

# Monitoring the COVID-19 Pandemic in Scotland

*11 May, 2020*

Numbers of new cases and new deaths, as reported by Health Protection Scotland (HPS), have been monitored on a daily basis (see Figures 1 and 2). To assess the rate of spread of COVID-19 in Scotland, we have considered the ratio of the sum of these metrics in the past week compared to their respective sums in the previous week. A similar ratio has been used to measure changes in the number of patients in hospital by comparing daily numbers of patients in hospital and ICU to those one week ago (see Figure 4). However, these statistics are potentially subject to biases and we list several caveats which should be considered when interpreting their values.

## Data

The cumulative number of cases and deaths has been reported each day since the start of the pandemic in Scotland by Health Protection Scotland (HPS). The numbers include deaths which have been registered with National Records of Scotland (NRS) where a laboratory confirmed report of COVID-19 in the 28 days prior to death exists. These numbers are expected to capture the majority of deaths occurring in hospitals, but a lower proportion of those in care homes and the community.

The National Records of Scotland (NRS) also provide a weekly report of all deaths where COVID-19 is mentioned on the death certificate (not just those confirmed by a test as provided by HPS). The report provides information by place of death, location, age and gender.

The number of COVID-19 patients in hospital and Intensive Care Units (ICUs) are reported on a daily basis. The terms used in this report refer to the number of patients with confirmed or suspected COVID-19 who are registered as being under that department's care at midnight (see Figure 3).

## Weekly comparisons

We have used ratios of both cases and deaths in the past week compared to the previous week (i.e. the total over the 7 days as a ratio of the total over the previous 7 days) to monitor the weekly rate of spread of COVID-19 (see Figures 4, 6, 7 and Table 1). Weekly totals are considered as they are less prone to week day variations than the daily values (see Caveats below).

Ratios for patients in hospital are calculated as the number of patients in hospital (or ICU) on a given day compared to the number of patients in hospital (or ICU) one week before (e.g. the ratio for May 11th is 'number of patients on May 11th' divided by 'number of patients on May 4th').

The confidence interval for the log of the ratio of two frequencies ( $w_1/w_2$ ) may be approximated by  $\{1/w_1 + 1/w_2\}$ , based on assuming a Poisson distribution for  $w_1$  and  $w_2$  ( $w_1$  = total cases (or deaths) in past week and  $w_2$  = total cases (or death) in previous week, or for number of patients in hospital  $w_1$ =number of patients on the given day,  $w_2$ =number of patients on that day the week before). The approximation is obtained from the standard formula:

$$\begin{aligned}
\text{Var}\{\log(a)\} &\approx \text{Var}(a)/\text{Mean}(a)^2 \\
&= a/a^2 \text{ for a Poisson frequency} \\
&= 1/a
\end{aligned}$$

The ratio on a log scale may be expressed:

$$\log(w1/w2) = \log(w1) - \log(w2)$$

giving

$$\begin{aligned}
\text{Var}\{\log(w1/w2)\} &= \text{Var}\{\log(w1) - \log(w2)\} \\
&= \text{Var}\{\log(w1)\} + \text{Var}\{\log(w2)\} \\
&= \{1/w1 + 1/w2\}
\end{aligned}$$

and

$$SE\{\log(w1/w2)\} = \sqrt{\{1/w1 + 1/w2\}}$$

The 95% confidence interval is then calculated as  $\log(w1/w2) \pm 1.96 \times SE$ , which is exponentiated to provide the confidence intervals displayed.

## Caveats

We list several caveats which should be borne in mind when considering the statistics presented:

Daily numbers of cases and deaths are affected by:

- Changes in testing policy which in turn is affected by the availability of tests and laboratory facilities for their analysis. For example, if testing is increased then less severe cases of COVID-19 are likely to be detected.
- Variations in hospital admission policy, e.g. if admission criteria are relaxed then a higher proportion of COVID-19 patients are admitted and tested, and then included in the daily case and (HPS) death statistics.
- Variations in reporting of deaths and test results across week days and due to public holidays (See Figure 8).

