Office for National Statistics

Article

Coronavirus (COVID-19) Infection Survey technical article: analysis of positivity after vaccination, June 2021

This release provides data about positivity after vaccination from the Coronavirus (COVID-19) Infection Survey. This analysis has been produced in partnership with University of Oxford.

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Next release:
To be announced

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1 . Main points

- The risk of identifying a new infection following vaccination was highest during the first 21 days after the first vaccination, after that the risk strongly decreased.
- Those who became infected post vaccination were less likely to have symptoms and less likely to have a high viral load compared with individuals who tested positive but have not been vaccinated.
- Characteristics linked to an increased risk of positivity post vaccination include individuals aged under 40 years, individuals working in patient-facing healthcare roles and in care homes, larger household size and greater deprivation; there was a trend towards lower positivity rates post-vaccination in rural areas.
- Ongoing monitoring of infection post vaccination is essential.
- This is the first stage in an analysis to explore positivity following vaccination. We welcome input and dialogue from users on its benefit and how we can continue to explore our data. We will continue to publish here and in academic journals.

2 . Sample

The data used in this analysis includes adults (aged 16 years and over) in the UK who have had a coronavirus (COVID-19) vaccination from 1 December 2020 to 31 May 2021, either self-reported or from the English national database. Only the first new episode of COVID-19 infection identified after vaccination from one or more positive swab tests was included in this analysis; this could be someone's first infection or second infection (re-infections) if their first occurred before vaccination. The analysis only included those receiving the Oxford-AstraZeneca or Pfizer vaccines as numbers receiving other vaccines were too few for analysis.

Table 1: Infection identified following vaccination by vaccine type in adults, observed sample counts
Number of coronavirus (COVID-19) infections after vaccination by vaccine type, 1 December 2020 to 31 May 2021, UK

COVID-19 Vaccine Type	Number vaccinated	Number (%) with a new positive infection after vaccination	Number received second dose	Number (%) with a new positive infection after second dose
Pfizer/BioNTech	105,367	824 (0.8%)	92,572	93 (0.1%)
Oxford /AstraZeneca	192,126	653 (0.3%)	118,346	61 (0.1%)
Total	297,493	1,477 (0.5%)	210,918	154 (0.1%)

Source: Office for National Statistics – Coronavirus (COVID-19) Infection Survey

3 . Time from vaccination to infection

In unadjusted analyses the risk of infection increased following first vaccination, peaking at around 16 days, followed by a strong decrease to around one month, that then slows but still declines continuously. (Unadjusted analysis refers to findings in the raw data whereas adjusted analysis refers to the model which adjusts for several factors, accompanying dataset 1c). This initial increase in the number of infections following vaccinations is consistent with other studies, including Coronavirus (COVID-19) Infection Survey (CIS) analysis to estimate risk of infection post vaccination compared with unvaccinated controls.

In those with infections post vaccination, the median number of days to infection after vaccination was 21 days (interquartile range: 11 – 40 days). However, 61.1% did not have a negative swab result after vaccination but prior to their positive swab result and so it is possible that these new positive infections started earlier, potentially before vaccination.

Other possible explanations for infections shortly after vaccination include exposure to COVID-19 at vaccination centres, change in behaviour following vaccination, or prompts to get vaccinated because of knowledge of individuals around them testing positive.

Based on raw counts (Table 1), the proportion with new infections was lower in those who received the Oxford-AstraZeneca vaccine (0.3%) than the Pfizer vaccine (0.8%). It is important to note that during the time data was collected for this analysis infection rates varied substantially, and this may affect the risk of a vaccinated adult becoming infected. After adjustment the early increase in infections was still slightly greater in those receiving the Pfizer vaccine (Figure 1). This may be because more individuals who received Pfizer were vaccinated between December 2020 and January 2021 when positivity rates were very high (accompanying dataset 1b), and exposure to COVID-19 at vaccination centres or elsewhere may have been greater. However, over time rates dropped slightly faster in those who received Pfizer as their first dose, potentially because more of these adults received a second dose (Table 1), and the model used in this analysis is not adjusted for these second doses. Further monitoring of time from vaccination to infection is essential.

Risk of infection following vaccination is given in Figure 1, the full model is available in the accompanying dataset.

