

# Monitoring the COVID-19 Pandemic in Scotland

*30 April, 2020*

Numbers of new cases and new deaths, as reported by Health Protection Scotland (HPS), have been monitored on a daily basis (see Figure 1). 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 hospital bed occupancy by comparing daily numbers of bed and ICU occupancy to those one week ago (see Figure 6).

## 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.

Bed occupancy numbers in Scottish hospitals are reported each day by NHS Boards. The number of hospital beds occupied by COVID-19 patients and the number of these patients in intensive care units (ICU) are provided.

Several caveats are listed below which should be considered when interpreting trends in the reported numbers.

## 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, 5 and 6). Weekly totals are considered as they are less prone to week day variations than the daily values (see Caveats below).

Ratios for hospital occupancy 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 28th April is ‘occupancy on 28th April’ divided by ‘occupancy on 21st April’).

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 bed occupancy  $w_1$ =beds occupied on the given day,  $w_2$ =beds occupied 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, testing of people in care homes and healthcare workers is being increased.
- Hospital admission policy – if admission criteria are relaxed then a higher proportion of Covid-19 patients are admitted and tested and hence included in the daily case and (HPS) death statistics.
- Differences in reporting of deaths to NRS and HPS due to variable factors such as lag caused by weekends and public holidays.

HPS death counts include individuals who are tested outside hospital. An increased frequency of testing in care homes coupled with the increasing number of deaths in this setting (see Figures 2 and 4) makes HPS numbers difficult to compare over time. The NRS ‘all COVID-19’ death numbers may allow a more consistent comparison to be made, and additionally 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 that from HPS.

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 occupancy data (see Figure 6). However, these data will not reflect cases in care homes, and a consistent criteria for admission to hospital or to ICU would need to be assumed in order to make comparisons over time.

The ratios by place of death (Figure 4) will be subject to variations in hospital admission policy. For example, if a greater proportion of care home residents are being admitted to hospital then, under an unchanged admission policy, we might expect the weekly ratio for care homes to be higher than the last reported value of 1.11 (95% CI: 0.95-1.29), and the weekly ratio for hospitals to be lower than the reported value of 0.89 (95% CI: 0.75-1.04) (data for week ending 2020-04-26).

The confidence interval for the ratios indicates 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 ratios less than (or greater than) 1 are expected to correspond to R numbers of less than (or greater than) 1, their values will not be the same.