An increase in testing is likely to cause less severely infected cases to be included and this may make comparisons of case numbers over time unreliable. Nevertheless, a decrease in cases would still provide strong evidence of a reducing rate of infection.

HPS death numbers include individuals who have positive tests but are not in hospital. Increased testing in the community (particularly in care homes) will cause more deaths to be counted and make HPS death numbers difficult to compare over time. The NRS death numbers are expected to allow a more consistent comparison, and also allow care home and other non-hospital deaths to be considered separately. However, these data are only issued on a weekly basis and they will be less up-to-date than the data from HPS. The latest weekly ratio for NRS deaths (available to 03/05/2020), 0.79 (95% CI 0.71-0.89), is now noticeably lower than that for HPS deaths 0.90 (95% CI 0.78-1.05) and might be expected to more accurately reflect the true underlying rate of spread of COVID-19 (see Figures 6 and 7).

Given the later availability of NRS data and the variable factors affecting both the number of cases and HPS deaths, some consideration might be given to hospital data (see Figure 4). However, these data will not reflect deaths in care homes, and will be affected by any change in criteria for admission to hospital or to ICU.

The ratios by place of death (see Figure 6) will also be subject to any variation in hospital admission policy. For example, if the proportion of care home residents being admitted to hospital has increased over a two week period, we might expect the ratio for deaths in care homes to be an under-estimate, and the ratio for hospitals an over-estimate.

The confidence intervals indicate the accuracy of the observed ratio of the two particular weeks considered. However, there are many factors which influence the ratios other than the true underlying rate of spread of COVID-19. Some of these will be systematic (as described in the above caveats) and others may be more random. The caveats should all be considered when interpreting the ratios, particularly when the confidence interval does not include 1. A modelling approach would be suggested to confirm whether the ratios have consistently fallen below 1 and to determine whether their values have stabilised. Note that while the ratios are related to the R number and values of less than (or greater than) 1 might be expected to correspond to R numbers of less than (or greater than) 1, their values will not be the same. Additionally this analogy is based on unchanged policies for testing and hospitalisation over the two week period used to calculate the ratio.

