

Article

Coronavirus (COVID-19) Infection Survey technical article: waves and lags of COVID-19 in England, June 2021

An analysis of published data on the waves and lags of coronavirus (COVID-19) from the Coronavirus (COVID-19) Infection Survey, the Scientific Advisory Group for Emergencies (SAGE) and Public Health England (PHE). This analysis has been produced in partnership with University of Oxford

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1 . Main points

- There were two waves of coronavirus (COVID-19) between March 2020 and May 2021 in England; there is no strict definition for when a wave starts and ends, however, we can estimate it using the reproduction rate (R), the growth rate and the positivity rate.
- The first wave of COVID-19 is estimated to have started in March 2020 and ended at the end of May 2020.
- The second wave of COVID-19 is estimated to have started at the beginning of September 2020; there was an initial peak in mid-November after which infection levels decreased before rising again in December following the emergence of the Alpha variant; the wave peaked in early January 2021 and ended at the end of April 2021.
- The time between COVID-19 infection and symptom onset varies between 1 and 14 days, with an average of 5 to 6 days.
- The median delay (lag) between symptom onset and hospital admission varies between 1 and 6.7 days depending on age and whether the patient lives in a nursing home.
- Time between symptom onset and death from COVID-19 ranges from 2 to 8 weeks, with reported median times of 16 or 19 days.

2 . Waves of COVID-19

Defining waves of coronavirus (COVID-19) in England

A wave of an epidemic is considered to be a period of increased transmission of a disease. However, there is no strict definition for a wave or how to determine when it starts or ends.

Here, we define the start of a wave as the beginning of sustained increase in transmission and infections. A wave ends when infections return to the low levels seen before it started. There are three measures we consider when establishing the start and end of a wave:

- reproduction (R) rate (how many people one person infects on average)
- growth rate (percentage change in the number of infections each day)
- positivity rate (the percentage of people testing positive for COVID-19)

For the purpose of this publication, we define sustained increase in infection levels as lower bound estimates for R rate remaining above 1, and for growth rate above 0 for at least three weeks. The beginning of that period is the start of a wave. Infection levels are classed as low when the positivity rate falls below 0.1% (these were the levels seen before the start of the second wave). This indicates the end of a wave.

Using these measures, we can estimate indicative dates for when a wave has started and ended, but they are not exact and should be treated with caution. Both R and growth rates are computed using epidemiological data (such as infection and hospitalisation statistics) from preceding weeks and therefore are not real-time measures.

Since the start of the coronavirus pandemic, there have been two waves of infections. However, this analysis focuses on the time period from April 2020 to May 2021 and therefore does not include data for a potential third wave as a result of increased infections in June 2021. More information on our headline estimates of the overall number of positive cases in England, Wales, Northern Ireland and Scotland are available in our [latest bulletin](#).

The first wave of COVID-19 in England

It is hard to determine when the first wave of the coronavirus pandemic began in England; the Coronavirus (COVID-19) Infection Survey (CIS) did not start producing positivity rate estimates until 26 April 2020, and the reporting of R by the Scientific Advisory Group for Emergencies (SAGE) did not start until 29 May 2020. We can estimate that it began in March 2020 as NHS Test and Trace data show that numbers of coronavirus cases started rising in early March, but testing capacity was limited at that time. The first wave likely peaked between the end of March and early April 2020.

National intervention began on 23 March 2020 and restrictions were gradually lifted between 13 May and 4 July 2020. From the time when the CIS commenced at the end of April 2020, the estimated percentage testing positive for COVID-19 first fell below 0.1% between 25 May and 7 June 2020 (CIS).

The second wave of COVID-19 in England

The second wave of COVID-19 started at the beginning of September 2020. The R rate published on 11 September was estimated to be above 1 (1 to 1.2) for the first time since the initial report (29 May 2020). The growth rate (percentage change in the number of infections each day) accelerated to between positive 1% and positive 4% in the week ending 11 September 2020 and the positivity rate started showing signs of increase in the week ending 5 September 2020.

