UK Health Security Agency

Estimating the proportion of COVID-19 cases detected by testing during the pandemic: September 2020 to March 2022

August 2022

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Introduction

Background

Over the course of the pandemic, the availability of coronavirus (COVID-19) testing in England increased substantially. The type of testing available also changed: PCR testing was the only testing technology in widespread use during the early stages of the pandemic. Other types of tests, most notably lateral flow device (LFD) tests, subsequently became widely used.

Table 1. Notable milestones in the availability of COVID-19 testing in England

Date	COVID-19 testing milestone
April 2020	Pillar 2 mass testing programme begins
May 2020	NHS Test and Trace (NHSTT) launched
June 2020	100,000 PCR tests per day regularly reached
November 2020	Asymptomatic LFD testing pilots begins; confirmatory PCR testing required for positive LFD results
December 2020	Care home dual technology asymptomatic testing regime for staff (incorporating PCR and LFD testing) begins
February 2021	Confirmatory PCR testing suspended
March 2021	Asymptomatic LFD testing in schools begins
	Confirmatory PCR testing resumed
April 2021	Universal testing offer begins: twice weekly regular LFD testing available to all
July 2021	Rosalind Franklin mega lab opens, expanding PCR testing capacity
November 2021	Asymptomatic testing guidelines updated: LFD testing based on personal assessment of risk
December 2021	Guidance introduced for close contacts to test daily with LFDs
January 2022	Peak testing day: 2.3 million tests reported
January 2022	Confirmatory PCR testing suspended
February 2022	'Living with COVID' begins: requirement for COVID-19 cases to self-isolate ends
April 2022	Universal testing offer ends

Aims

The purpose of this report is to explore different methods to estimate the proportion of cases identified through testing during the pandemic, providing insight into how the coverage of testing progressed.

The report does not include any investigation of what happened as a result of those tests, that is, how people's behaviour was affected on receipt of the test result and the extent to which onwards transmission was reduced. It also does not include any analysis of breakdown by demographic characteristics. Some groups were disproportionately affected by COVID-19, and not all groups had the same access to testing. This report does not explore these differences. This report describes the development of a metric to estimate the proportion of COVID-19 cases detected by the testing service. Policy changes are plotted along the timeseries of the metric to explore whether any patterns emerge.

Trends and relationships between the proportion of cases detected and other data sets are then explored, including testing volume and prevalence.

Calculation of the metric for the proportion of cases detected

Defining the metric

One method of measuring testing performance of the COVID-19 National Testing Programme is to identify the proportion of cases detected as a ratio of the true number of cases in the population.

The definition of a case, taken from the coronavirus.data.gov.uk[1] dashboard at the time of analysis, is:

"COVID-19 cases are identified by taking specimens from people and testing them for the SARS-CoV-2 virus. If the test is positive, this is a case. Some positive rapid lateral flow test results are confirmed with lab-based polymerase chain reaction (PCR) tests taken within 72 hours. If the PCR test results are negative, these are not reported as confirmed cases. Individuals are only counted once, people who test positive again after a given time period are not counted as new cases, these are instead counted as infection episodes. Infection episodes will be counted separately if there are at least 90 days between positive test results."

[1] Cases definition to include multiple infection episodes from 31 January 2022 (accessed September 2022)

There is high confidence that cases recorded the data management systems of the national testing programme are true cases as there is little incentive to incorrectly record this information. However, it is well documented that a low proportion of LFD test results were reported into the national data management systems compared to the numbers that were distributed, and it is likely that among the unreported results there were genuine cases which would not have been accounted for in the official data.[2]

The true number of cases within the population was more uncertain. For this, data from the ONS COVID-19 Infection Survey[3] were used to generate an estimate for this variable. The calculation for the proportion of cases detected is given in formula (i) below.

$$Cases\ detected\ (\%) = \frac{NHSTT\ cases\ reported}{ONS\ incidence\ (adjusted)} \quad \text{(ii)}$$

NHS Test and Trace cases reported

Cases were reported daily but display a cyclic weekly pattern, with fewer on the weekends and more at the start of the week.

The data for NHSTT cases reported were extracted from the national testing programme dashboard for England only and cover the period from May 2020 to March 2022, that is, from NHSTT being established to the end of the universal testing offer. NHSTT data from September 2020 onwards was used to calculate the percentage of cases detected.

ONS incidence

The ONS COVID-19 Infection Survey provided a daily estimate for the total number of people who would test positive with a PCR in the country on any given day, that is, the positivity rate. This estimate of positivity rate was converted to daily new cases, that is, incidence, by dividing by the average length of infection (10 days).

The incidence rate was adjusted to account for the difference in PCR cycle threshold (Ct) value used in the ONS COVID-19 Infection Survey and the NHSTT Ct. ONS used a maximum Ct value of 37 to 38, where NHSTT used up to 31 to 32, thus missing any cases picked up in the 32 to 38 Ct value range. To provide a reasonable adjustment to make the 2 data sets comparable, the ONS figures were multiplied by 0.75 (in other words, the case numbers were reduced by a quarter). While this approximation is sufficient for the high-level analysis performed here, it should be emphasised that cycle threshold values are not always directly comparable between assays due to variations in limits of detection, reagents, sample

[2] Test and Trace in England: progress update
[3] Coronavirus (COVID-19) Infection Survey, UK (ONS)

preparation and so forth. Therefore, this method would need to be carefully considered should a more detailed assessment of testing performance be required.