Figure 1: Risk of infection continues to decline over time following first vaccination

Modelled adjusted infection rate following first vaccination by type of vaccine, 1 December 2020 to 31 May 2021, UK

Notes:

1. All estimates are subject to uncertainty, given that a sample is only part of the wider population.
2. A confidence interval gives an indication of the degree of uncertainty of an estimate, showing the precision of a sample estimate. The 95% confidence intervals are calculated so that if we repeated the study many times, 95% of the time the true unknown value would lie between the lower and upper confidence limits. A wider interval indicates more uncertainty in the estimate. Overlapping confidence intervals indicate that there may not be a true difference between two estimates.
3. Prediction made at reference categories: 60 year old, male, not patient-facing/care home/social care worker, household size = 3, not multigenerational, living in major urban area, median deprivation (50^{th} percentile), no long-term health conditions, first dose only, first vaccinated 9 February 2021.

Download the data

.XLSX

4 . Viral load

The strength of a positive test is determined by how quickly the virus is detected, measured by a cycle threshold (Ct) value. The lower the Ct value, the higher the viral load and stronger the positive test. Positive results with a high Ct value can be seen in the early stages of infection when virus levels are rising, or late in the infection, when the risk of transmission is low. A Ct value less than 30 is considered a strong positive test. You can find more information on Ct values in this paper.

The median Ct value for infection post vaccination was 31.3 (interquartile range: 23.8 to 33.7). A total of 42.7% new positive infections had a Ct value less than 30, and 57.3% had a Ct value greater than 30. Evidence of symptoms at visits within the first 35 days of the first positive in the episode was reported in 37.3% of new positive infections following vaccination.

Overall, there were fewer symptomatic cases as well as cases with a higher viral load after vaccination compared with people who hadn't been vaccinated. Our symptoms analysis can be found in the latest edition of Coronavirus (COVID-19) Infection Survey: characteristics of people testing positive for COVID-19 incountriesof the UK.

5 . Characteristics linked to infection post vaccination

Recipients of the different vaccine types differed in several characteristics (accompanying dataset 1b). Of those who received the Oxford-AstraZeneca vaccine, individuals were typically younger, less likely to work in patient-facing healthcare roles, and received their vaccines later on in the vaccination programme. This may be due to the vaccines being approved at different time points.

Characteristics linked to infection after vaccination may be reflective of higher positivity rates regardless of vaccination in some groups, not because of vaccination.

In the adjusted model, there were strong effects of age on post-vaccination infection, with risks increasing particularly in adults aged under 40 years. Those who reported working in patient-facing healthcare roles continued to have higher positivity rates post vaccination. A similar association was identified for those who reported working in care homes, potentially reflecting greater occupational exposure. Risks of positivity post vaccination increased as both household size and deprivation increased. Furthermore, positivity rates were lower in those living in rural villages compared with major urban areas.

Figure 2: Infection following vaccination shows a non-linear relationship with age, with risk increasing particularly in adults aged under 40 years

Relationship between age at visit and risk of positivity after vaccination by hazard ratio against the reference category of age 60 years, 1 December 2020 to 31 May 2021, UK

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In addition to this, there was a strong decrease in positivity post vaccination the later the first vaccination occurred in calendar time, likely reflecting declining rates post lockdown. There was no evidence that the effect of the characteristic factors mentioned above varied over time since vaccination.

The strong effects of these factors led to variation in the predicted rate of infections post vaccination (accompanying dataset 1d).

6 . Coronavirus (COVID-19) Infection Survey technical data

Coronavirus (COVID-19) Infection Survey technical data
Dataset | Released 17 June 2021
Findings from the Coronavirus (COVID-19) Infection Survey technical data

7 . Collaboration

This analysis was produced by Owen Gethings - Office for National Statistics (ONS) Senior Statistical Officer, in collaboration with our research partners at the University of Oxford, the University of Manchester, Public Health England (PHE) and Wellcome Trust. Of particular note are:

- Sarah Walker - University of Oxford, Nuffield Department for Medicine: Professor of Medical Statistics and Epidemiology and Study Chief Investigator.
- Koen Pouwels - University of Oxford, Health Economics Research Centre, Nuffield Department of Population Health: Senior Researcher in Biostatistics and Health Economics.
- Thomas House - University of Manchester, Department of Mathematics: Reader in mathematical statistics.

8 . Glossary

Hazard ratio

The hazard ratio is a measure commonly used in survival analysis to compare the risk of occurrence of an event of interest (eg death or testing positive) in two groups (eg treatment group versus control group, in this case by vaccine type) at a given time.

