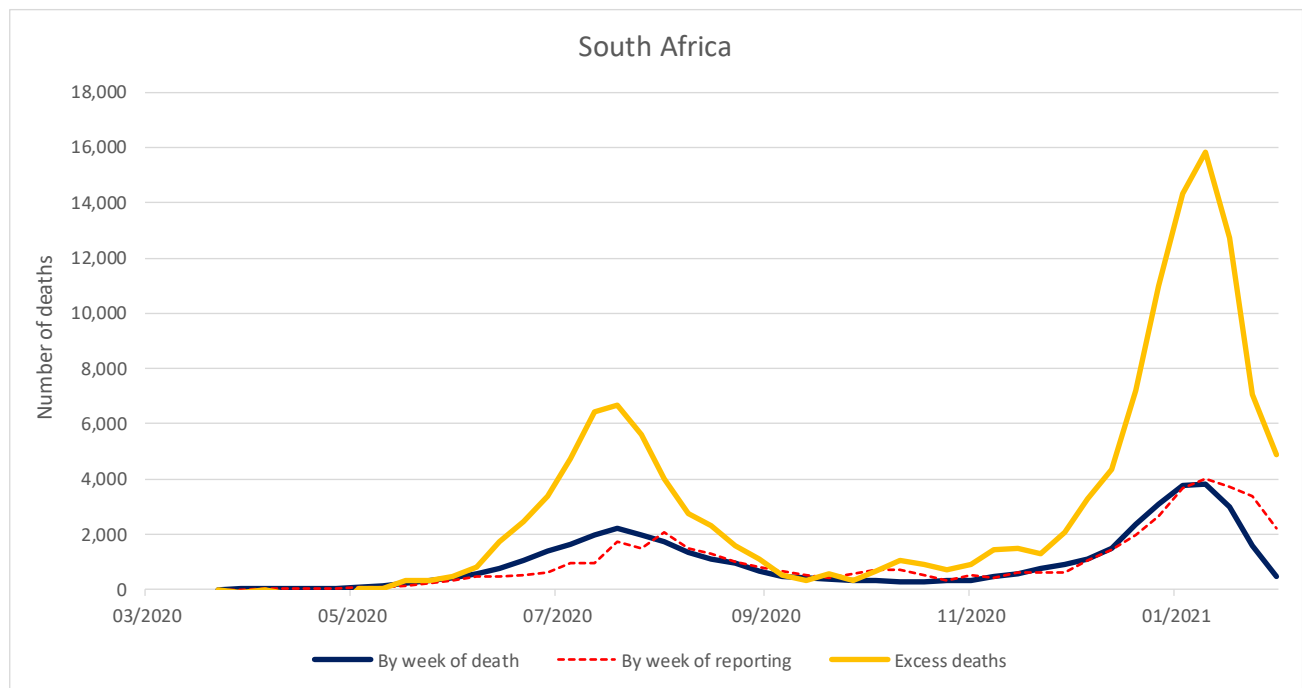


Figure 5: Official COVID-19 deaths (classified by week of death; and week of reporting) and compared to estimated excess deaths, South Africa

The effect of delays in reporting can be seen in the discrepancy, especially around the time of the first peak in July 2020, and in the weeks following, when reported deaths lagged their occurrence by several weeks, on average COVID-19. The discrepancy towards the second half of January again reflects delays in notifying recent deaths to the national department, and the reporting of deaths that had occurred in preceding weeks.

There is a clear gap between the confirmed COVID-19 deaths and the excess deaths which is proportionately larger during the surges. Nevertheless, it is important to note that – particularly when classified by date of death (as opposed to date of reporting), there is a strong temporal correspondence in the timing of the peaks.

Nationally, the evolution of officially reported deaths (classified by date of reporting, and date of occurrence), and the estimated number of natural excess deaths⁵ is shown in Table 1.