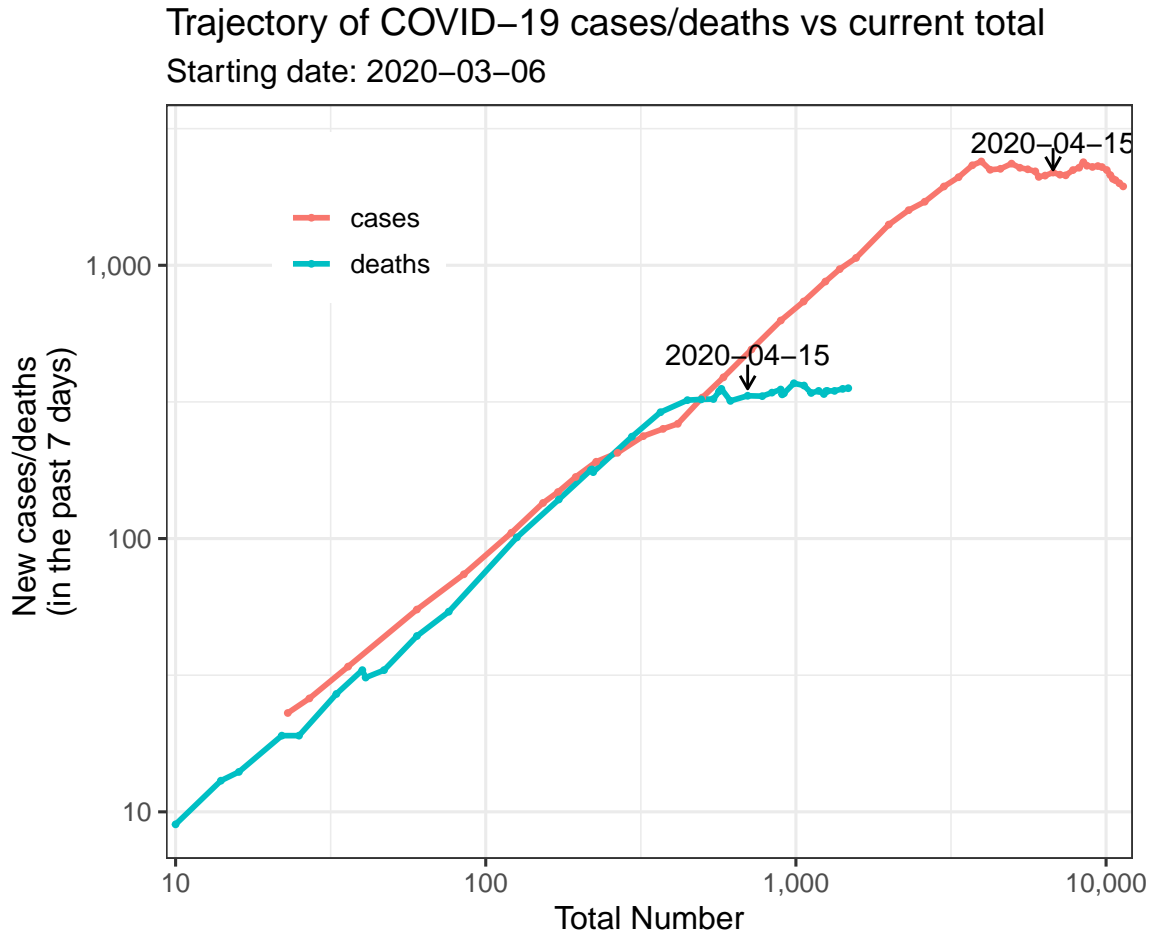


Figure 1: Trajectories of COVID-19 cases and deaths vs respective cumulative numbers. Data source: HPS