The ONS positivity rate estimate is published with 95% credible intervals[4] which have been used to check the upper and lower bounds of the detected cases metric. No anomalous effects were observed, and the credible intervals were satisfactorily close to the estimate made here.

ONS positivity rate figures dating from September 2020 can be found in the ONS COVID-19 Infection Survey.[5]

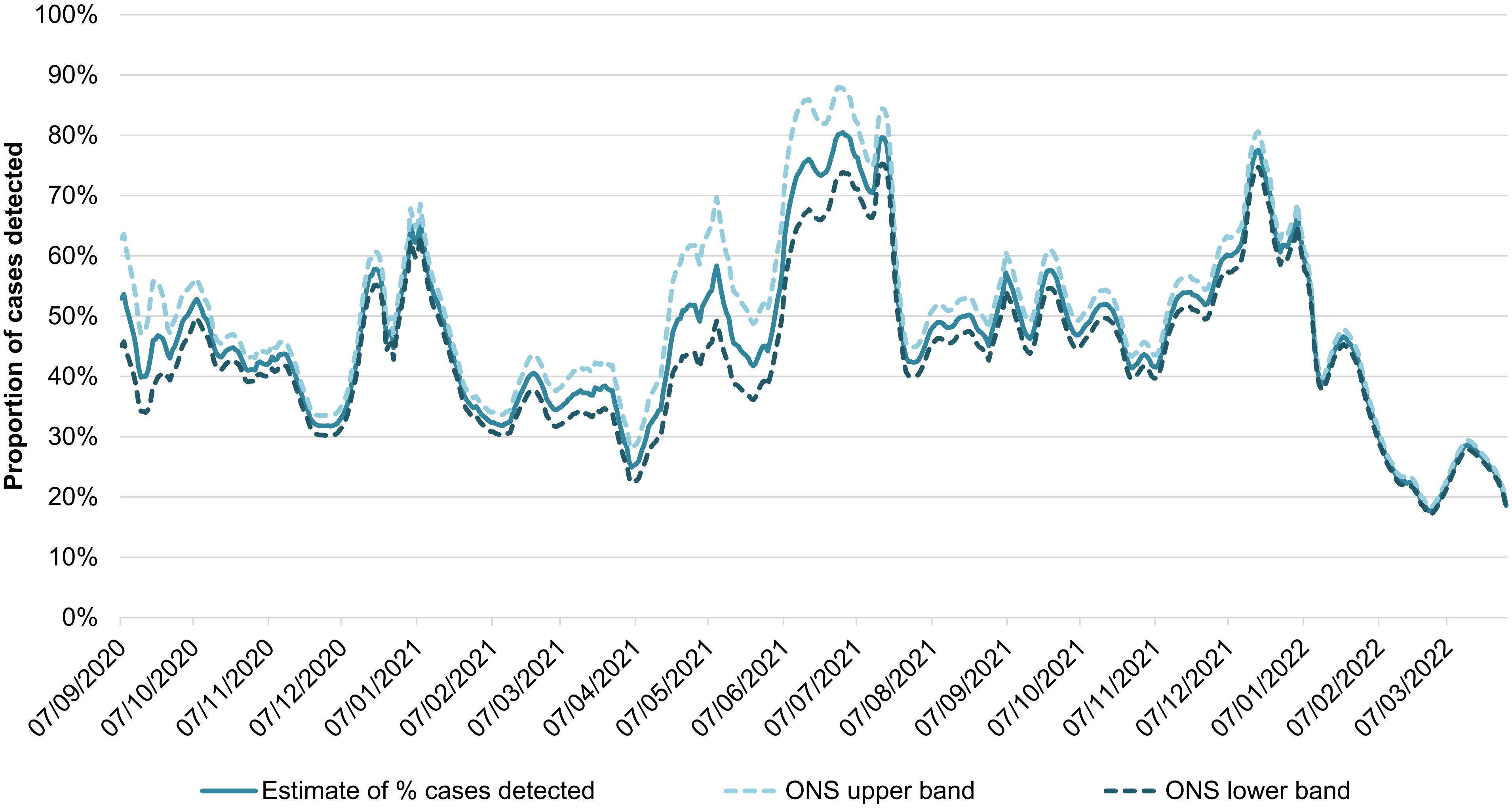
Results

The output for this metric is presented in Figure 1 where the estimated percentage of cases detected is plotted against time. To account for weekly variability in the data, a 7-day rolling average was used. The ‘ONS upper band’ and the ‘ONS lower band’ refer to where the proportion of cases detected have been calculated using the upper and lower 95% credible interval estimates from ONS COVID-19 Infection Survey.

