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# Learning about the effectiveness of contact tracing from when it failed – a natural experiment from England

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# Learning about the effectiveness of contact tracing from when it failed – a natural experiment from England

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# Key findings

- Reports about the failures of contact tracing have pervaded the media during COVID-19 pandemic: contact tracers face resistance from the population, adherence rates to self-isolation are low etc. So far, there is a **lack of causal evidence for the effectiveness of contact tracing that policymakers can rely on**.

- New research **provides evidence** that **contact tracing in England may be highly effective** in containing the spread of the pandemic.

- Context: Due to a technical error at Public Health England, at least 15,841 individuals who tested positive for COVID-19 between 20 September and 2 October had not been referred to the national contact tracing system on 3 October. The **data glitch created a "natural experiment"** that allows us to evaluate the effect of contact tracing.

- By chance, the loss of case information was more severe for some areas of England than others.

- Areas that were more strongly affected by the lack of contact tracing subsequently experienced a sharp increase in COVID-19 infections and COVID-19 related deaths.

- Conservative estimates suggest that the failure to contact trace is associated with **more than 125,000 additional infections and more than 1500 deaths cumulative over the six weeks following the data glitch.**

- The delay in contact tracing was further associated with a subsequent worsening of the regional performance of the test and trace system.

# How should policy makers fight the COVID-19 pandemic?

The current scientific and public debates acknowledge the paramount importance of so-called "non-pharmaceutical interventions", i.e. methods to fight the pandemic that do not require treatments or vaccines. Public health experts suggest that even after vaccines and treatments become available, such measures will remain necessary for a considerable amount of time. A central measure to contain COVID-19 has been to build up testing-and-tracing capacities.

## The case of contact tracing: promise and challenges

Contact tracing comprises two key elements: first, people who have tested positive are contacted and asked to submit information on their recent close contacts, and second, contact tracers attempt to reach each contact and encourage them to self-isolate for a period of time (WHO, 2020). This simple strategy has been a central pillar of communicable disease control in public health for decades.

The eradication of smallpox in the 1970s, for example, is routinely credited to exhaustive contact tracing (Fenner et al., 1988). The relative success of some countries in dealing with the COVID-19 pandemic has repeatedly been associated with the effectiveness of their COVID-19 tracing systems.

Despite the simple appeal of contact tracing, **significant doubts about its effectiveness remain**. The success of contact tracing depends on the skills of contact tracers, who are often engaged at short notice and not well trained for their role. More importantly, contact tracing may fail even if it is successfully implemented: there is by now substantial evidence that people are often unwilling to cooperate with contact tracers. Infected persons may not want to share complete or accurate information about their contacts, e.g. because distrust the government, are afraid of scams, social stigma, or have other privacy and cybersecurity concerns. An even more pressing problem is that contacts may not believe contact tracers. This can lead to non-adherence to self-isolation, undermining the very purpose of contact tracing. For reasons like these, **a better, evidence-driven understanding of the effectiveness of contact tracing is necessary as the basis of public health policy.**

## Scientific research about the effectiveness of contact tracing

Policy evaluations are important because government interventions can have unintended consequences (Fetzer, 2020). The **existing literature** on the effectiveness of contact tracing mostly **relies on correlational evidence** (Klinkenberg et al., 2006; Kendall et al., 2020; Kretzschmar et al., 2020; Afzal et al., 2020; Kucharski et al., 2020; Park et al., 2020; Grantz et al., 2020). However, correlational evidence in favour of the effectiveness of a policy is inherently problematic: because correlation does not imply causation, it may be that a correlation between more contact tracing and fewer newer infections is really driven by a third factor that drives both of these effects and does not tell us anything about the true effectiveness of contact tracing. For example, an observed increase in contact tracing may have been the consequence of a broader public health initiative that simultaneously mandated stricter contact restrictions. It is not clear then whether the decrease in infection is really driven by more contact tracing or new contact restrictions.

