Office for National Statistics

Statistical bulletin

COVID-19 vaccine effectiveness estimated using Census 2021 variables, England: 31 March 2021 to 20 March 2022

Estimates of the risk of hospital admission for coronavirus (COVID-19) and death involving COVID-19 by vaccination status, overall and by age group, using anonymised linked data from Census 2021. Experimental Statistics.

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1 . Main points

- Vaccine effectiveness (VE) is the reduction in risk as a result of receiving a vaccine; it is estimated by comparing the risk in vaccinated and unvaccinated individuals, taking into account differences in the vaccinated and unvaccinated populations (confounding factors).
- We used linked, population-level datasets based on anonymised individuals in Census 2021, adjusting for a wide variety of confounding factors, to estimate vaccine effectiveness against coronavirus (COVID-19) hospitalisation and death involving COVID-19.
- Between 21 March 2021 and 20 March 2022, vaccine effectiveness against hospitalisation for COVID-19 was 52.2% (95% confidence interval: 51.4% to 52.9%) for a first dose, 55.7% (confidence interval: 55.2% to 56.1%) for a second dose, and 77.6% (confidence interval: 77.3% to 80.0%) for a third dose.
- Vaccine effectiveness against COVID-19 mortality was 58.7% (confidence interval: 52.7% to 65.9%) for a first dose, 88.6% (confidence interval: 87.5% to 89.5%) for a second dose, and 93.2% (confidence interval: 92.9% to 93.5%) for a third dose.
- Protection increases with subsequent doses and is high for the third dose or booster as has been shown in previous research, however results are slightly lower in general than previously published estimates.
- Although these estimates take into account many sociodemographic and health-related differences between people in different vaccination statuses using up-to-date data sources, some residual confounding remains; this includes confounding because of prioritisation of the clinically vulnerable in young people, and delayed vaccination of more frail older people.

Census estimates provided here may be very slightly different to the estimates provided in other census products. This is because of the application of statistical disclosure control (SDC) processes to the census data to prevent the identification of individuals in published statistics.

2 . Understanding the data

The coronavirus (COVID-19) vaccine has been shown in both clinical trials and real-world effectiveness studies to be effective at preventing infection, hospitalisation, and death from COVID-19. Estimating vaccine effectiveness in the real world as the roll-out of booster vaccinations continues is vital to assess the impact of the vaccination campaign.

Vaccine effectiveness provides a measure of the percentage reduction in an outcome (for example, infection, hospitalisation, or death) among people who are vaccinated compared with those who are not. To provide an accurate measure of vaccine effectiveness, factors that affect both the likelihood to be vaccinated and the likelihood of the outcome, known as confounding factors, must be controlled for.

The age-standardised mortality rates that we publish by month provide an indication of the impact of the vaccine, but they only take into account differences in age. These are subject to confounding, where characteristics of the populations differ by vaccination status. These differences in characteristics may lead to differences in mortality that are not caused by the vaccine. By contrast, in this publication we provide a more in-depth assessment of the impact of vaccination, by estimating vaccine effectiveness against COVID-19 hospitalisation and death involving COVID-19 while controlling for a range of confounding factors. The quality of the data used to adjust for confounding is important to sufficiently adjust the estimates. Here, we used anonymised data from Census 2021 to adjust for socio-demographic and self-reported health confounding factors. We also use data from Hospital Episode Statistics and General Practice Extraction Service (GPES) data for Pandemic Planning and Research version 3 (GDPPR) to further adjust for health-related factors. More information on the data used in this publication is in Section 9: Measuring the data.

The confounding factors that we adjusted for are:

- age on Census Day (21 March 2021)
- sex
- self-reported ethnic group
- religious affiliation
- region of residence
- index of multiple deprivation
- level of highest qualification
- English language proficiency
- National Statistics Socio-economic classification (NS-SEC)
- key worker status, derived from Standard Occupational Classification (SOC) 2020 classification
- care home residency
- long-term health problem or disability
- self-reported general health
- body mass index (BMI)
- number of comorbidities as defined in the QCOVID model
- frailty
- hospitalisation within the last 21 days

To calculate our estimates of vaccine effectiveness, we used a Cox Proportional Hazard model. This is a regression model that compares the time to an outcome such as death in vaccinated people to that in unvaccinated people, taking into account confounding factors. Hazard ratios are estimated using the Cox Proportional Hazard model, where a hazard ratio of 1 means there is no difference in risk, a hazard ratio above 1 means the risk is greater for the vaccinated group, and a hazard ratio of less than 1 means the risk is lower for the vaccinated group. Vaccine effectiveness is then calculated from the hazard ratio as 1 minus the hazard ratio. A vaccine effectiveness of 90% means the vaccine reduces the incidence of the outcome by 90% in vaccinated people compared with unvaccinated. A vaccine effectiveness of 0% means the vaccine has no effect on the risk of the outcome occurring. See Section 9: Measuring the data for more information.