[4] ONS COVID-19 Infection Survey defines credible intervals as follows: “A credible interval gives an indication of the uncertainty of an estimate from data analysis. The 95% credible intervals are calculated so that there is a 95% probability of the true value lying in the interval. A wider interval indicates more uncertainty in the estimate. Overlapping credible intervals indicate that there may not be a true difference between 2 estimates. For more information, see our methodology page on statistical uncertainty.”

[5] Office for National Statistics (2020). “Coronavirus (COVID-19) Infection Survey, UK”: 11 September 2020

Figure 1. Proportion of cases detected through testing plotted as a time series between 7 Sep 2020 and 31 March 2022[6]



[6] Proportion of cases detected is calculated using the point estimate of positivity rate from the Coronavirus (COVID-19) Infection Survey, UK (ONS) 'ONS upper band' and 'ONS lower band' refer to the proportion of cases detected if it is assumed the upper or lower 95% credible interval for the positivity rate from the study is used.

As a testing service matures (with increasing capability and capacity and more refined approaches) it might be expected that the proportion of cases metric would increase. However, there is no immediately obvious trend to be seen in the detected cases curve. Instead, it fluctuates around a mean of approximately 50%. The metric peaks in 3 places: in late 2020 to early 2021; in the summer of 2021; and in late 2021 to early 2022.

The cases detected metric estimates the greatest proportion of cases identified in the summer of 2021, reaching 83.5%. Detected cases fall rapidly near the start of 2022.

Limitations

The figure derived from the ONS data was an estimate of the number of cases in the population, and not an empirical value to compare to the number of NHSTT cases. However, some of the limitations of the calculation of the absolute value of the proportion of cases detected do not apply when considering how the metric changes over time. Rises and falls in the metric should therefore be considered more instructive than the absolute value of the proportion of cases detected at any one time.