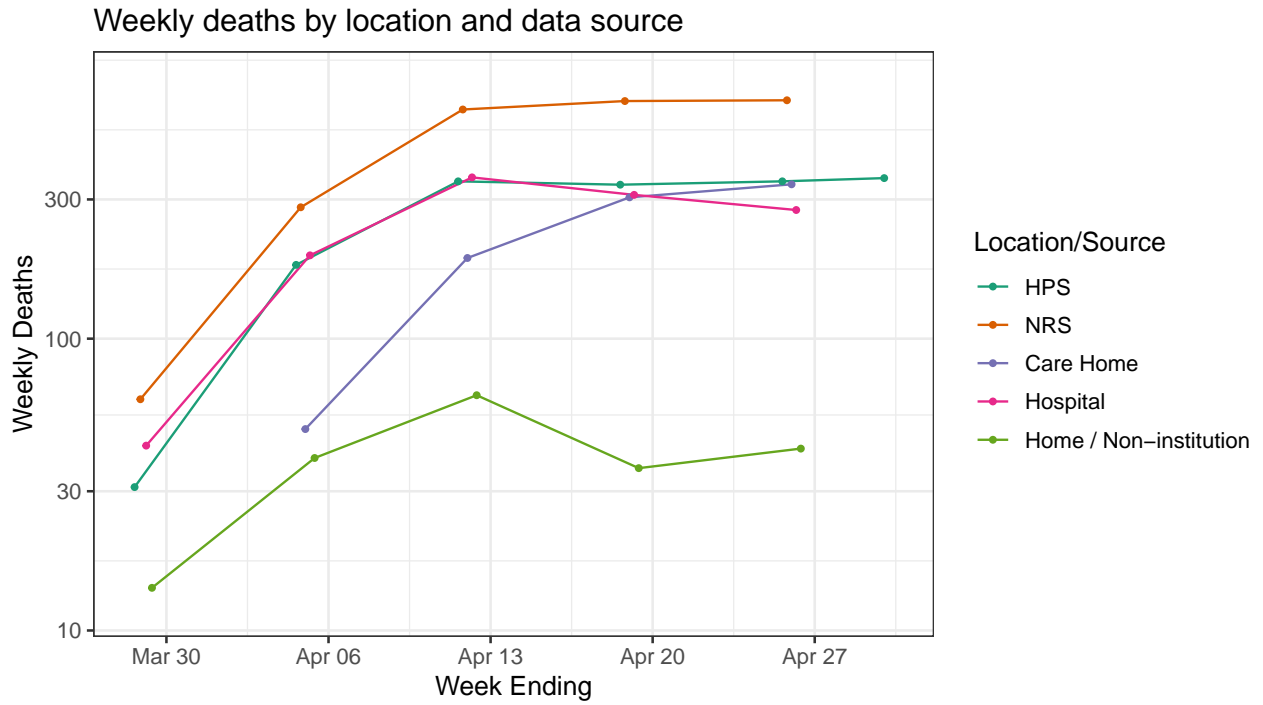


Figure 2: Number of deaths per week, compared by location and data source

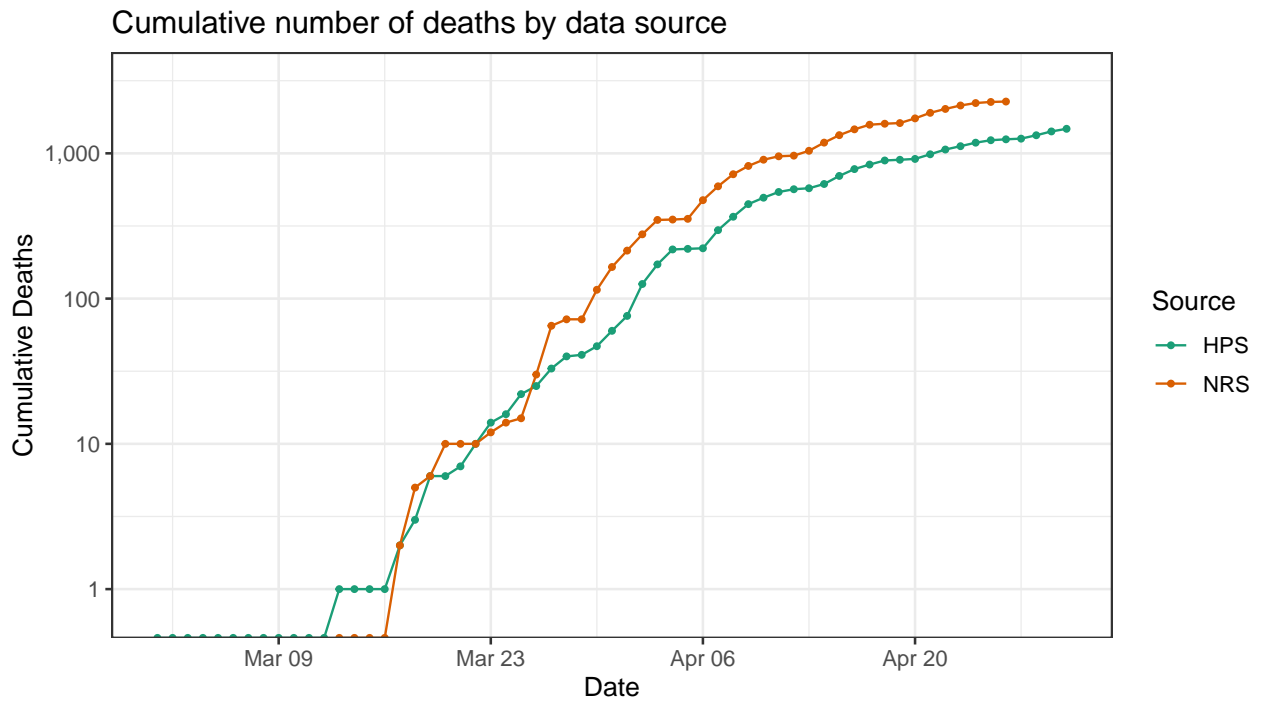