This is why the gold standard to evaluate the effectiveness of any policy is an experiment. An experiment occurs when we have a situation in which only the factor of interest – contact tracing in this case – varies in a way that is randomly determined, so that we can observe its distinct effect on some outcome of interest – here, the spread of COVID-19. Based on an experiment, we can talk about the *casual* effect of contact tracing. Causal experiments for a policy are notoriously difficult to conduct because it may not be ethically justifiable to conduct more contact tracing in one area than another, for example. However, sometimes there are situations where random variation in whether an area is "experimentally treated" – e.g. how much contact tracing it experiences – occurs because of uncontrollable factors in nature. This allows us to study the causal impact of a factor without randomly assigning areas into treatment and control groups. In those cases, we talk about "natural experiments".

## A natural experiment on the effectiveness of contact tracing

Between 25 September and 2 October 2020, a total of 15,841 COVID-19 cases in England (around 15 to 20% of all cases) were not immediately referred to the contact tracing system due to a data processing error. Case information had been truncated from an Excel spreadsheet due to a row limit, which was discovered on 3 October. By chance, the loss of case information was more severe for some areas of England than others. This source of quasi-random variation allows us to investigate whether areas that were more strongly affected by the lack of contact tracing subsequently experienced a worse spread of COVID-19.

### Context: contact tracing in England

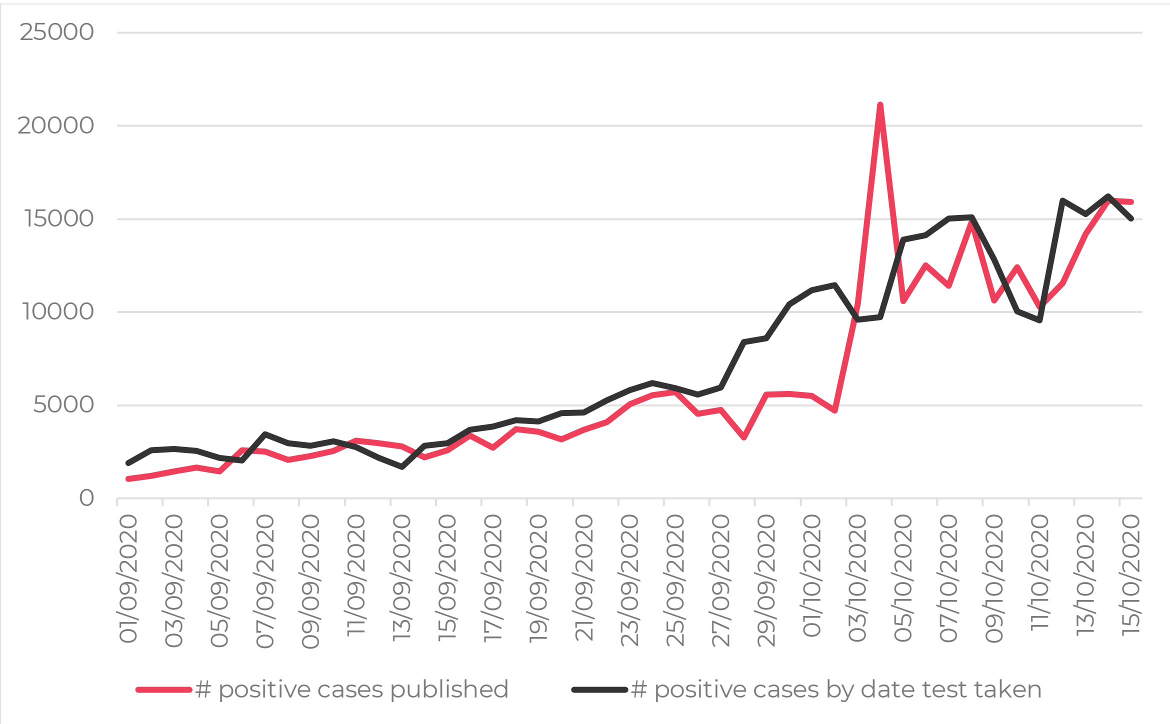
In England, laboratories report positive COVID-19 test results to Public Health England (PHE) on a daily basis. The PHE aggregates all nationwide test results using an automated reporting dashboard, which forms the basis for the official reporting of case numbers as well as contact tracing. Specifically, data on positive cases are passed on to the NHS Test and Trace (Test and Trace) system, a government-funded service that was established in 2020 to organise all contact tracing at the national level. Infected persons are contacted via a text, email alert or phone call and asked to share details of their recent close contacts and places they have visited. They can respond online via a secure website or by telephone with a contact tracer. NHS initially employed a team of 25,000 contact tracers.