The assumption that a positive case would remain positive for 10 days was used to scale the ONS data to daily incidence. It was quite possible that this figure would be affected by varying properties of different variants and by vaccine uptake – both of which can affect the severity of symptoms from COVID-19 infections and could potentially affect the number of days for which a case tests positive. This could result in an apparent (but not genuine) change in the proportion of cases detected. In addition, the adjustment applied to the ONS data to account for the higher Ct value is approximate and does not account for many factors, including variations in practice between laboratories.

The implications of under-reporting of LFD results are more difficult to assess. A direct impact is that many cases detected by LFDs were not included in the data and the proportion of cases identified will therefore be an underestimate. However, without a greater understanding of the extent to which behaviour in response to a positive result differed between those who did and did not report results, it is difficult to assess if it would be appropriate to include non-reporting individuals in an estimate of the proportion of cases estimated.

Hypotheses for influences on the proportion of cases detected

Introduction

Here, 3 possible mechanisms are considered which could have influenced the proportion of cases detected.

Testing: guidance, policies, and volume

Hypothesis 1

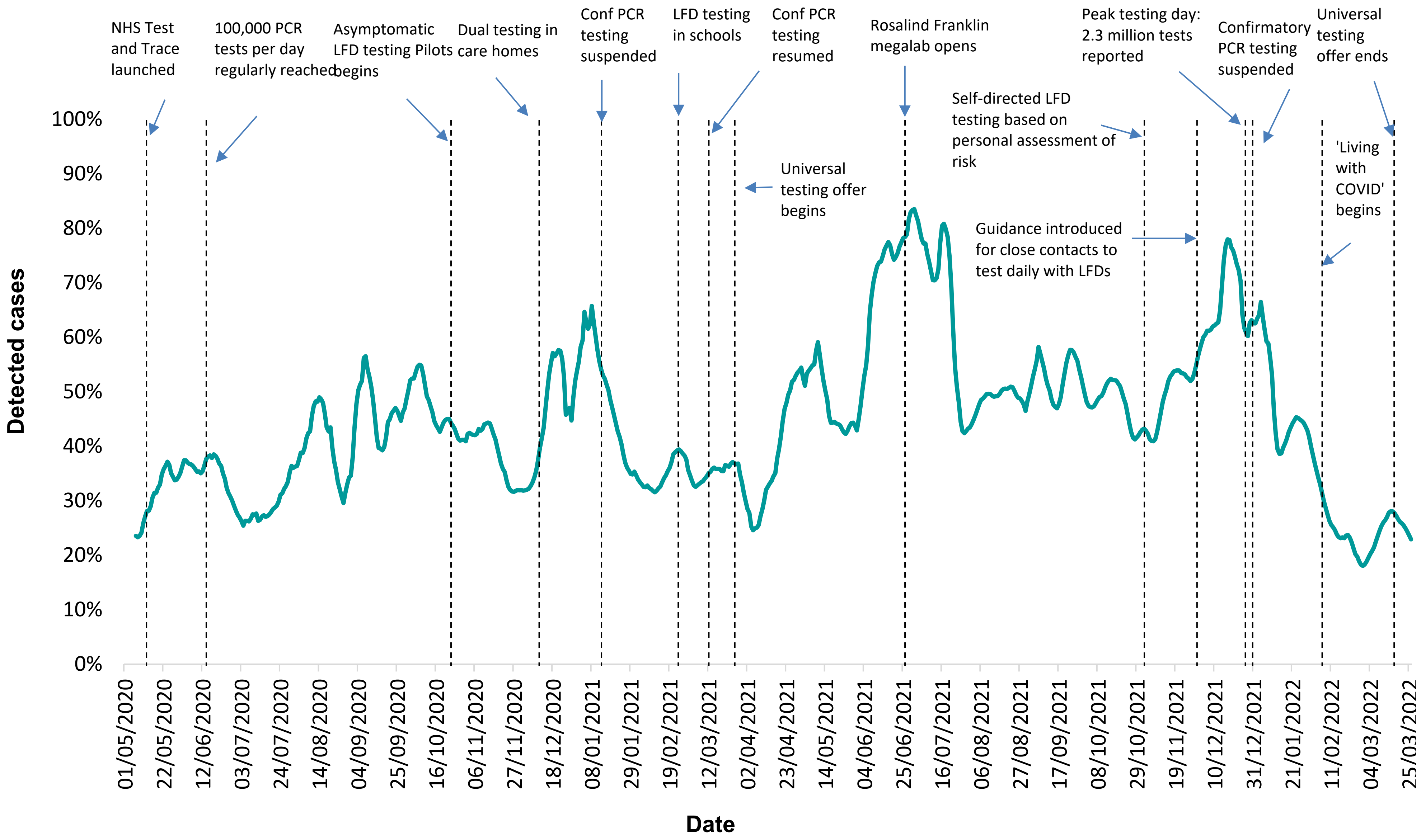
Hypothesis 1: that an increase in availability of testing and guidance to test leads to a greater proportion of cases detected until a point is reached at which additional testing does not yield an increased proportion tests being positive. However, the number of positive cases identified as a proportion of all cases continues to increase.