Figure 3: Cumulative number of deaths, compared by data source

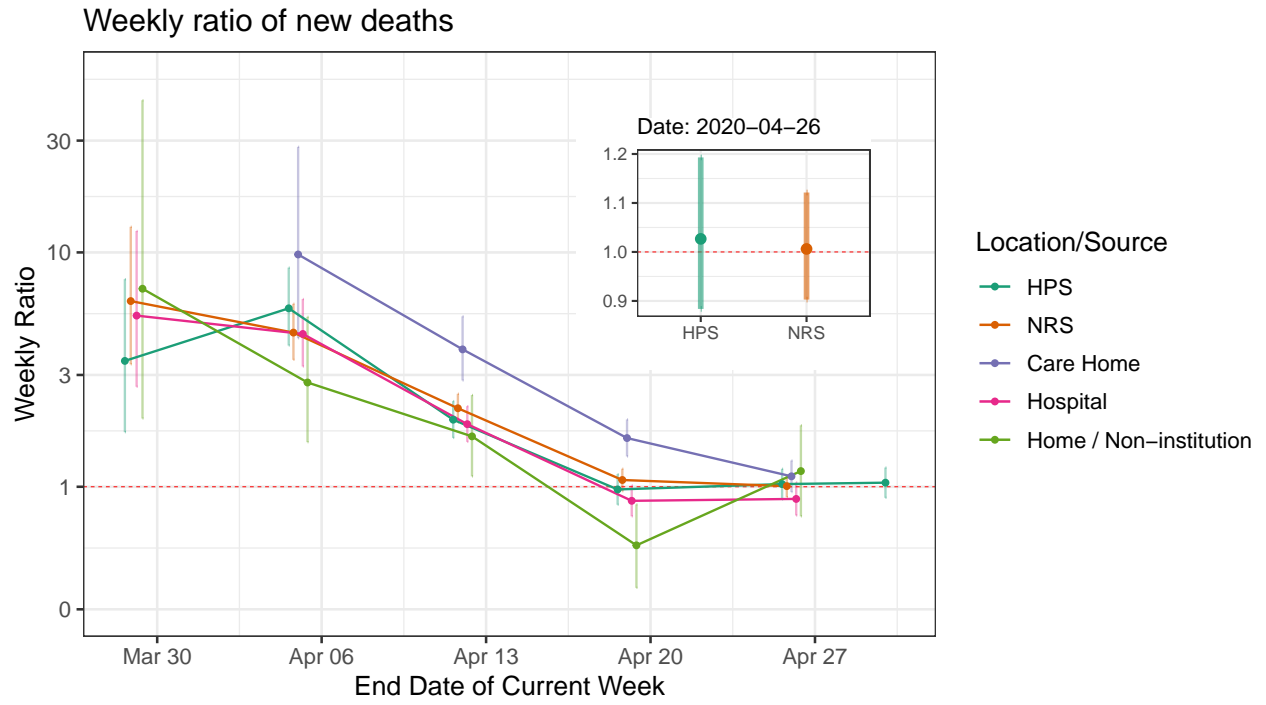


Figure 4: Ratio of new deaths during current week vs previous week, compared by location and data source