### The data glitch

On 4 October, 2020, the PHE released a public statement on a "technical issue" discovered in the night of 2 October to 3 October. An internal investigation had revealed that 15,841 positive cases had accidentally been missed in the data reported to Test and Trace. PHE reported that the original reporting dates for these cases would have been between 25 September and 2 October. While the data glitch did not affect people receiving their individual COVID-19 test results, an anticipated 48,000 close recent contacts of COVID-19 patients had not been traced in a timely manner and had therefore not been encouraged to isolate.

The evolution of the daily number of newly reported cases in England is shown in Figure 1 (red line). The figure also shows the number of positive test results based on the dates on which tests were actually taken (black line). The reason why these two curves are not identical is what we call the "typical reporting lag": because laboratory tests need to be evaluated and processed, each new test enters the official statistics with a delay of typically two to five days. Therefore, the red line trails behind the black line. Note, however, that there is a clearly visible date range in which the divergence between the two lines becomes much more pronounced, and reported cases much more substantially lag behind the tests taken. This is the time when the data glitch occurred. True cases spiked, but reported cases stayed relatively low. On 3 October, we witness a large spike in reported cases, which is when the correction occurred. In the seven days preceding the discovery of the data glitch on 3 October, newly reported cases averaged 4,853 per day, ranging from a low of 3,277 to a high of 5,599. Due to the correction, the officially reported number increased to 10,436 on 3 October and to 21,140 on 4 October, before levelling off to an average of 11,814 reported new cases per day in the subsequent seven days.

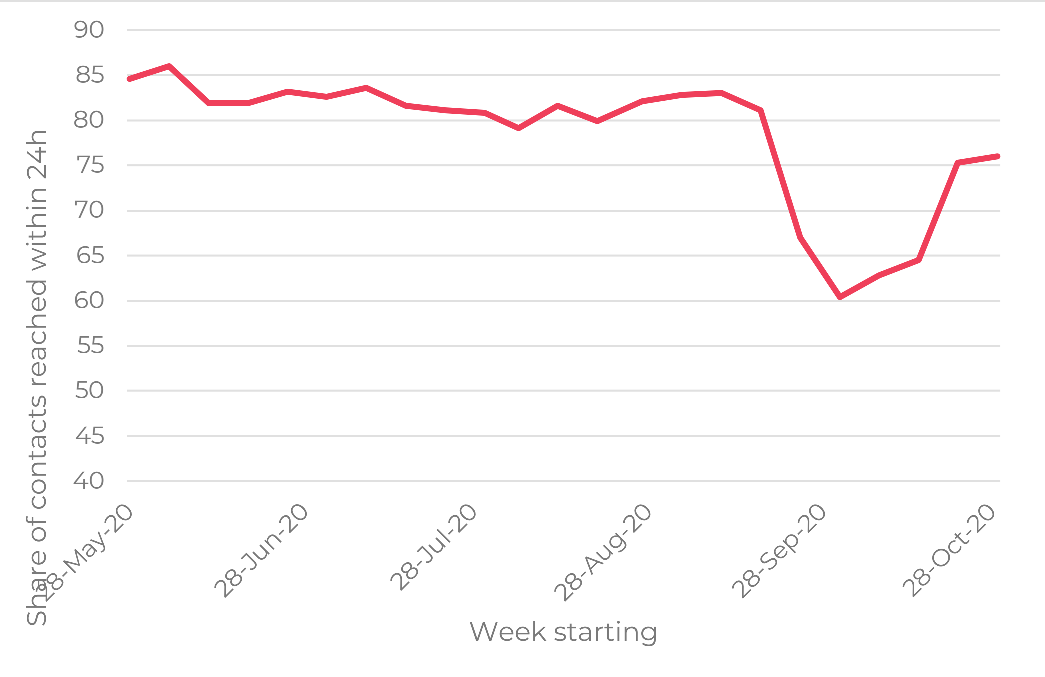
**Figure 1: Number of cases reported by publishing date and by date on which the COVID-19 test was taken**




Notes: Figure plots the number of positive cases based on the date that case results are published as well as the number of positive cases based on the date that the test was taken (not when the result was made public). There is a notable divergence between positive results published and positive test results from Sept 20 to Oct 2 capturing the delayed referral of positive cases to contact tracing.