During the pandemic, the government made numerous announcements about measures to be taken in the response to COVID-19,[7] ranging from national lockdowns to small policy amendments. Most will not have had a noticeable effect on the metric. While initial test capacity was low, and was restricted to symptomatic individuals, testing capacity was ramped up significantly with the Lighthouse labs and by July 2020, up to 100,000 tests were routinely performed on a daily basis. There were some major operational and policy changes, such as the introduction of asymptomatic testing and the twice weekly LFD testing for the whole population (the ‘universal testing offer’),[8] which may be expected to have prompted an observable change in the proportion of cases detected.

A timeline of some of the testing milestones has been plotted on top of the key metric in Figure 2.

[7] House of Commons Library. ‘The coronavirus timeline: Measures taken by the House of Commons’ UK Parliament 2021
[8] Twice weekly rapid testing to be available to everyone in England

Figure 2. Proportion of cases detected over time with COVID-19 testing milestones superimposed



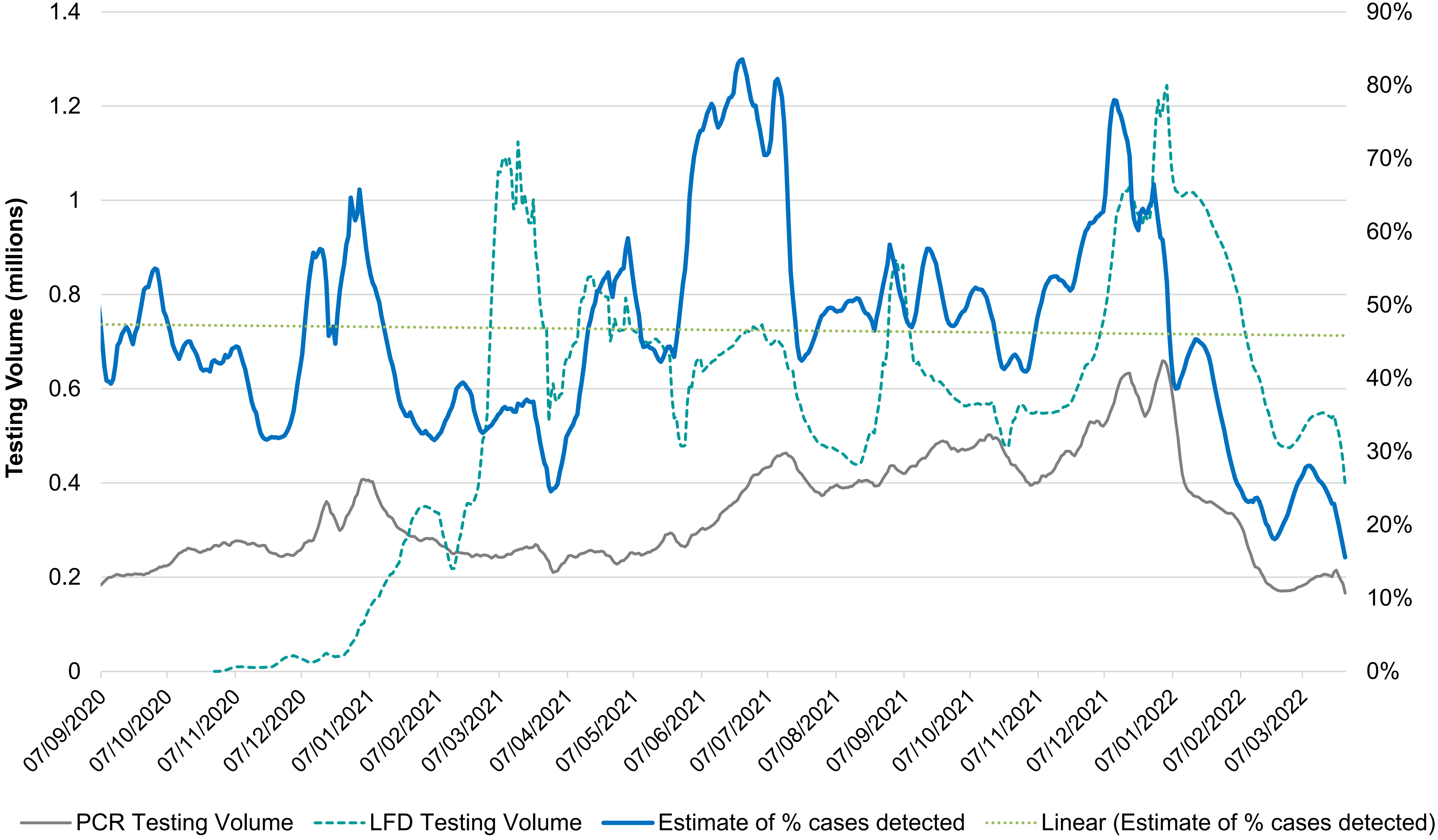
There was no obvious change in trend following most of the milestones plotted. However, there was a noticeable difference in detection rate after the implementation of the Universal Testing Offer on 9 April 2021. Three months after this was implemented, the estimated detected cases increased by 60 percentage points to an all-time high. However, the increase was short-lived, and the detected cases metric quickly fell back to around 50%. In late 2021, when guidance changed from twice weekly asymptomatic testing to a self-directed approach (that is, test when you feel it's the right thing to do) another increase in detected cases was seen. It should be noted that this coincided with the onset of the Omicron driven wave of infections. This pattern supports the hypothesis that expanding access did increase identification.