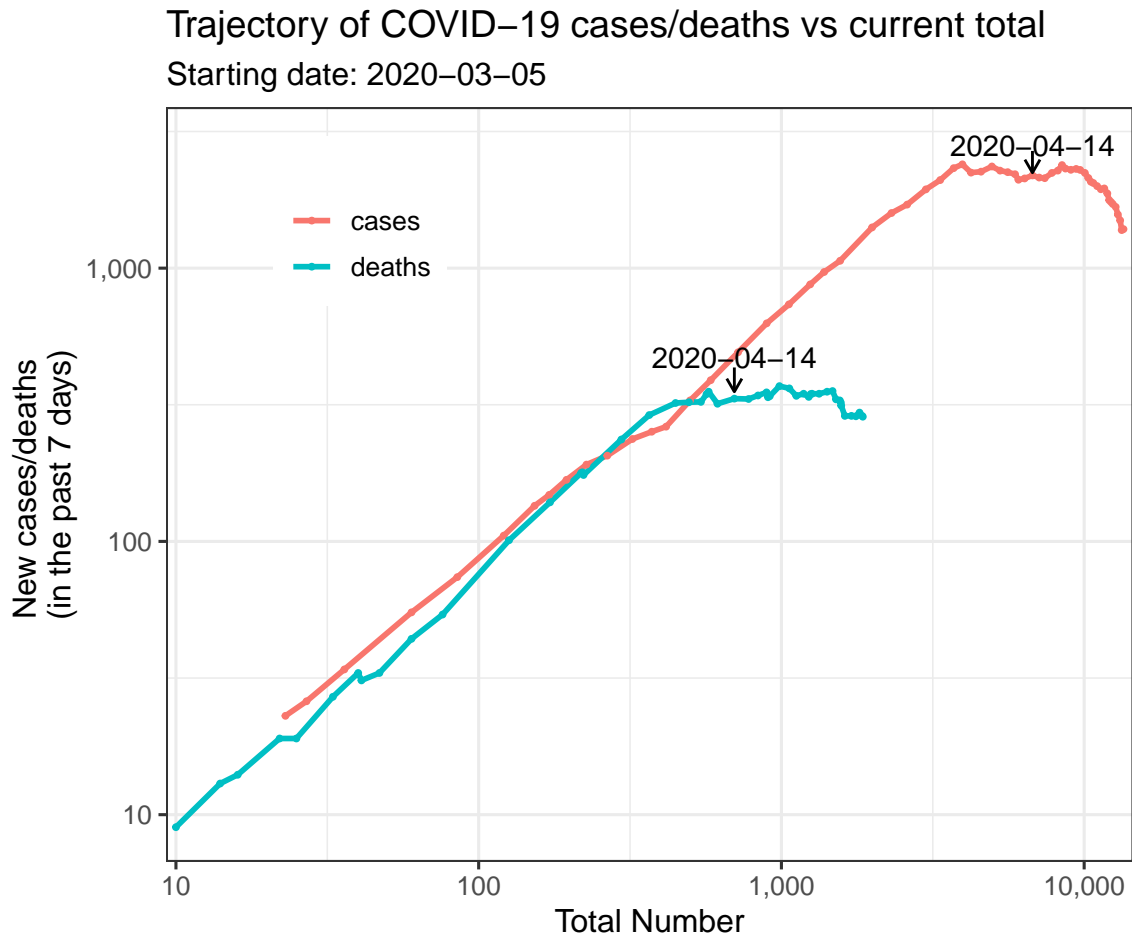


Figure 1: Trajectories of COVID-19 cases and deaths vs respective cumulative numbers. Data source: HPS