Table 1 Cumulative officially reported/confirmed COVID-19 deaths and proportion of excess deaths⁶, to week ending 6 February 2021, South Africa

Region	Official confirmed deaths	Excess deaths from natural causes	Proportion of excess deaths
South Africa	44,509	137,731	32%
Province			
Eastern Cape	10,664	31,951	33%
Free State	2,774	6,066	46%
Gauteng	8,137	22,521	36%
KwaZulu-Natal	8,666	33,791	26%
Limpopo	1,452	12,117	12%
Mpumalanga	1,005	8,919	11%
Northern Cape	576	2,540	23%
North West	953	4,614	21%
Western Cape	10,306	15,214	68%

While all provinces show the same temporal correlation between the reported and excess deaths, with the exception of the Western Cape (where delays in reporting deaths are less significant), the estimated excess deaths exceed the officially reported deaths by significant amounts. Equivalent plots to Figure 5 for the nine provinces are shown in Figure A1 in the Annexure. These comparisons suggest that, nationally, the true number of COVID-19 deaths could be 2 to 3 times higher than that officially reported, albeit with substantial variation between provinces. Nevertheless, it is important to note that in periods where reported COVID-19 deaths, classified by date of occurrence, were fewer, in almost every province excess death (as well as the p -scores, as shown in Figures 3 and 4) fell to much lower levels. In contrast, in periods of surging mortality, the difference between the reported COVID-19 deaths and the estimated number of excess natural deaths is marked.

Estimating the possible proportion of excess deaths attributable to COVID-19

It has been argued by some commentators that the temporal and geographic correspondence between the excess deaths and the proportion of positive tests suggests that all or most of the excess deaths are due to COVID-19. However, correlation does not actually permit the apportionment of the estimated excess deaths between deaths attributable to COVID-19 and deaths attributable to collateral causes (arising, for example, from constraints on, or overburdening of, the health care system).

As an initial attempt to estimate the proportion of excess deaths that could be attributed to COVID-19, we analyse the proportion of excess deaths that are confirmed COVID-19 (by date of death) over-time and then,

⁵ With baseline adjusted to account for COVID-19 deaths early in the epidemic.

⁶ Because of the lag in reporting COVID-19 deaths and/or the increase in collateral deaths over the peaks of waves, this proportion falls during a wave and increases after the wave has passed.

extrapolate the number of confirmed COVID-19 to estimate an upper bound to the true number of COVID-19 deaths.

As can be seen from Figure 6, the ratio of the cumulated reported COVID-19 deaths (by date of occurrence) to the cumulative number of excess natural deaths was very high in the early weeks⁷, and then began to fall rapidly due to significant under-reporting of COVID-19 deaths. From the end of July 2020, the ratio increased over time to a higher, more stable level of around 44% suggesting that the reporting system was fully developed and established. There is a decline in this ratio over the most recent eight weeks due, presumably, to missing late reports of deaths in this period.

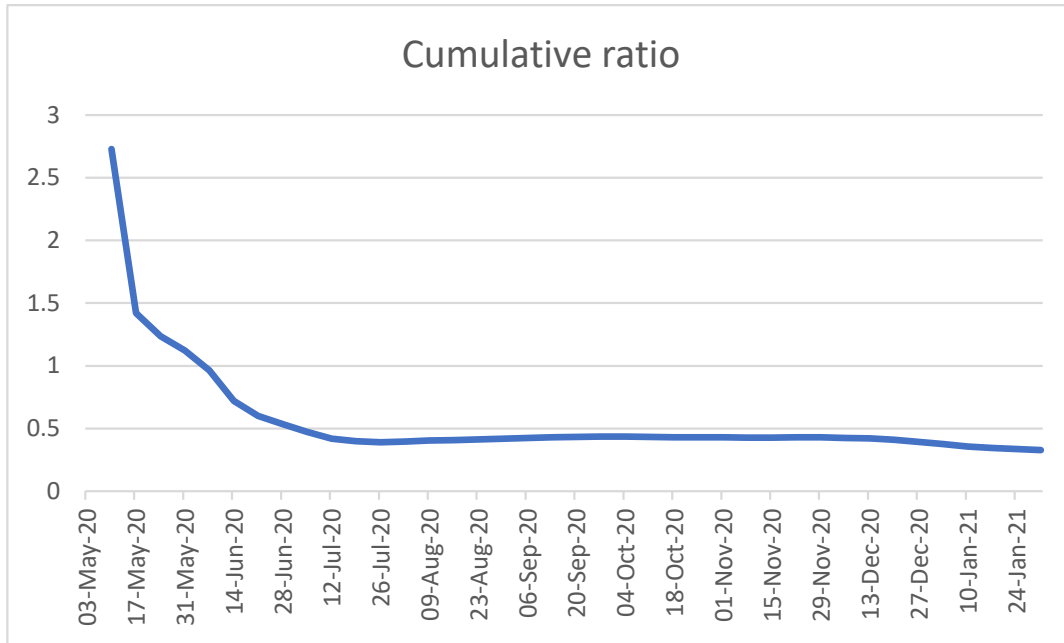


Figure 6: Ratio of the cumulative reported COVID-19 deaths (by date of occurrence) to the cumulative number of excess natural deaths