The first indication that this development of infections at the national level is indeed related to contact tracing is the simultaneous worsening of the performance of contact tracing. Note that contact tracing is a highly time-sensitive matter: if contacts are not reached in a timely fashion, infected contacts may be in contact with other people, who in turn may infect others and so on. Therefore, a central metric for the performance of contact tracing is its speed: out of all contacts that were reached at a given point in time, how many were reached within the first 24 hours after their contact details became available to contact tracers? Figure 2 shows the share of all contacts who hadn't been reached within the first 24 hours, across time. While the fraction of those who were reached within the first 24 hours hovered above 80% in the weeks preceding the data glitch, the fraction plummeted to just above 60% when the misreporting and late referrals to contact tracing started. Figure 2 clearly documents that the performance of contact tracing significantly declined around the same time when reported cases started to diverge from the true number of cases in Figure 1.

**Figure 2: The speed of contact tracing over time**




Notes: Figure plots the share of contacts of individuals who were advised to self-isolate by time taken to reach them. The vertical axis presents the share of all contacts of individuals that were asked to self-isolate that have been reached within 24h. This excludes data pertaining to cases where the individuals that are supposed to self-isolate have not been contacted and may also exclude individuals who have not provided any details of close contacts. Individuals that were asked to self-isolate in response to a positive test in weeks 39 and 40 were affected by the Excel error.

While Figure 1 and 2 display the progression of the pandemic and contract tracing before, during and after the data glitch at the national level, note that the natural experiment relies on the fact that different areas may have been affected to different degrees by the temporary loss of case information that led to late referrals to contact tracing.

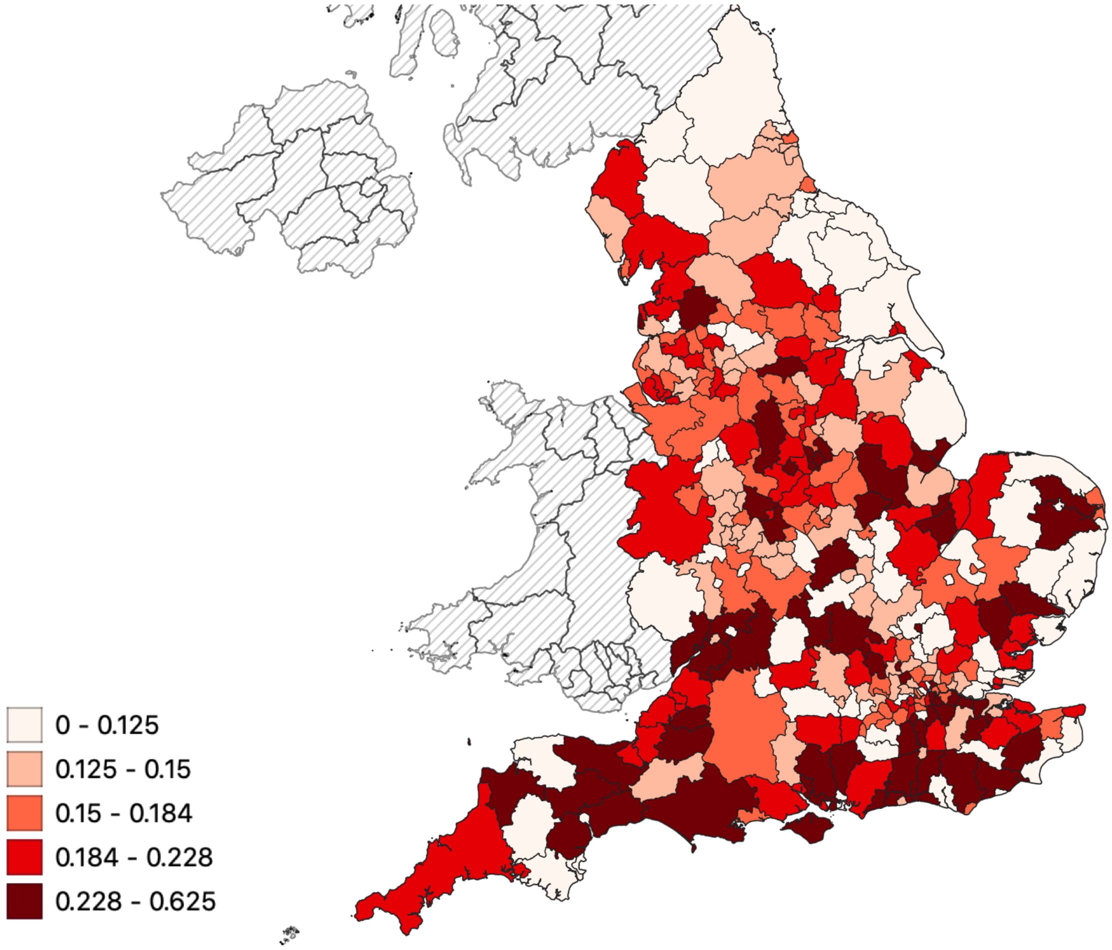
## Identifying local variation in the effect of the data glitch on contact tracing