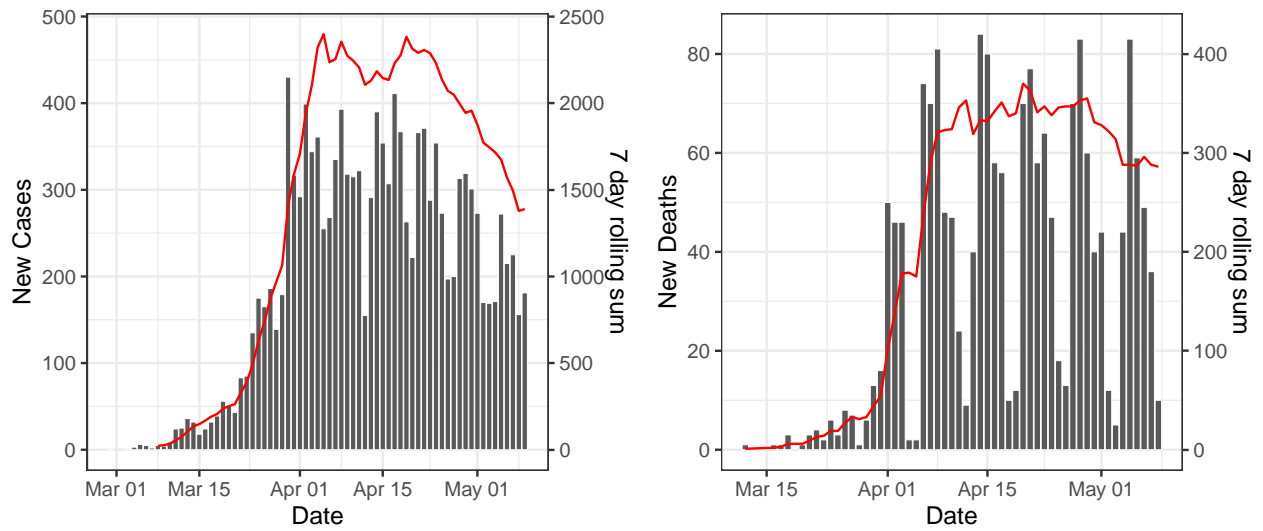


Figure 2: Daily cases and deaths and 7 day rolling sum

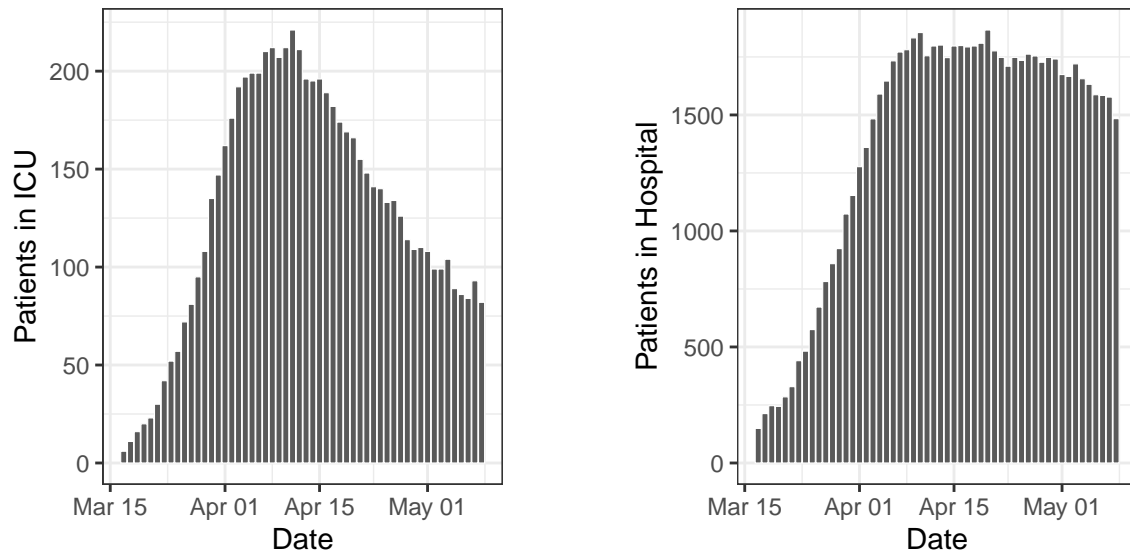


Figure 3: Number of patients in hospital and ICU at midnight. Daily totals include both confirmed and suspected COVID-19 cases