In the week ending 10 September, the positivity rate increased to 0.11%. Infections initially peaked in mid-November 2020 when the positivity rate was estimated at 1.22% (95% credible interval: 1.15% to 1.29%) and then all three rates started to decline. The positivity rate was falling until 5 December 2020, when it was estimated at 0.88% (95% credible interval: 0.83% to 0.94%). There was a national intervention between 5 November and 2 December 2020, immediately followed by the introduction of a new tier-based system of local coronavirus restrictions.

Following a decline in infections, all three rates began increasing again in December 2020. The R rate increased to between 1.1 and 1.3, and the growth rate increased to between positive 2% and positive 4% on 18 December. The positivity rate increased from 0.88% (95% credible interval: 0.83% to 0.94%) to 1.04% (95% credible interval: 0.98% to 1.10%) in the week ending 12 December 2020. These increases were driven by the emergence of a new variant of coronavirus (B.1.1.7 also known as Alpha), which was first identified in the UK in September 2020.

The second wave peaked with the positivity rate reaching its highest point in the week ending 9 January 2021 at 2.08% (95% credible interval: 2.00% to 2.17%). There was national intervention introduced on 5 January 2021, which began gradually easing from 8 March 2021. The estimated percentage testing positive for COVID-19 first fell below 0.1% between 26 April and 2 May 2021.

Figure 1: There were two waves of COVID-19 infections in England between March 2020 and May 2021

Estimated percentage of the population testing positive for COVID-19 on nose and throat swabs, number of new COVID-19 cases by specimen date and 90% confidence interval estimates for the reproduction (R) rate and growth rates, 1 March 2020 to 22 May 2021

Notes:

1. The estimated dates for the first wave are shown as 23 March 2020 to 30 May 2020. Please note that the start is based on national intervention following the limited data at the time and should be interpreted with caution.
2. The estimated dates for the second wave are shown as 7 September 2020 to 24 April 2021.
3. CIS estimates are plotted at a reference point believed to be most representative of the reference period. Estimates until 5 July are fortnightly weighted estimates and after that date, they are weekly modelled estimates.
4. CIS estimates are subject to uncertainty, given that a sample is only part of the wider population. The fortnightly weighted estimates use 95% confidence intervals. After 5 July, a Bayesian model is used to calculate weekly estimates and provides 95% credible intervals. 95% credible intervals are calculated so that there is a 95% probability of the true value lying in the interval.
5. CIS statistics refer to infections reported in the community, by which we mean residential households. These figures exclude infections reported in hospitals, care homes and/or other institutional settings.
6. NHS Test and Trace data show the number of people with at least one positive COVID-19 test result, either lab-reported or rapid lateral flow test, by specimen date. Positive rapid lateral flow test results can be confirmed with PCR tests taken within 72 hours. If the PCR test results are negative, these are not reported as cases.
7. In NHS Test and Trace data, people tested positive more than once are only counted once, on the date of their first positive test.
8. Estimates for R and growth rates are shown as a range, and the true values are likely to lie within this range.
9. In the R and growth rates data, dates provided refer to the date of publication. The estimates were calculated using the data available at the time and do not necessarily represent the current understanding of R and growth rates for those dates. Estimates have not been revised to include new data.

[Download this chart](#)

3 . Time between COVID-19 infection, symptoms, hospitalisation and death

Defining a lag

A lag is the time period or delay between two events. In relation to coronavirus (COVID-19), we can look at delays between:

- being infected
- developing symptoms
- hospitalisation
- death

Note that not everybody who becomes infected develops symptoms, needs hospital care, or dies, therefore, the delays are given for those who do.

In this article, we focus on the clinical course of coronavirus disease for an individual. This can be dependent on personal characteristics, such as age or pre-existing health conditions, but should be similar across different countries.