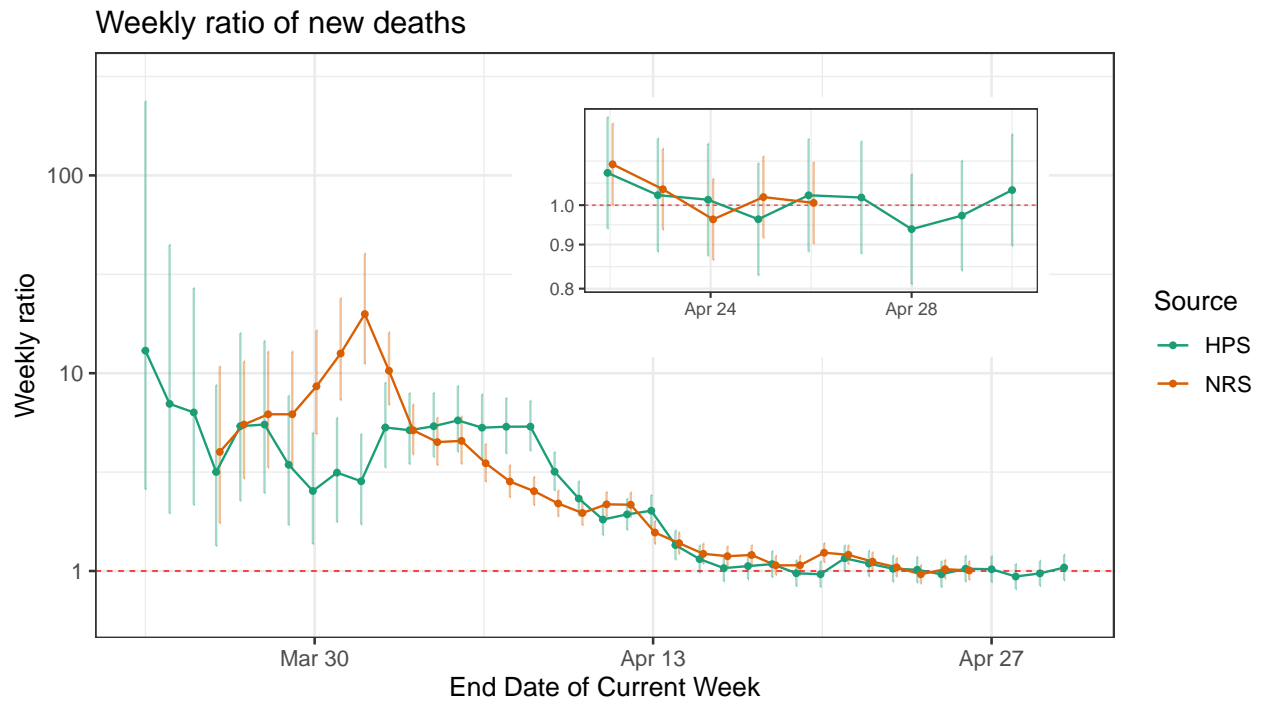


Figure 5: Ratio of new deaths during current week vs previous week, compared by data source