Flexible parametric model

Time-to-event data is commonly analysed using the Cox proportional hazards model. The Cox model makes no assumptions about the shape of the underlying hazard function and does not produce smoothly varying estimates of rates over time. In contrast, a flexible parametric model uses restricted natural cubic spline functions to model the baseline cumulative hazard (used here), baseline cumulative odds of survival, or some more general baseline distribution in survival analysis models. This provides a smoothly varying estimate of the rates of events over time, as shown in Figure 1. Both models directly estimate relative effects, eg hazard ratios. However, Cox models usually estimate a constant effect of a covariate on the hazard over time (proportional hazards assumption). Flexible parametric models can easily allow the hazard ratio to vary over time, eg to be non-proportional, as shown in Figure 1 where the hazards for the two vaccine types cross.

9 . Data sources and quality

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.

Methods and technical information

Time at risk is assessed from the date of first vaccine dose. People can test positive on a swab once or repeatedly, and sometimes have negative tests between positives. We group positive tests into infection "episodes", defining a new infection episode by a new positive test 90 days or more after an initial first positive test and following a previous negative test, or, if within 90 days, a subsequent positive test following four consecutive negative tests. This reflects lack of standard definitions for new (re-)infections based on swab tests alone; antibody status is not available for most participants nor are whole genome sequences for most positives in the survey so we cannot use these to define new infection episodes. Any positive episode recorded in the survey before vaccination was excluded from this analysis (including all positive swab tests within it). For adults with a new positive episode starting strictly after vaccination, the time of the event was calculated as the difference between the date of first vaccination and the date of the initial positive in the episode following vaccination. For adults not testing positive, the time of the event was defined as the difference between the date of vaccination and their last negative test.

Individuals receiving Oxford-AstraZeneca and Pfizer vaccines differed in several characteristics considered (accompanying dataset 1b), particularly date of first vaccination, age, working in patient facing healthcare, and reporting long-term health conditions. A total of 2.2% of adults included in this analysis had already had a positive antibody result prior to vaccination; 46.4% had previous negative antibody results only, and 51.3% were never tested for antibodies before vaccination.

Flexible parametric models were used to investigate how the overall rate of infection after vaccination varied over time from vaccination, adjusting for other potential confounders.

The regression model adjusts for the following factors: age, urban or rural classification of living area, sex, ethnicity, household size, multigenerational households, deprivation, if ever reported working in person-facing social care role, if ever reported being a care home worker, if ever reported being a patient- facing health care worker and if ever reported long term health conditions. See accompanying dataset 1c for technical details of the model and p values.

10 . Related links

Coronavirus (COVID-19) Infection Survey, UK
Bulletin | Updated weekly
Estimates for England, Wales, Northern Ireland and Scotland. This survey is being delivered in partnership with University of Oxford, University of Manchester, Public Health England and Wellcome Trust.

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.

Coronavirus (COVID-19) Infection Survey: antibody and vaccination data for the UK
Article | Updated fortnightly
Antibody and vaccination data by UK country and English regions from the Coronavirus (COVID-19) Infection Survey. This survey is being delivered in partnership with University of Oxford, University of Manchester, Public Health England and Wellcome Trust.

Impact of vaccination on SARS-CoV-2 cases in the community: a population-based study using the UK's COVID-19 Infection Survey
Academic article | 23 April 2021
Data from the Coronavirus (COVID-19) Infection Survey were used by academic partners from the University of Oxford to examine the effect that community vaccination has had on positivity by comparing the likelihood of testing positive between participants who have had at least one dose of a coronavirus (COVID-19) vaccine and those who have not been vaccinated.

The impact of SARS-CoV-2 vaccines on antibody responses in the general population in the United Kingdom
Academic article | 23 April 2021
Data from the Coronavirus (COVID-19) Infection Survey were used by academic partners from the University of Oxford to examine the impact of SARS-CoV-2 vaccines on antibody responses in the general population in the UK.

Ct threshold values, a proxy for viral load in community SARS-CoV-2 cases, demonstrate wide variation across populations and over time
Academic article | 4 April 2021
Data from the Coronavirus (COVID-19) Infection Survey were used by academic partners from the University of Oxford to examine Ct threshold values as a measure of viral load.

Coronavirus and vaccination rates in people aged 70 years and over by socio-demographic characteristic, England
Article | Released 29 March 2021
First dose COVID-19 vaccination rates among people aged 70 years and older who live in England, both in private households and communal establishments. Includes estimates for the population as a whole by age and sex, and for ethnic minorities, religious groups, those identified as disabled and by area deprivation.

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) roundup
Web page | Updated as and when data become available
Catch up on the latest data and analysis related to the coronavirus pandemic and its impact on our economy and society.

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.