Lag on a national level (delay between peaks of numbers of new COVID-19 infections, hospitalisations and deaths) will be affected by additional factors, which can lead to substantial variability across countries. For example, when infection is recorded will be affected by how long it takes to get a test and what the criteria are to get tested (for example, contact with a confirmed case or specific symptoms). As the time course and outcomes of the disease are dependent on age, age structure of the population can have a considerable impact on the lag. The delay between infections and deaths can be influenced by quality of healthcare, but also the preventative measures implemented¹.

Time between infection and symptoms

There is a period between a person being infected with COVID-19 and showing symptoms, during which they still might be infectious to others. This is called the incubation period. This is estimated to last between 1 and 14 days for COVID-19, and the average time to develop symptoms is 5 to 6 days²; 97.5% of those who develop symptoms will do so within 11.5 days of infection³.

Until an individual develops symptoms, they may not take a test, and there might be further delay between the test being booked and taken. This would affect the lag on a national level, resulting in a longer lag between infection and a positive test. This would not affect surveillance data, where participants are tested irrespective of having symptoms (as collected by the Coronavirus (COVID-19) Infection Survey) but can have an impact on national reports of new cases, such as NHS Test and Trace data.

Time between a symptom onset and hospitalisation

Time from developing symptoms and being admitted to hospital varies, with age having the largest impact on the length of the delay. Median times from symptom onset to hospitalisation vary between 1 and 6.7 days depending on age and whether or not the patient lives in a nursing home⁴.

In people aged under 20 years, delay is the shortest, with a median of just 1 day (more than 2.6 days for a quarter of patients) compared with 4 days for people aged 20 to 60 years and 60 to 80 years (more than 6.7 days for a quarter of patients), and 1.6 days for those aged 80 years and over (more than 4.3 days for a quarter of patients)⁴.

Median time from symptom onset to admission to an Intensive Care Unit (ICU) is estimated to be between 6 and 10.5 days in different studies^{5,6,7}.

Time between symptom onset and/or hospitalisation and death

The World Health Organization (WHO) reported time between developing symptoms and deaths ranging from two to eight weeks⁸. Median time between symptom onset and death differs between studies and was estimated as 16 or 19 days^{6,9}. Similarly, reported median times between ICU admission and death varied across studies and were estimated as 7 or 12.5 days^{6,7}.

References

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8. World Health Organization (2020), [Report of the WHO-China Joint Mission on Coronavirus Disease 2019 \(COVID-19\)](#).
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4 . Glossary

Growth rate

While R rate indicates whether the number of infections is increasing or decreasing, the growth rate illustrates how quickly it is changing. Growth rate is an estimate of the percentage change in the number of infections each day. The higher the rate, the faster the speed of the change.

Positivity rate

In this article we refer to the positivity rate as the proportion of people that have tested positive for the coronavirus (COVID-19) using nose and throat swab tests at any given time. The Coronavirus COVID-19 Infection Survey (CIS) estimates positivity in the community population. CIS positivity rates refer to everybody that had the infection within a given week. This is different to the incidence rate, which refers to the proportion of “new” positive COVID-19 cases.

Please note that the NHS Test and Trace records infections among people experiencing symptoms or referred for testing (for example, by their employer). It only includes new COVID-19 cases when computing the positivity rates (incidence of the disease).

R rate

The reproduction (R) rate is the average number of secondary infections produced by a single infected individual.

An R rate of 1 means that every infected person will pass it on to one other person on average. In this case, the total number of infections is stable. If R is greater than 1, the number of infected people is increasing; if R is below 1, the number is decreasing.

Transmission

The spread or transfer of a pathogen (for example, a virus) from an infected individual to others.

5 . Data sources and quality

Coronavirus (COVID-19) Infection Survey

The Office for National Statistics (ONS) [Coronavirus \(COVID-19\) Infection Survey \(CIS\)](#) estimates the number of infections in the community population in England, Wales, Northern Ireland, and Scotland.