The link between the metric and testing guidance and availability can be explored in greater detail by investigating how the metric compares with the volume of tests reported.

It might be expected that a greater volume of tests would lead to a greater proportion of cases being detected. However, as can be seen in figure 3, comparing the volume for each of PCR and LFD tests against the detected cases metric does not reveal a clear, consistent correlation. The peaks in LFD volume do not align neatly with those for the detection estimate. However, these plots do follow the same decreasing trend from January 2022 onwards.

The PCR volume shows some mirroring of the highs and lows, with less of the volatility between peaks visible in on the metric.

Figure 3. Testing volumes for PCR and LFD test types reported by NHSTT are superimposed onto the detected cases estimate

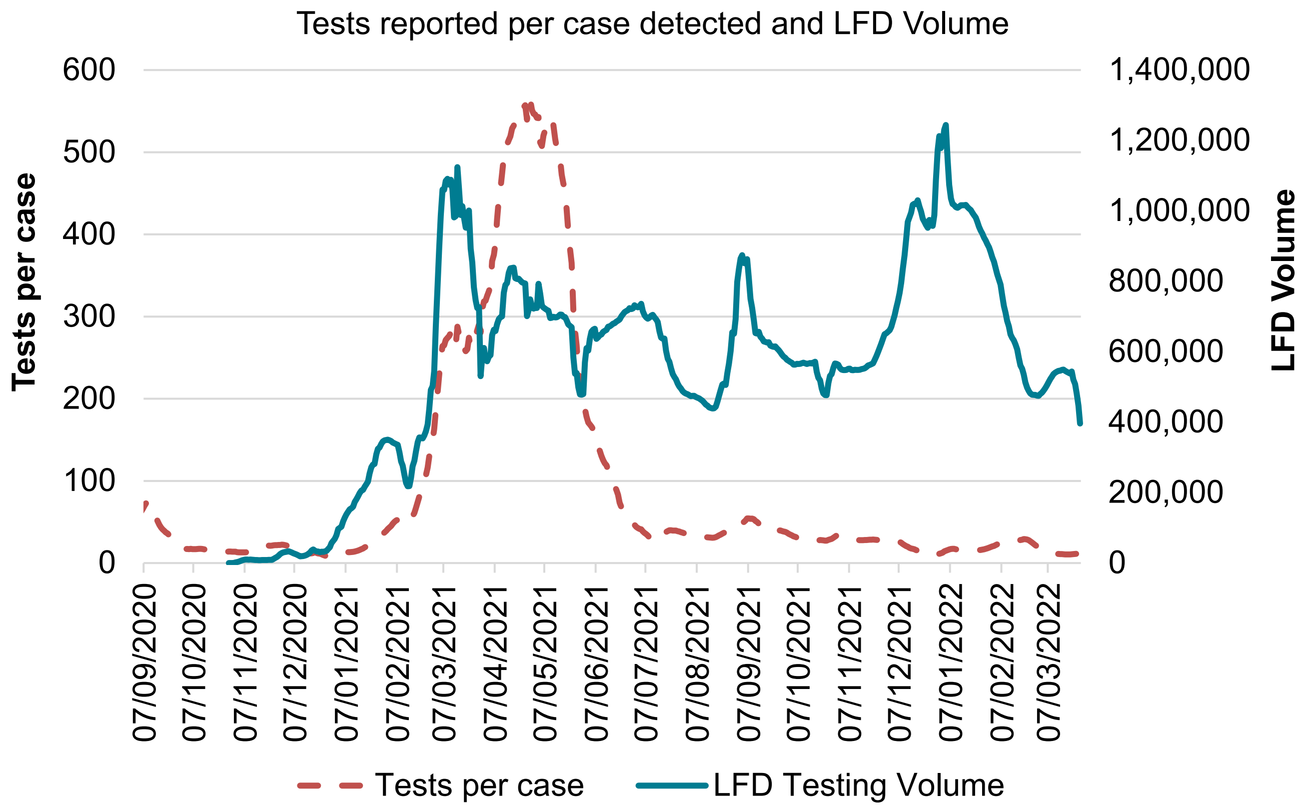


There are various possible explanations for the volume of PCR tests showing some similar patterns to the metric but that being less the case for the volume of LFD tests. These include:

1. PCR testing was primarily for symptomatic individuals and LFDs were primarily for asymptomatic testing – so increases in PCR testing are more likely to be linked to genuine cases taking tests.
2. For much of the pandemic, the guidance was to take a confirmatory PCR test after a positive lateral flow test. This would have meant that genuine cases were more likely to take PCR tests.
3. The behaviour of individuals is likely highly to be influenced by the presence or absence of symptoms; as such, testing behaviour is likely to reflect the number of cases in the country or region at any given time Uptake of LFD testing may be more influenced by factors such as policy to protect vulnerable groups or general testing concerns than PCR testing. It can also be noted that LFDs are perceived as easy to use, accurate and convenient. When they became freely available, the public could test at their convenience and checking symptoms has been one of the primary reasons people provide when taking an LFD test.

Figure 4 shows a plot of the number of tests reported per case detected and the volume of LFD test results reported.

Figure 4. LFD test volume superimposed onto tests used per positive case identified



The sharp peak in tests reported per case detected in spring 2021 is illustrative of the high amount of testing during a low prevalence period, prompted by the rollout of universal offer and the return to schools. It is notable that there is no observable difference in cases detected when the policy of twice-weekly LFD testing changed to the self-directed testing policy, suggesting that these were both valid approaches. However, from this analysis, it is not possible to assess whether the different approaches were affected by the demographic characteristics of the people accessing testing.

The findings in this section do not conclusively prove or disprove that increases in the availability of testing and guidance to test lead to a greater proportion of cases detected. An increase in availability of testing from zero is of course necessary to increase the proportion of cases detected.

It was difficult to ascertain from these findings where the point lies (in terms of volume or type of test) beyond which additional testing had a minimal effect on the proportion of cases detected. But it is noticeable that, following the widespread introduction of LFDs, the peaks in the proportion of cases detected became higher and more sustained than previously.