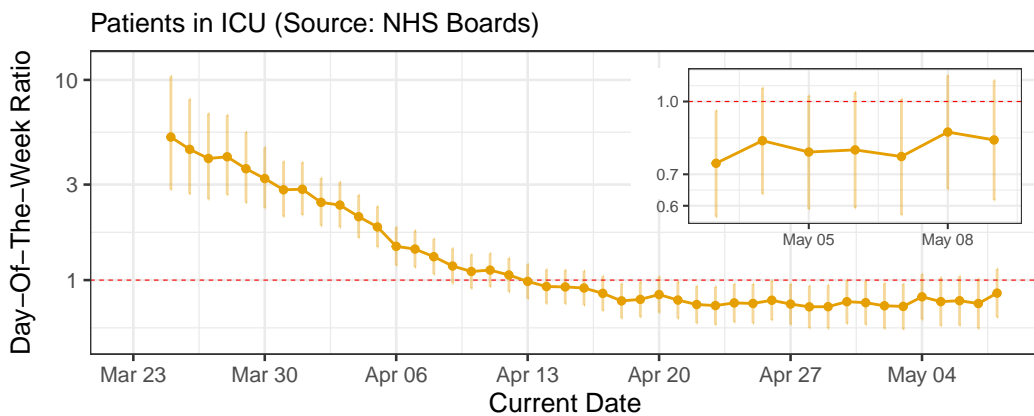
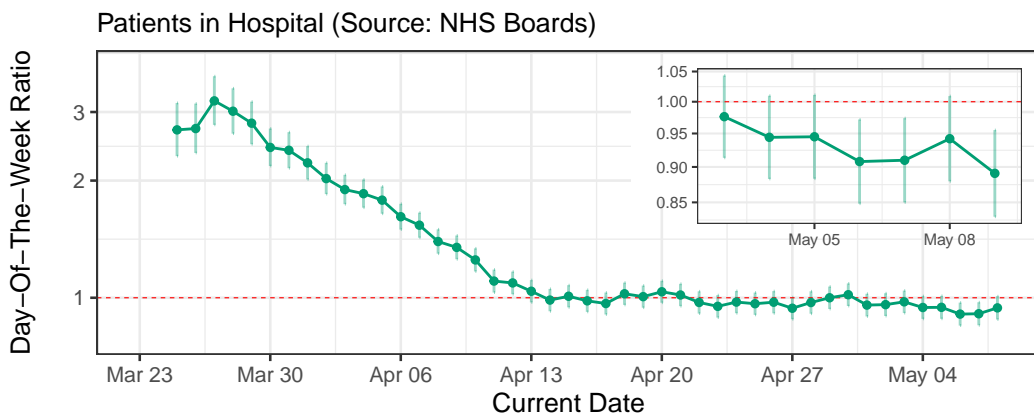
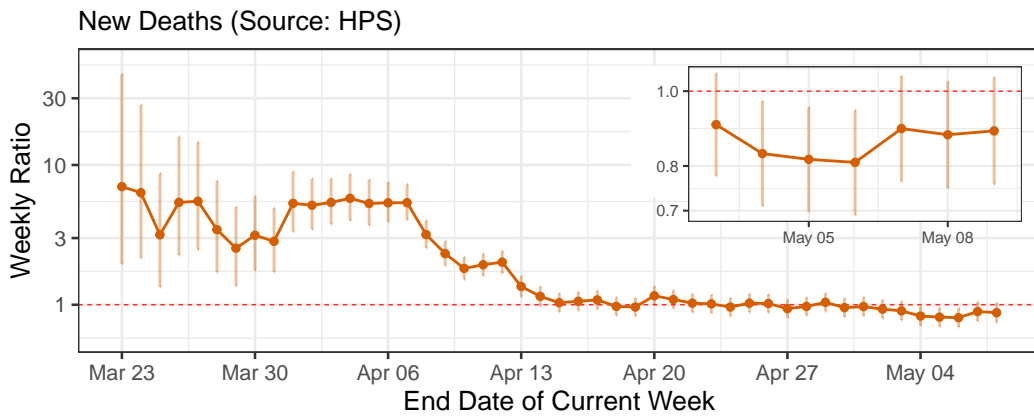
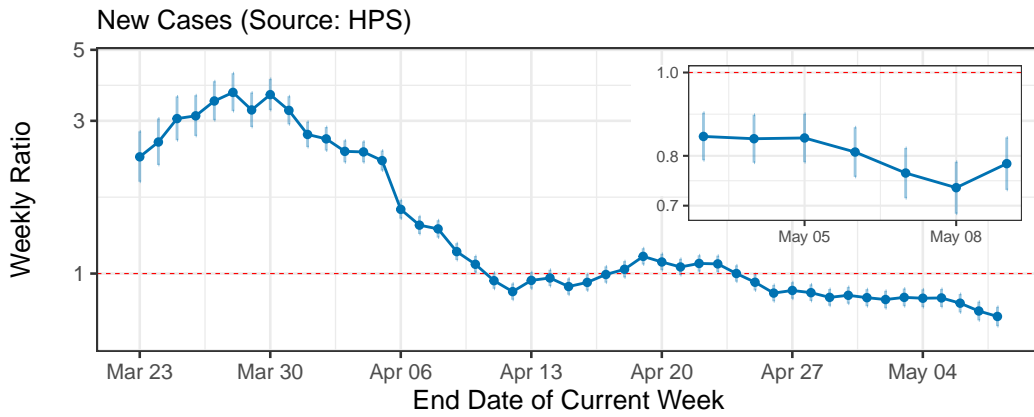


Figure 4: Weekly ratios for new cases and new deaths are ratios of weekly sums, plotted on a log10 scale. Day-of-the-week ratios for patients in hospital and ICU are ratios of daily counts, measured 7 days apart and plotted on a log10 scale. Figure insets highlight ratios and trends for the last 7 days.