Because PHE did not publish data on the location of cases that were affected by the data glitch, we reconstruct the local measure of late referrals to contract tracing from the existing data. To do so, we use the fact that in normal times, almost all positive test results are reported within five days following the date on which the tests were taken. For example, for tests taken shortly before the data glitch occurred, in the week of 12 September to 19 September, 95% of all positive results had been reported five days later. This information on typical reporting lags allows us to infer, at the local level, the number of positive test results that were reported surprisingly late as a result of the data glitch.

Specifically, we construct a number of “missed cases” by looking at test dates that precede the date on which the error was discovered (3 October) by so much that, under normal circumstances, virtually all positive cases should have been reported *before* that correction date. Specifically, we would expect that all tests taken between 20 September and 27 September should have entered the statistics and been referred to contact tracing before 3 October. In practice, this fraction was much lower.

For each Lower Tier Local Authority (LTLA) in England, we calculate the effect of the data glitch on contact tracing by summing up the number of positive cases from tests taken between 20 September and 27 September that were not yet reported on 2 October. We divide the resulting number by the total number of positive cases during those test dates (irrespective of their reporting dates). This yields the share of total cases that was not referred to contact tracing in each LTLA. We find that there is substantial variation in the degree to which different areas were affected, which is visible from Figure 2. Areas coloured in a darker shade of red experienced a higher share of late referrals than areas with a lighter shade of red.

**Figure 2 – Share of COVID-19 positive cases between 20 Sep – 27 Sep referred to contact tracing only by 3 Oct due to the Excel data transmission error**




Notes: Figure illustrates the geographic distribution of the fraction of cases tested from 20 Sept to 27 Sept that were not referred to contact tracing until 3 Oct or 4 Oct.

All this shows is that there is substantial variation in the extent to which different areas experienced failures of timely contact tracing as a consequence of the data glitch.

In our working paper (Fetzer and Graeber, 2020), we show that this variation is effectively random. This means: whether an area's contact tracing was more strongly affected by the data glitch is unrelated to any other characteristic of the area, such as its population size or its previous COVID-19 trajectory. As a result, we can use this variation to examine the causal effect of contact tracing – or, more correctly, failures of contact tracing – on the subsequent development of the pandemic.

## Estimating the effect of contact tracing failures on COVID-19

To determine the effectiveness of contact tracing, we compare the progression of the pandemic in areas which were, by chance, strongly affected by late referrals to contact tracing to areas that were less strongly affected. In the paper, these analyses are conducted using a "difference-in-differences" regression approach.

The idea of this approach is that, for each area, we look at the difference between COVID-19 infections or deaths before and after the data glitch. We then study whether this local change over time looks different for areas which experience many later referrals to contact tracing to those that experience few late referrals.

Our regression approach also rules out many alternative explanations by taking into account factors that might also affect the spread of COVID-19: for example, we control for more than 50 different area characteristics and for an area's previous trend in COVID-19 infection dynamics.

