Results

England

*Case counts and Rt estimates*

Across England, positive Covid-19 tests peaked at # cases, # admissions, and # deaths per day in March. From this level, counts among admissions and deaths declined more gradually than from all positive tests through April and May (time to a -50% decline from peak of 40, 45, and 30 days respectively; figure 1A). This mean that counts among all positive tests matched counts of admissions on 20th May, at 900 cases. Admissions and test-positive cases then gave approximately the same counts through June (+- 10%), with all three counts declining by 10% from 20th May to Jun 27th. This trend continued for counts of admissions and deaths from Covid-19 until August 20th. However, from late June, case counts from all reported test-positive cases increased rapidly (+10% over 7 days) and then gradually (+10% until 30 days until August 20th).

*Relationship between Rt estimates*

Rt estimates from all sources of cases moved in sine waves throughout the time series (figure 1B), but the frequency, amplitude, and trend of waves varied both by data source and within each Rt estimate over time. The net effect of the differences in wave frequency and amplitude is seen in the ratios between each Rt estimate (Figure 1C-E). Over April through to mid-June, all Rt estimates were below 1, associated with a declining epidemic. Rt estimates from both admissions and deaths had no clear linear trend, with Rt centred around 0.85 and 0.8 respectively in each wave. Estimates from admissions had low amplitude waves (+- 0.01) with approximately monthly periodicity until the mid-June peak, after which Rt from admissions fell to a time-series minimum of 0.78 before increasing linearly through July and August.

Over April through June, Rt estimates from deaths saw higher amplitude and lower frequency waves than that from admissions (respective average wave amplitude +- 0.01 and +- 0.2 from centre, periodicity 3 weeks, 4 weeks). Unlike other estimates, Rt from deaths saw a trough at 0.75 in late May, before rising to meet the Rt from admissions at 0.9 in mid-June. Rt from deaths and admissions then remained in synchrony from mid-June through to August (mean ratio of median estimates 1.05, 95%CI 1.0-1.1). By the 28th June, when Rt from deaths and admissions saw a trough at 0.8, Rt from cases peaked at 1.3 in a rapid high amplitude wave, having risen 70% in 7 days. Through July and August, Rt from both deaths and admissions increased linearly, to reach 0.9 (August 1st) and 0.95 (August 15th) respectively, while Rt from cases experienced a second wave with lower amplitude (0.5, peak 1.2 on July 31st). Therefore, Rt from admissions was near parity with (10% lower than) the Rt from test-positive cases by late August.

Regions

*Case counts and Rt estimates over time*

Earliest date after the peak that Rt crossed below 1:

Regions varied in the timing of the first epidemic wave. The key point when Rt crossed below 1, indicating a declining epidemic, was spatially variable when estimated from cases (earliest median estimate below 1 on 28 March in London, latest 23 April in South West, both estimates from cases: a range of 28 days around a mean of 9 April). However, the timing at which Rt crossed below 1 was more consistent when estimated from admissions or deaths (range among regions 4 days and 8 days respectively, with an identical mean of 1 April).

Consistent features: cases higher average Rt estimate and higher frequency + amplitude of variation than admissions or deaths

* North East and Yorkshire, and South West, saw the highest amplitude waves in cases

*Relationship between Rt estimates*

* All regions had Rt estimates (therefore the relationships between Rt estimates) as waves – not smooth linear relationship; but synchrony, frequency/amplitude, presence / direction of trend varied by region and over time
* Admissions and deaths:
  + Admissions or deaths similar through the time-series in London, North West, South West
  + in Midlands and South East, similar until July, then diverge
  + In North East & Yorkshire, diverge over mid May to early July
  + In East of England, similar centre, but dissimilar characteristics over time (out of phase, different frequency + amplitude, no trend in deaths some decline in admissions)
* Cases to admissions and deaths
  + London: similar increasing trend over series, stronger trend and less variation
  + London, South East, Midlands, North West – similar over April through June/July