Positivity rate

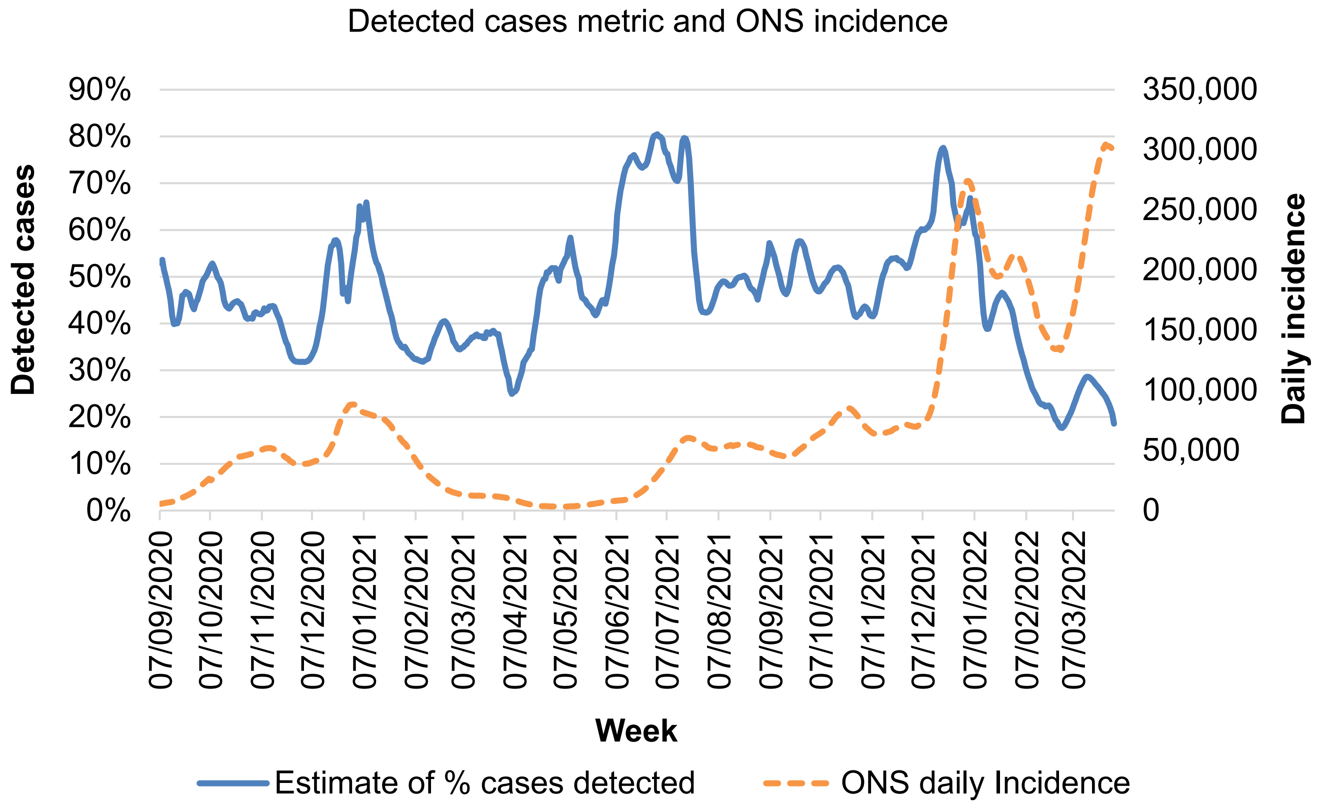
Hypothesis 2

Hypothesis 2: that higher positivity rates lead to a lower proportion of cases detected (because there are more cases to detect). This hypothesis was assessed using the ONS positivity rate from the COVID-19 Infection Survey[9] which was converted to an incidence rate as per the method described above. The incidence essentially sets the upper bound for the number of positive cases that could be identified by testing. It would be reasonable to expect the testing regime to perform differently in periods of high and low positivity, particularly at times when testing was targeted at certain groups.

There were times during the pandemic when high prevalence led to the capacity of the testing programme coming close to being reached. In the event of exceeding capacity this would have limited the number and proportion of positive cases identified. Meanwhile, when prevalence was low, no such bottle necks existed and so detection rates would be expected to be higher. A plot of incidence (from September 2020 when the ONS COVID-19 Infection Survey began) has been superimposed onto the detected cases metric in Figure 5 to assess the plausibility of this theory.

[9] The ONS COVID-19 Infection Survey states that it does not report prevalence since to calculate it would require an accurate understanding of the swab test's sensitivity (true-positive) and specificity (true-negative rate).

Figure 5. Incidence of COVID-19 cases superimposed onto detected cases metric



There was some alignment between the peaks in the 2 time series, which was counter to what would be expected if the hypothesis were correct.

The peak in incidence at the end of 2020 and beginning of 2021 coincided with a rise in cases detected (and also with the sharp increase in use of LFDs, see Figure 4). There were also peaks in both time series in late summer 2021 and at the end of 2021 and beginning of 2022. The greatest divergence is in the spring of 2022, with the end of widespread availability of LFDs, which coincides with the rise of the Omicron variant.

However, there were other peaks in the cases detected metric that were not mirrored in the incidence time series. Most notably, there was a peak in cases detected in spring 2021, when the universal offer was introduced, which was at a time of low incidence.

The hypothesis that higher prevalence leads to a lower proportion of cases being detected is not supported by this analysis. Rather, the opposite – that higher prevalence leads to a higher proportion of cases being detected – appears to have some evidence to support it, though not conclusively. This could be because, during periods of higher prevalence, people were more aware of the possibility of becoming infected and so test more – and this change in behaviour outweighs the effect of there being more cases to detect.

Close contacts identified

Hypothesis 3

Hypothesis 3: that higher numbers of contacts identified leads to a higher proportion of cases detected (because contacts, who are at greater risk of becoming cases, are encouraged to test).

Close contacts were those who had spent 15 minutes or more within 2 metres of an individual who has recently tested positive. This data was collected by NHS TT for the purpose of contact tracing and providing guidance (for the majority of the pandemic, this was to self-isolate for 10 days). There were various testing policies aimed specifically at contacts, which were expected to lead to increased case-finding, and we may therefore expect to see the detected cases estimate increase around peaks in volume of close contacts identified.