Our regressions analyses deliver causal estimates of the effectiveness of contact tracing. We find that, under very conservative assumptions, around 21% of all new infections in England (more than 120,000 out of a total of 600,000) in the 6 weeks following the discovery of the data glitch may be associated with late referrals due to the data glitch. Similarly, our analyses suggest that a share of around 21% (more than 1,500) of all new COVID-19 related deaths is linked to late referrals.

Our analyses allow us to break down the effect of the contact tracing failure to the regional levels. We show the total effect of contact tracing failures on COVID-19 deaths by region in Figure 4 and the effect on COVID-19 infections in Figure 5. Both figures suggest that the North West was the region that was most severely affected. The corresponding numbers are provided in Table 1 and Table 2. It is important to flag up that the geographic variation in Figure 3 does not map in variation presented in Figures 4 and 5. This is driven by a host of factors, but, most importantly, is due to the fact that the number of cases that were affected by the Excel error is ultimately driven by the disease dynamics between 20 September and 2 October. Naturally, areas with more COVID-19 cases would have been more significantly exposed in the form of a higher absolute number of cases that were not contact traced, resulting mechanically in bigger absolute effects on new COVID-19 cases and fatalities linked to it.

**Figure 4: Additional COVID-19 deaths that can be empirically linked to the contact tracing failure**

**Figure 5: Additional COVID-19 cases that can be empirically linked to the contact tracing failure**


Notes: Figures provide a quantification exercise of the implied effects of the delayed contact tracing of COVID-19 positive cases that tested positive between September 20 to September 27 on subsequent infections and deaths across English regions from calendar week 39 to 44 inclusive.

## Bottom line: contact tracing may be very effective in England

Previous scientific research did not provide policymakers with a causal estimate of the effectiveness of contact tracing measures. This study delivers such casual analysis by exploiting a unique source of quasi-experimental variation: failures of contact tracing due to a data transmission error that affected different regions differently.

Our main findings are consistent with the previous state of evidence: despite numerous challenges faced by a contact tracing system such as a population's potential lack of trust, non-adherence and privacy concerns, this non-pharmaceutical intervention can have a strong impact on the progression of an infectious disease. In the context under consideration, the non-timely referral to contact tracing due to a data blunder has likely propelled England to a different stage of COVID-19 spread at the onset of a second pandemic wave.

**Table 1 – Impact of delayed contact tracing on new COVID-19 infections between calendar week 39 to week 44**

| Region | Cases | Number of COVID-19 cases due to failure and delays to contact tracing | | | | | |
|---|---|---|---|---|---|---|---|
| | | Col (1) from Table 1 | | | Col (3) Appendix Table A5 | | |
| | | Estimate | 90% CI | | Estimate | 90% CI | |
| North East | 44878 | 16573 | 11559 | 21587 | 11404 | 6828 | 15979 |
| North West | 161232 | 66903 | 46661 | 87145 | 46036 | 27565 | 64506 |
| Yorkshire & ... | 101873 | 27164 | 18945 | 35382 | 18691 | 11192 | 26190 |
| East Midlands | 59919 | 12703 | 8860 | 16547 | 8741 | 5234 | 12248 |
| West Midlands | 63546 | 17922 | 12500 | 23345 | 12332 | 7384 | 17280 |
| East of England | 29047 | 6339 | 4421 | 8257 | 4362 | 2612 | 6112 |
| London | 61371 | 19017 | 13263 | 24771 | 13085 | 7835 | 18336 |
| South East | 43307 | 10845 | 7564 | 14126 | 7462 | 4468 | 10456 |
| South West | 32208 | 7128 | 4972 | 9285 | 4905 | 2937 | 6873 |
| England | 597381 | 184595 | 128745 | 240445 | 127018 | 76056 | 177981 |

Notes: Table provides a quantification exercise of the implied effects of the delayed contact tracing of COVID-19 positive cases on subsequent infections and deaths across English regions from calendar week 39 to 44 inclusive. The table draws on the midpoint estimate as well as the lowest point estimate across exercises. It provides further the ranges associated with 90% confidence intervals for the individual point estimates. The column head makes a reference to the specific point estimates leveraged.