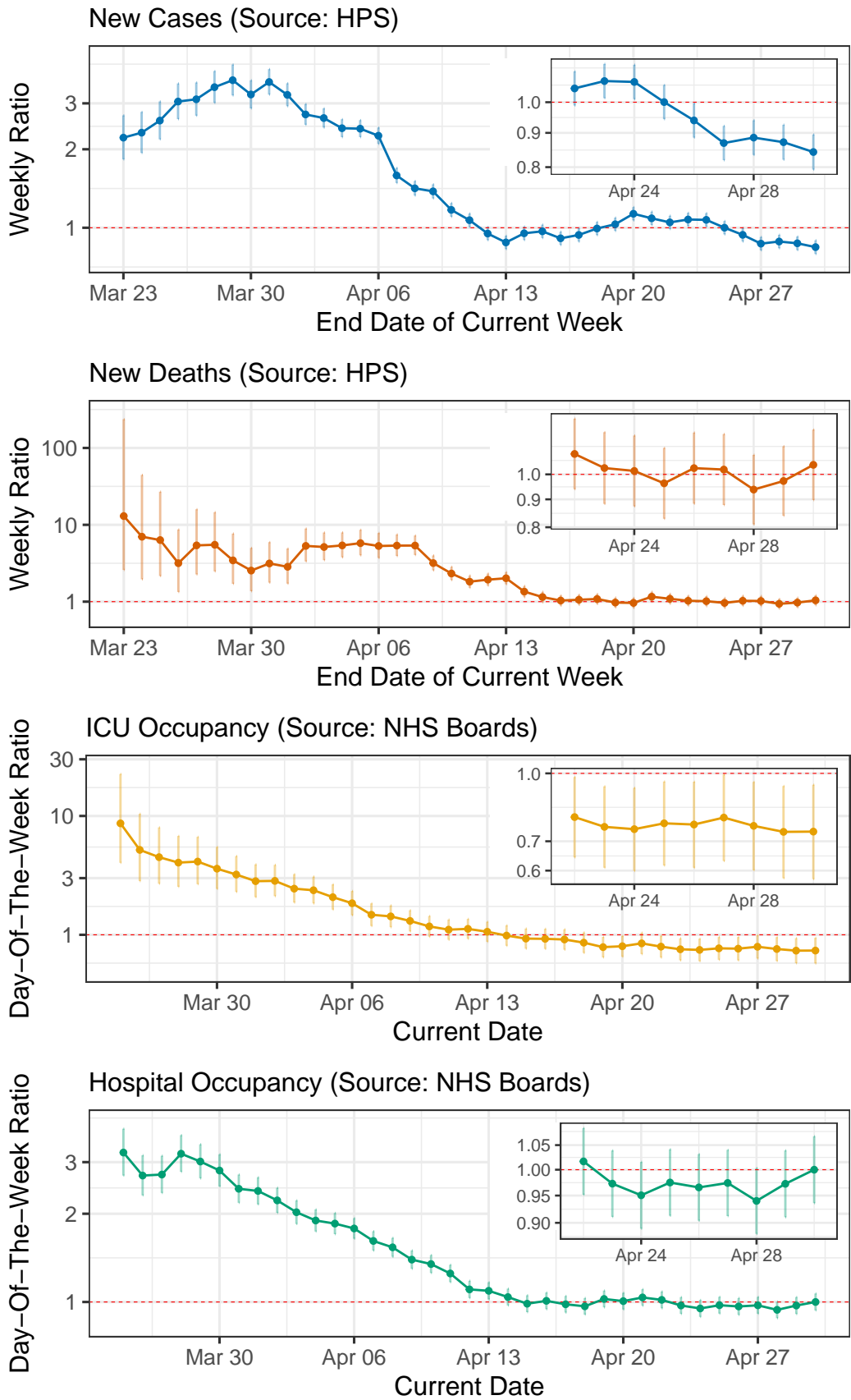


Figure 6: Weekly ratios for new cases and new deaths are ratios of weekly sums, plotted on a log10 scale. Day-of-the-week ratios for hospital occupancy and ICU occupancy are ratios of daily counts, measured 7 days apart and plotted on a log10 scale. Figure insets highlight more recent ratios and trends.