People tested are from randomly selected residential households and may or may not have any COVID-19 symptoms. Nose and throat swabs are taken from all household members aged two years and over. It excludes those in hospitals, care homes or other institutional settings. Positivity rates are calculated for seven-day periods and adjusted to represent the population. Results are published in a weekly bulletin, with releases on the [characteristics of people testing positive](#) and [antibody data](#) published fortnightly. The survey is delivered in partnership with University of Oxford, University of Manchester, Public Health England and Wellcome Trust.

More information on [measuring the data](#) and its [strengths and limitations](#) is available in the Coronavirus (COVID-19) Infection Survey statistical bulletin.

Our [methodology article](#) provides further information around the survey design, how we process data, and how data are analysed.

NHS Test and Trace data

Surveillance data on new cases of COVID-19 by specimen date are available on the [GOV.UK dashboard](#). NHS Test and Trace data record the number of individuals with at least one positive COVID-19 test result, either lab-reported or rapid lateral flow test (England only), by specimen date. Positive rapid lateral flow test results can be confirmed with PCR tests taken within 72 hours. If the PCR test results are negative, these are not reported as cases. Individuals who test positive more than once are only counted once, on the date of their first positive test.

Data for England include only pillar 1 cases until 2 July 2020, from when pillar 2 cases are also included. Pillar 1 data come from testing in Public Health England (PHE) labs and NHS hospitals for those with a clinical need, and health and care workers. Pillar 2 data come from the UK government testing programme, which covers COVID-19 testing in the wider population. Pillar 2 data are collected by commercial partners.

More information on the different methods used in CIS and NHS Test and Trace data is available in our [comparative article](#).

Growth and R rates

[The R value and growth rates](#) are available as estimated ranges for the UK, the four nations, and NHS England regions. Both rates represent the transmission of COVID-19 over the past few weeks because of the time delay between someone being infected, having symptoms, and needing healthcare. As they are averages over very different epidemiological situations, they should be regarded as a guide to the general trend rather than a description of the epidemic state.

The R value and growth rates are estimated by several independent modelling groups based in universities and Public Health England (PHE). The modelling groups discuss their individual R estimates at the Science Pandemic Influenza Modelling group (SPI-M) -- a subgroup of SAGE. SPI-M uses several models, each using data from a variety of sources in their estimates of R and growth rate. Epidemiological data, such as hospital admissions, ICU admissions and deaths, usually take up to three weeks to reflect changes in the spread of disease.

You can read more about how the R and growth rates are produced in this [methodology guidance](#).

6 . Related links

[The R value and growth rates](#)

Guidance | Updated weekly

The latest reproduction number (R) and growth rate of coronavirus (COVID-19) published by Department of Health and Social Care and Scientific Advisory Group for Emergencies

[GOV.UK coronavirus dashboard](#)

Dashboard | Updated daily

The official UK government website for data and insights on coronavirus (COVID-19).

[Coronavirus \(COVID-19\) Infection Survey technical articles](#)

Article | Updated as and when data become available

Series of technical articles presenting in-depth analyses of data from Coronavirus (COVID-19) Infection Survey and other sources.

[COVID-19 Infection Survey: methods and further information](#)

Methods article | Updated 26 March 2021

Information on the methods used to collect and process the data, and calculate the statistics produced from the COVID-19 Infection Survey pilot

[Coronavirus \(COVID-19\) latest insights](#)

Interactive tool | Updated as and when data become available

Explore the latest data and trends about the coronavirus (COVID-19) pandemic from the Office for National Statistics (ONS) and other official sources.

[Coronavirus \(COVID-19\) Infection Survey: characteristics of people testing positive for COVID-19 in England](#)

Article | Updated fortnightly

Characteristics of people testing positive for COVID-19 from the Coronavirus (COVID-19) Infection Survey, including antibody data by UK country, and region and occupation for England. Antibodies data published before 3 February 2021 are available in this series.