Dividing the number of confirmed COVID-19 deaths (by date of death) by the estimate of completeness provides a possible estimate of the true number of COVID-19 deaths on the assumption that the numbers of confirmed COVID-19 deaths (by date of death) track in parallel the true numbers of deaths, shown as “Est. COVID-19 deaths1” in Figure 7. The implication of this is that collateral deaths account for much higher proportions of the excess deaths during the height of the surges. An alternative approach is to assume that it is the weekly excess deaths that track the true number of weekly COVID-19 deaths over time. This produces the second estimate of the true number of COVID-19 deaths shown in Figure 7 (as “Est. COVID-19 deaths2”). In this case the collateral deaths are a fixed proportion of the deaths over time.

⁷ Because the baseline at that point was set to match the reported deaths by date of reporting, which turned out, once data on deaths by date of occurrence became available, to underestimate the number of confirmed COVID-19 deaths.

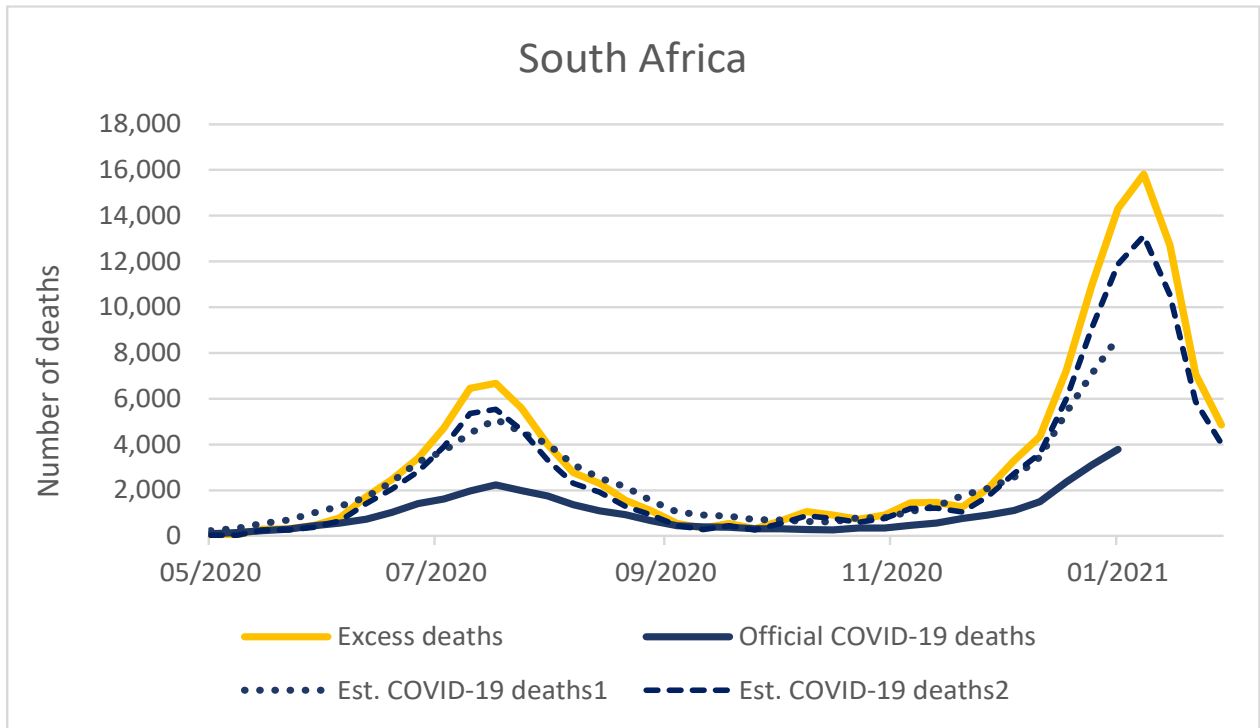


Figure 7: Official COVID-19 deaths (classified by week of death), estimated true number of COVID-19 deaths and excess natural deaths, South Africa

In both scenarios, the estimate of the cumulative proportion of excess deaths that can be considered to be non-COVID related through to 9 January 2021⁸ is approximately 17% (i.e., just under 85% of the excess deaths are attributable to COVID-19). In the first scenario, it varies over time while in the second scenario it remains fixed over the whole period.