Table 1: Most recent estimates of ratios and their 95% confidence intervals (CI). Weekly ratios for new cases and new deaths are ratios of weekly sums. Day-of-the-week ratios for number of patients in hospital and ICU are ratios of daily counts, measured 7 days apart. Date: 09/05/2020.

Measure	Ratio	95% CI
New Cases (Source: HPS)	0.78	0.73-0.84
New Deaths (Source: HPS)	0.89	0.76-1.04
Patients in Hospital (Source: NHS Boards)	0.89	0.83-0.96
Patients in ICU (Source: NHS Boards)	0.83	0.62-1.11

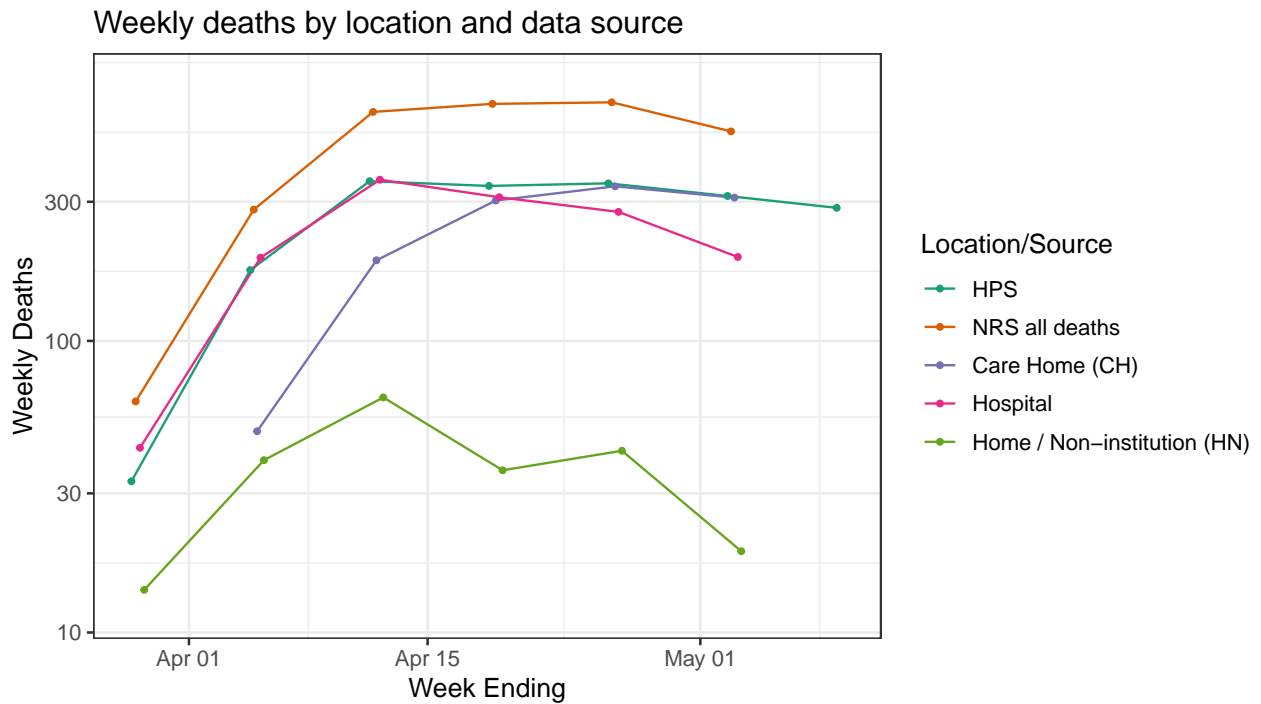


Figure 5: Number of deaths per week, compared by location and data source

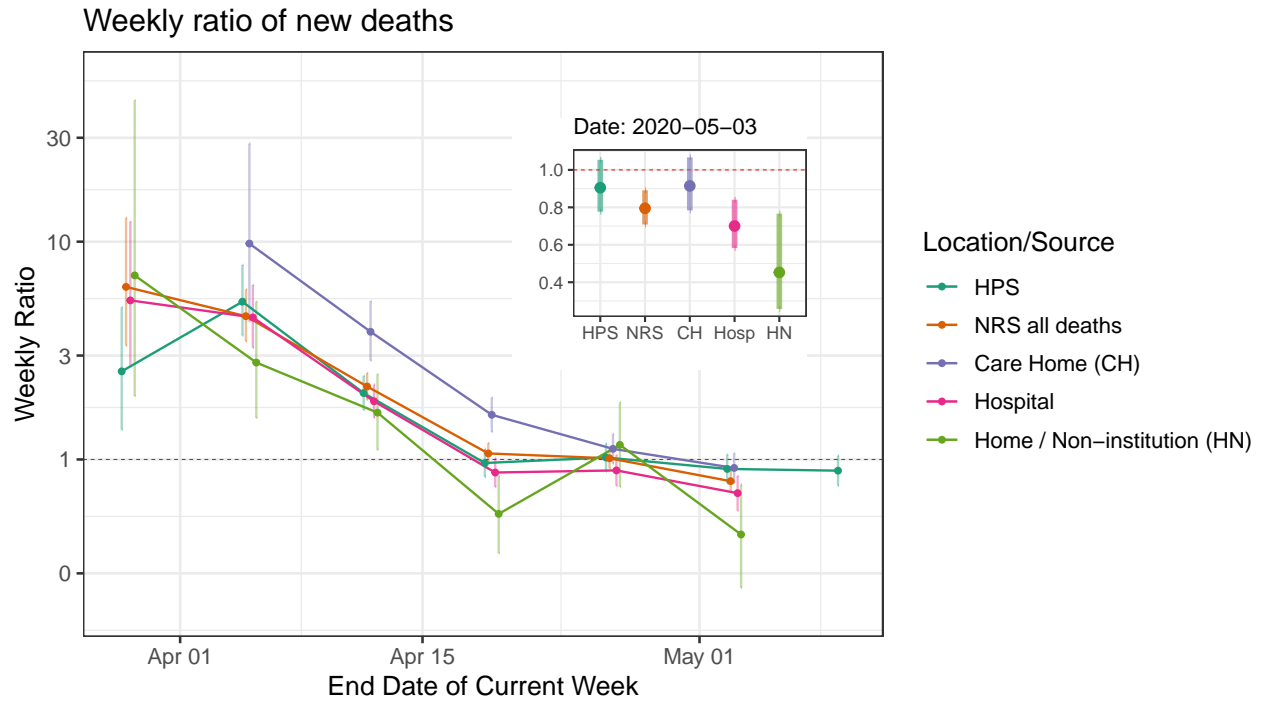


Figure 6: Ratio of new deaths during current week vs previous week, compared by location and data source. Figure inset highlights the last date that both HPS and NRS data are available for.