Figure 6. Weekly close contacts identified superimposed onto weekly detected cases estimate

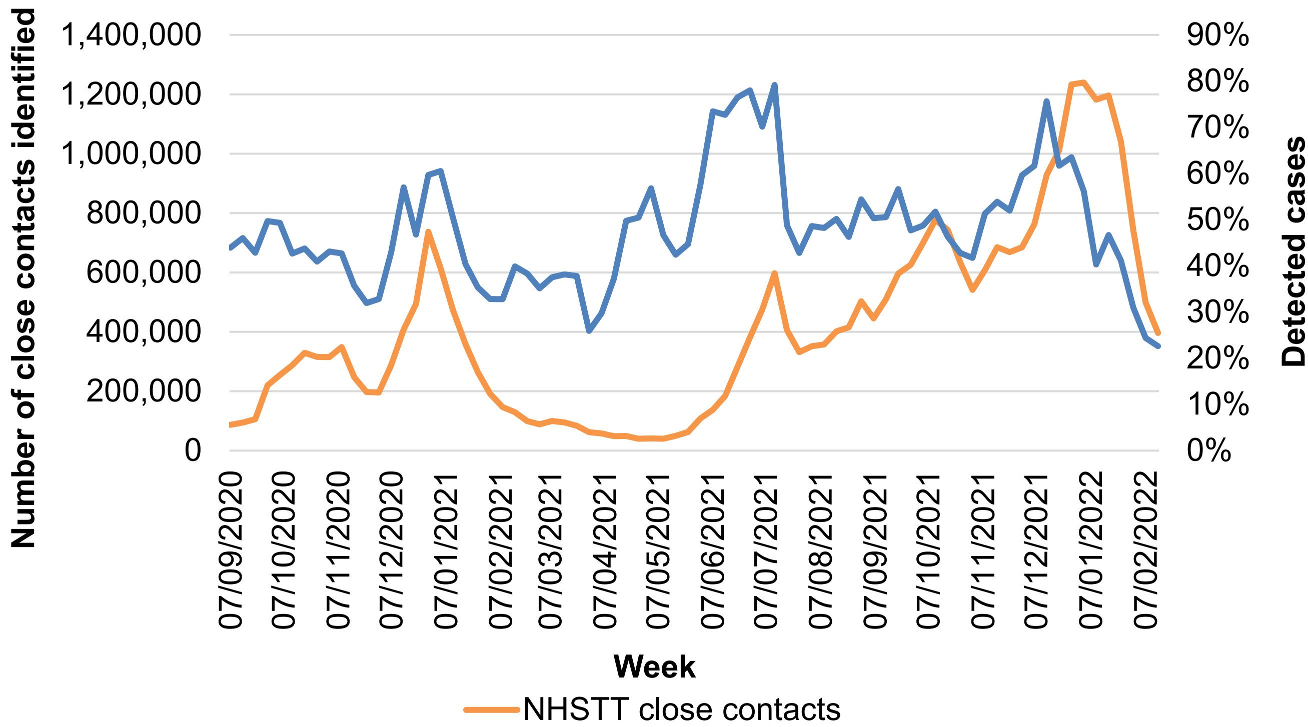


Figure 6 shows a strong alignment between the peaks in the volume of close contacts identified and the detected cases estimate. However, there appeared to be lower correlation during periods where there were fewer contacts identified. Close contacts identified and NHSTT cases are intrinsically linked (contacts need to have been named by a case), and this may be a reflection of that rather than confounding any relationship found with the detected cases estimate.

It is therefore difficult to draw conclusions about the hypothesis on the basis of this analysis alone.

Conclusions

In this analysis, a metric was developed to estimate the proportion of COVID-19 cases that were detected by the national testing programme over the course of the pandemic. This provides an indication of the effectiveness of the testing programme and allowed for examination for clues about factors that may have influenced how the metric fluctuated. It was found that the proportion of cases varied considerably over time, and that the relationship with other measures considered was complex and not easy to evaluate. While it would be expected that testing policy changes had an impact on the output metric, the volume and speed at which changes were made during the COVID-19 pandemic meant that it was difficult to directly link single policy changes to significant outcomes. Importantly, the move from twice LFD testing to advising the public to test when they feel at risk appeared to have little effect in terms of the ratio of tests to identified cases, suggesting self-directed asymptomatic testing was an equally valid approach.

However, some patterns emerged. The most important factor influencing the proportion of cases detected appears to be the level of testing. For example, the introduction of the universal offer in April 2021 and the corresponding rise in LFD usage was followed by the biggest peak in the proportion of cases detected the following summer. Another point to be made is the issue of sustaining testing uptake and whether this can be achieved through regulatory means or through a guidance-based approach such as the one mentioned above. In addition, there was some alignment between peaks in PCR use (which, in contrast to asymptomatic LFD testing, was more focused on symptomatic testing) and peaks in the proportion of cases detected. Notably, after the widespread introduction of LFD tests, the proportion of cases detected was consistently higher than it was previously.

The effect of prevalence was unclear and, if anything, counter to what might have been expected because people appeared to test more in times of high prevalence – and this increase in testing outweighed the increase in cases to be detected.

There was alignment between the volume of contacts and the detected cases estimated. However, this could be more a function of these 2 measures being intrinsically linked than a reflection of a causal relationship.

About the UK Health Security Agency

UKHSA is responsible for protecting every member of every community from the impact of infectious diseases, chemical, biological, radiological and nuclear incidents and other health threats. We provide intellectual, scientific and operational leadership at national and local level, as well as on the global stage, to make the nation heath secure.

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