On the other hand, if one assumes that late reporting of confirmed COVID-19 deaths (by date of occurrence) in future weeks will be sufficient to maintain the completeness found during the trough between the waves then only around 5% of excess deaths might be considered not to be attributable to COVID-19 causes (i.e., about 95% attributable to COVID-19 causes). This is a plausible scenario given likely challenges of routine reporting of confirmed COVID-19 deaths during the surges.

The provincial estimates of the true numbers of COVID-19 deaths using these two approaches are shown in Figure 8. In the case of KwaZulu-Natal, Limpopo and Western Cape, the two estimates are relatively close over the whole period. In the case of Free State and Gauteng the two estimates differed in the 1st wave but are very close in the 2nd wave, possibly indicating that reporting of COVID-19 deaths was not well established during the 1st wave. The flattening of the reported number of COVID-19 deaths in the Eastern Cape during the 2nd wave stands out, as does the very low numbers of reported COVID-19 deaths in the 2nd wave in North West. These discrepancies may reflect data reporting issues or health system issues. The numbers in the Northern Cape are too few to characterise. Further work is needed to interpret the data at provincial level.

⁸ Although there are data on the numbers of confirmed COVID-19 deaths by date of occurrence for the most recent four weeks, these have been excluded due to the possibility that they are significantly underestimated due to late reporting of deaths.