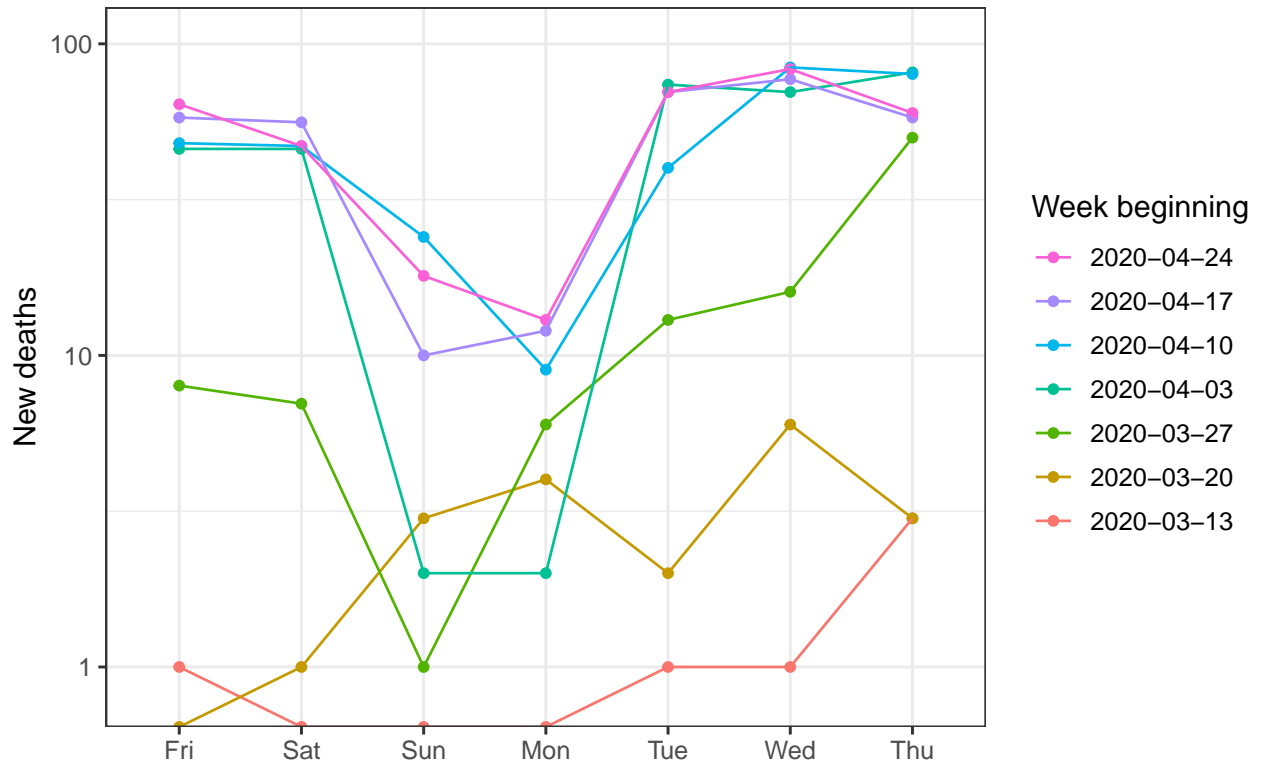


Figure 7: Number of deaths by weekday, shown for different weeks

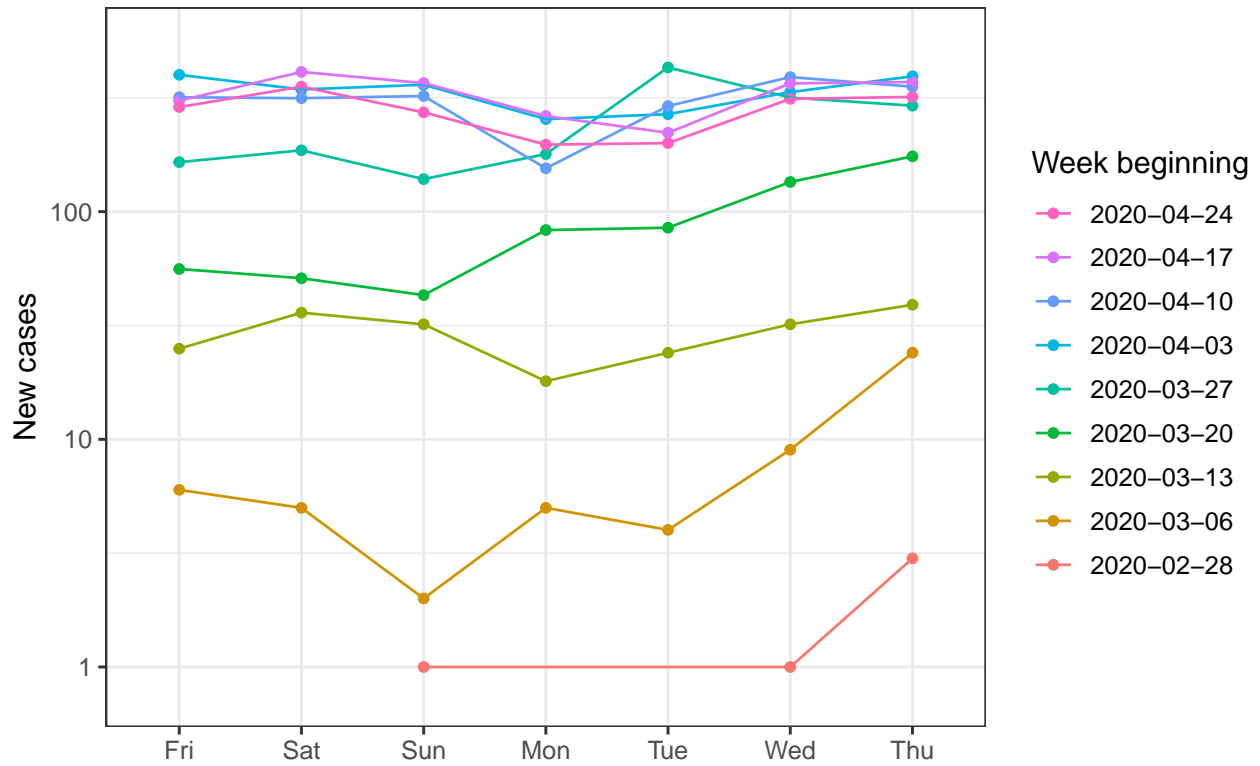


Figure 8: Number of cases by weekday, shown for different weeks

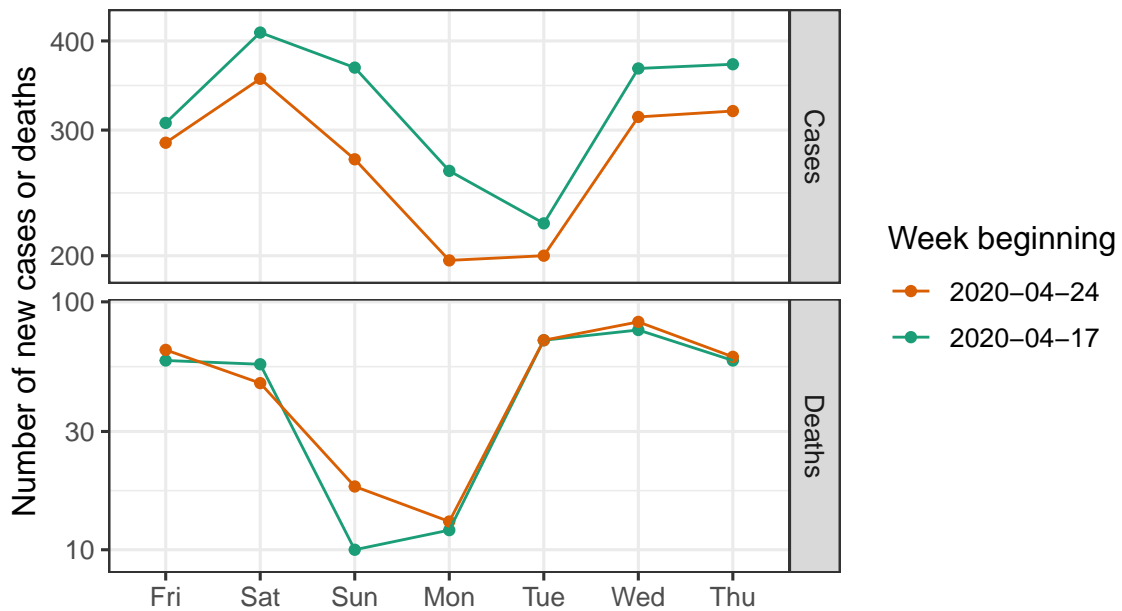


Figure 9: Number of cases and deaths by week day, shown for the last two weeks. Note that the distribution of cases and deaths in w/b 2020-04-13 may be affected by an extended reporting lag due to Easter weekend.

This report was produced by members of Epigroup and The Roslin Institute at the University of Edinburgh.