## Table 2 – Impact of delayed contact tracing on new COVID-19 deaths between calendar week 39 to week 44

| Region | All COVID- 19 Deaths | Number of new COVID-19 deaths between calendar week 39 to 44 linked to contact tracing failure | | | | | |
|---|---|---|---|---|---|---|---|
| | | Col (1) from Table 1 | | | Col (3) Appendix Table A5 | | |
| | | Estimate | 90% CI | | Estimate | 90% CI | |
| North East | 694 | 209 | 86 | 331 | 136 | 26 | 246 |
| North West | 2195 | 842 | 348 | 1337 | 550 | 107 | 992 |
| Yorkshire & ... | 1085 | 342 | 141 | 543 | 223 | 43 | 403 |
| East Midlands | 653 | 160 | 66 | 254 | 104 | 20 | 188 |
| West Midlands | 747 | 226 | 93 | 358 | 147 | 29 | 266 |
| East of England | 474 | 80 | 33 | 127 | 52 | 10 | 94 |
| London | 529 | 239 | 99 | 380 | 156 | 30 | 282 |
| South East | 547 | 137 | 56 | 217 | 89 | 17 | 161 |
| South West | 272 | 90 | 37 | 142 | 59 | 11 | 106 |
| England | 7196 | 2324 | 960 | 3689 | 1516 | 295 | 2738 |

Notes: Table provides a quantification exercise of the implied effects of the delayed contact tracing of COVID19 positive cases on subsequent infections and deaths across English regions from calendar week 39 to 44 inclusive. The table draws on the midpoint estimate as well as the lowest point estimate across exercises. It provides further the ranges associated with 90% confidence intervals for the individual point estimates. The column head makes a reference to the specific point estimates leveraged.

## References


**Afzal, Ibrahim, Raheema Abdul Raheem, Nazla Rafeeq, and Sheena Moosa**, "Contact tracing for containment of novel coronavirus disease (COVID-19) in the early phase of the epidemic in the Maldives," *Asia Pacific Journal of Public Health*, 2020, p. 1010539520956447.

**Fetzer, Thiemo**, "Subsidizing the spread of COVID19: Evidence from the UK's Eat-Out-to-Help-Out scheme," *CAGE Working Paper*, 2020, (517).

**Fetzer, T., & Graeber, T. (2020)** "Does Contact Tracing Work? Quasi-Experimental Evidence from an Excel Error in England.", *CAGE Working Paper, 2020*.

**Grantz, Kyra H, Elizabeth C Lee, Lucy D'Agostino McGowan, Kyu Han Lee, C Jessica E Metcalf, Emily S Gurley, and Justin Lessler**, "Maximizing and evaluating the impact of test-trace-isolate programs," *medRxiv*, 2020.

**Kendall, Michelle, Luke Milsom, Lucie Abeler-Dörner, Chris Wymant, Luca Ferretti, Mark Briers, Chris Holmes, David Bonsall, Johannes Abeler, and Christophe Fraser**, "Epidemiological changes on the Isle of Wight after the launch of the NHS Test and Trace programme: a preliminary analysis," *The Lancet Digital Health*, 2020.

**Klinkenberg, Don, Christophe Fraser, and Hans Heesterbeek**, "The effectiveness of contact tracing in emerging epidemics," *PloS one*, 2006, *1* (1), e12.

**Kretzschmar, Mirjam E, Ganna Rozhnova, Martin Bootsma, Michiel E van Boven, Janneke van de Wijgert, and Marc Bonten**, "Time is of the essence: impact of delays on effectiveness of contact tracing for COVID-19," *medRxiv*, 2020.

**Kucharski, Adam J, Petra Klepac, Andrew Conlan, Stephen M Kissler, Maria Tang, Hannah Fry, Julia Gog, John Edmunds, CMMID COVID-19 Working Group et al.**, "Effectiveness of isolation, testing, contact tracing and physical dis- tancing on reducing transmission of SARS-CoV-2 in different settings," *medRxiv*, 2020.

**Park, YJ, YJ Choe, O Park, SY Park, YM Kim, J Kim et al.**, "COVID-19 National Emergency Response Center, Epidemiology and Case Management Team. Contact tracing during coronavirus disease outbreak, South Korea, 2020," *Emerg Infect Dis*, 2020, *26* (10).