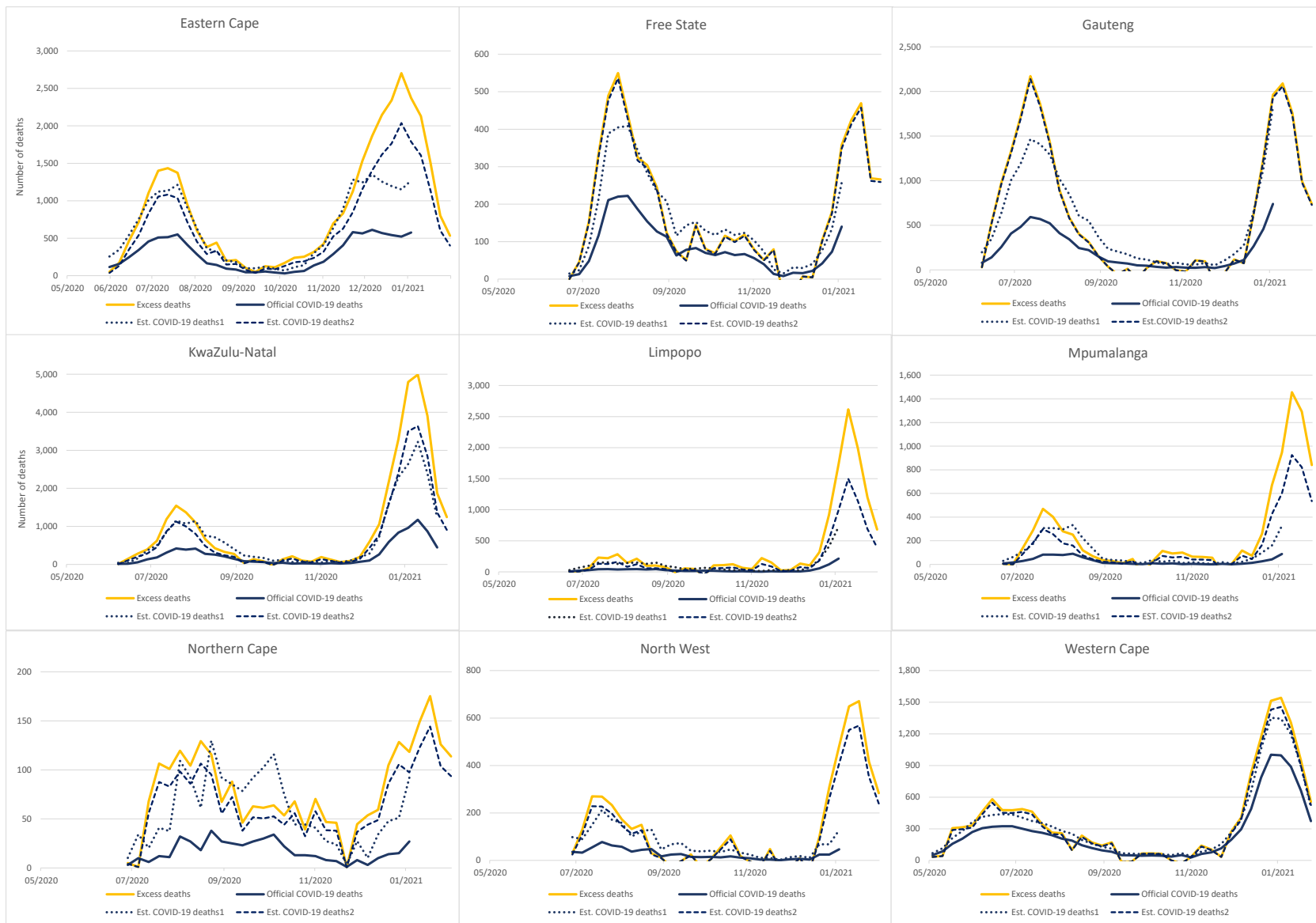


Figure 8: Official COVID-19 deaths (classified by week of death), excess natural deaths and two time series of estimated true number of COVID-19 deaths by province

Although the approach described above is approximate and is not applicable to data on confirmed COVID-19 deaths by date of reporting (i.e., the cumulative total generally tracked as a measure of the epidemic), it is useful in determining a plausible range of the proportion of excess deaths that might be considered attributable to COVID-19, and the proportions that might be considered attributable to collateral causes. However, the method does not lend itself to analysis of fine-grained temporal patterns of the proportion of excess deaths that might be attributed to COVID-19 and whether the overall proportion collateral will be the same for different age-groups. Further work is required to gain a more robust insight into this important aspect of the evolving patterns of mortality during the pandemic.

Conclusions

At both national and provincial levels, relative excess mortality (the p -score) rises and falls with a slight lag following the reported proportions testing positive. This and the close temporal correspondence between the confirmed COVID-19 deaths to the numbers of excess deaths for much of the epidemic, suggests strongly⁹ that the majority of the excess deaths from natural causes that have been identified in the country (probably 85%-95% of the excess deaths depending on extent to which the data used are missing deaths yet to be reported) are due to COVID-19.

The analysis of excess deaths has revealed extraordinary insights into mortality trends in the country. For example, during the early part of 2020, it became clear that the impact of lockdown and the use of non-pharmaceutical interventions led to a prevention of large numbers of expected deaths due to influenza and other respiratory viruses. In addition, the trends suggest that nationally, and in most provinces, except for Free State and Gauteng, the mortality impact of COVID-19 has been more severe in the 2nd wave than in the 1st, corresponding with the more virulent spread of the pandemic.

While this analysis also suggests that most of the aggregated excess deaths are likely due to COVID-19, a full accounting for the causes of death can only be attempted once the confidential portions of the Department of Home Affairs' Death Notification Form have been captured and coded to ICD-10 causes. This will take some time, and – even once those data are available – may prove to be less informative than anticipated, since more than 10 percent of all such forms provide insufficient information to reliably attribute an underlying cause of death. In the interim, the COVID-19 data linkage project will go some way to support the estimates we have made. An analysis of a sample of those confidential Death Notification Forms might shed more light on the causes of death during the COVID-19 pandemic in South Africa, even though the full impact of the pandemic on collateral deaths may take some time to unfold.

⁹ Since collateral deaths are largely limited to only those that are proportional to the confirmed COVID-19 deaths or excess deaths over time, i.e., possibly those resulting from overburdened health care, and not (at least not yet) from other causes such as the economic impact of lock-down. In addition, detailed analysis of the deaths in the Western Cape suggests that nearly all of the difference between the numbers of excess deaths and the numbers of confirmed COVID-19 deaths can be accounted for by probable COVID-19 deaths missed for various reasons (such as deaths occurring within 28 days of testing positive but not in hospital, false negatives, etc.)