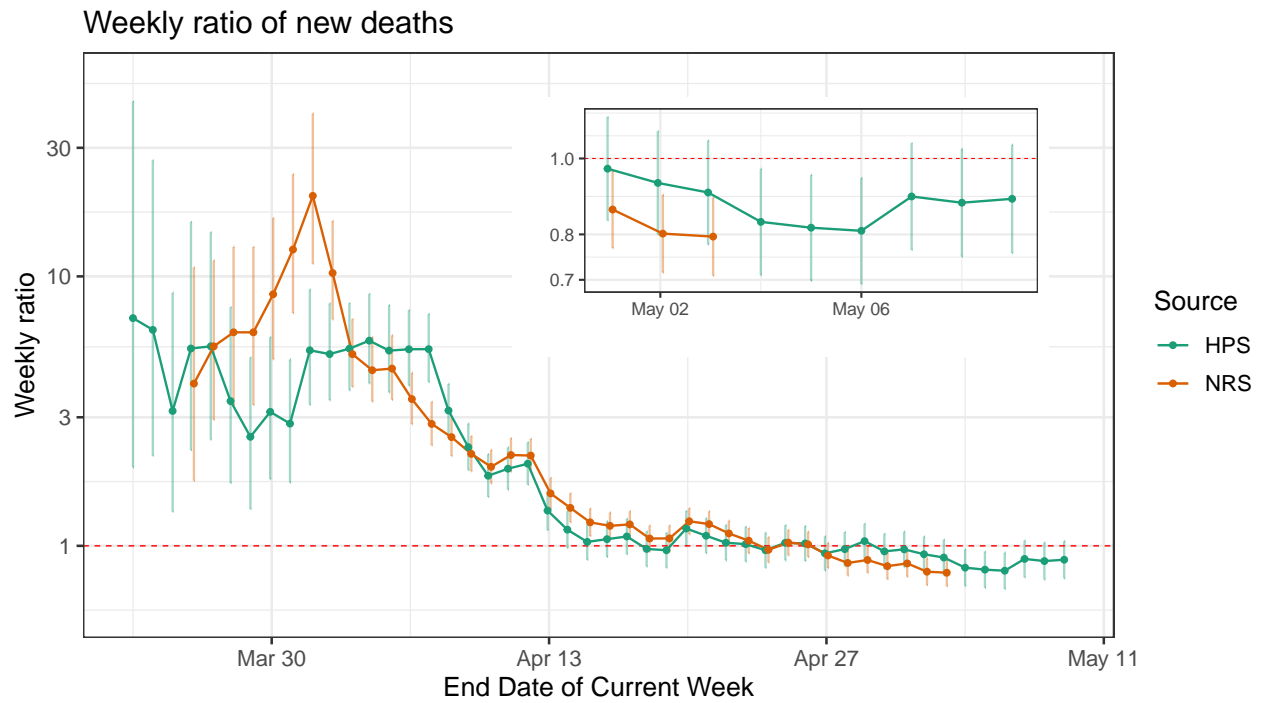


Figure 7: Ratio of new deaths during current week vs previous week, compared by data source

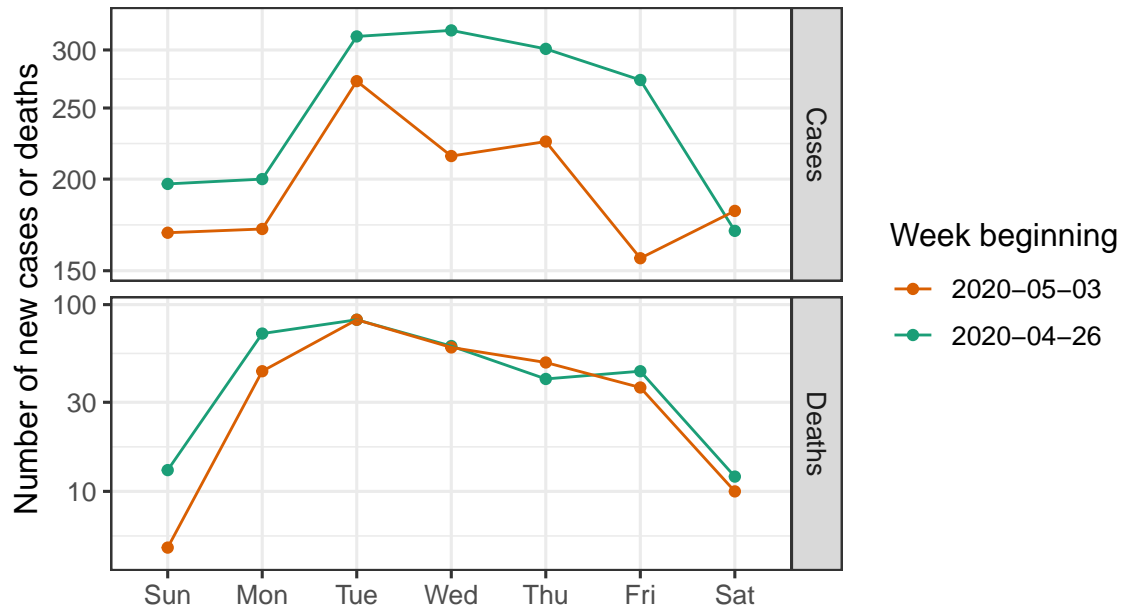


Figure 8: Number of cases and deaths by week day, shown for the last two weeks.

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