Acknowledgements

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Annexure

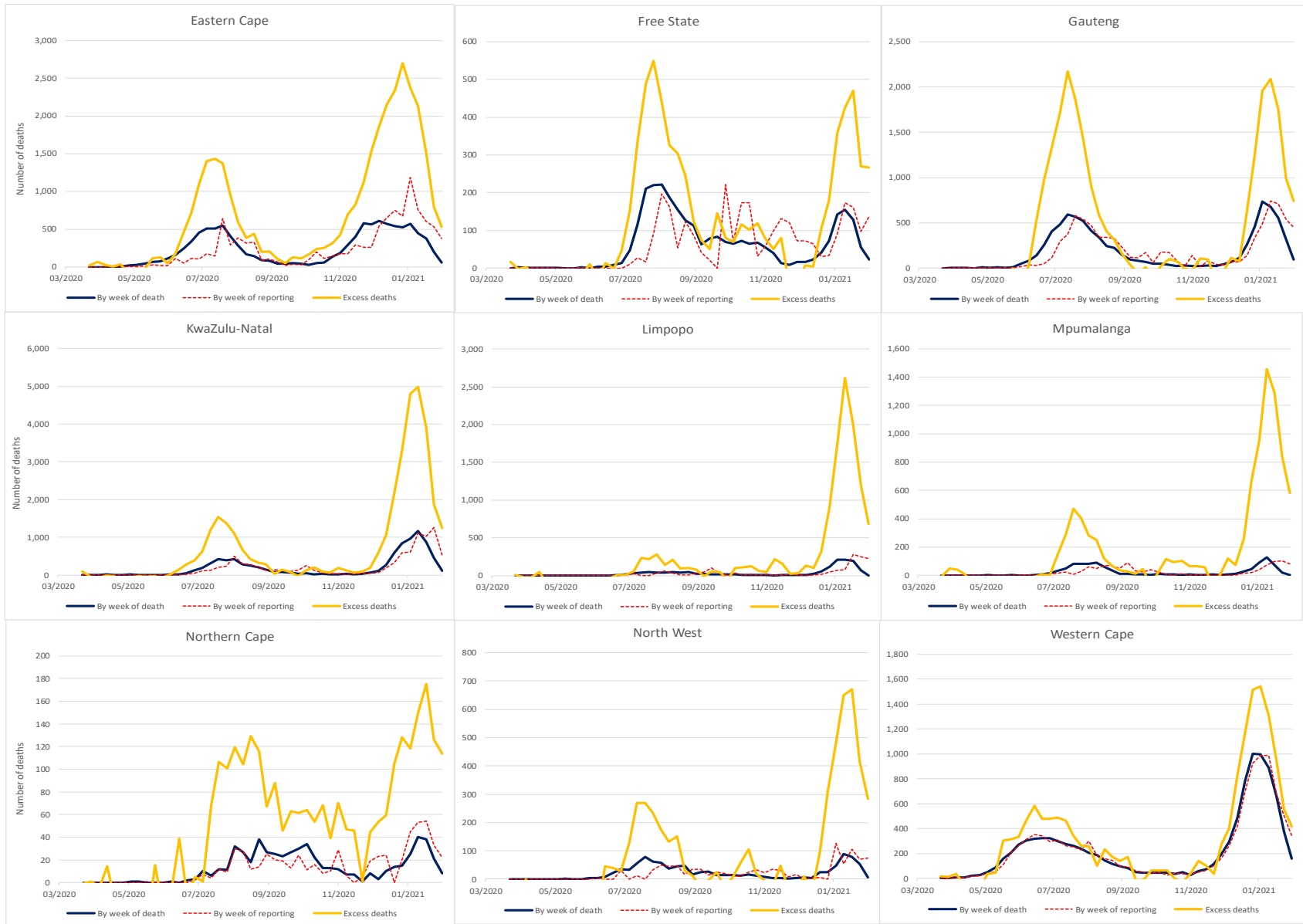


Figure A1: Official COVID-19 deaths (classified by week of death; and week of reporting) and estimated excess deaths by week and province