We calculated vaccine effectiveness for different doses (first, second and third dose or booster) and time since dose, to observe how the effectiveness changes over time. The vaccination statuses used were:

- unvaccinated (those with no vaccination or who were vaccinated with a first dose less than 21 days ago)
- first dose (those who were vaccinated with a first dose at least 21 days ago to earliest of less than 91 days after first dose or less than 21 days after second dose)
- over three months after first dose (those vaccinated with a first dose at least 91 days ago to less than 21 days after the second dose)
- second dose (those who were vaccinated with a second dose at least 21 days ago to earliest of less than 91 days after second dose or less than 21 days after third dose)
- three to six months after second dose (those vaccinated with a second dose at least 91 days ago to earliest of less than 182 days after second dose or less than 21 days after third dose)
- over six months after second dose (those vaccinated with a second dose at least 182 days ago to less than 21 days after third dose)
- third dose (those vaccinated with a third dose at least 21 days ago to less than 91 days after third dose)
- over three months after third dose (those vaccinated with a third dose at least 91 days ago)

3 . Vaccine effectiveness against COVID-19 hospitalisation and mortality

Overall

Vaccine effectiveness (VE) against hospitalisation for coronavirus (COVID-19) was 52.2% (95% confidence interval: 51.4% to 52.9%) for a first dose, 55.6% (confidence interval: 55.2% to 56.1%) for a second dose, and 77.6% (confidence interval: 77.3% to 78.0%) for a third dose or booster. The estimate of VE was negative over three months after the first dose, however this group of people are those who did not receive a second dose when eligible. Therefore, it is possible that not all confounding because of differences in health is taken into account. There is no consistent evidence of waning protection against COVID-19 hospitalisation after vaccinations; there is a decrease in VE over three months after the third dose, but not after the second dose.

Vaccine effectiveness against COVID-19 mortality was 58.7% (confidence interval: 52.7% to 63.9%) for a first dose, 88.6% (confidence interval: 87.5% to 89.5%) for a second dose, and 93.2% (confidence interval: 92.9% to 93.5%) for a third dose of the vaccine. Vaccine effectiveness decreases with time after the second and third doses.

Figure 1: Vaccine effectiveness for the third dose against COVID-19 mortality was over 90%

Vaccine effectiveness against coronavirus (COVID-19) hospitalisation and death involving COVID-19, England, 21 March 2021 to 20 March 2022

Notes:

1. 95% confidence intervals are indicated by the horizontal bars.

2. The model was adjusted for age (as a natural spline), plus socio-demographic characteristics (sex, region, ethnicity, religion, Index of Multiple Deprivation (IMD) decile, National Statistics Socio-economic classification (NS-SEC) category, highest qualification, English language proficiency, and key worker status), plus health-related characteristics (disability, self-reported health, care home residency, number of QCOVID comorbidities (grouped), body mass index (BMI) category, frailty flag and hospitalisation within the last 21 days).

3. Estimates are calculated for residents of England, who were enumerated in Census 2021 and could be linked to an NHS number, who were alive and aged 16 years and over on Census Day (21 March) 2021, and who did not have ambiguous or erroneous vaccination data.

4. The time at risk was the earliest of time until the outcome occurred or 20 March 2022.

5. COVID-19 hospitalisation is based on the date of the start of a hospital episode and is defined as an inpatient episode in Hospital Episode Statistics where the primary diagnosis was COVID-19, identified by the International Classification of Diseases 10th Revision (ICD-10) codes U07.1 (COVID-19, virus identified) or U07.2 (COVID-19, virus not identified).

6. Deaths involving COVID-19 are based on date of occurrence and are defined as a death where either of the (International Classification of Diseases 10th Revision (ICD-10) codes U07.1 (COVID-19, virus identified) or U07.2 (COVID-19, virus not identified) is mentioned on the death certificate.

Download the data

.csv

Age-group breakdown

VE against COVID-19 hospitalisation by age group follows broadly similar trends to the non-age stratified VE among the older age groups (aged 30 to 64 years, aged 65 to 79 years, and aged 80 years and over). In those aged 16 to 29 years, negative vaccine effectiveness was observed for individuals over three months after the third dose. This could be because of the prioritisation of clinically young people, meaning people in this category were more likely to have poorer health and these differences may not be fully accounted for using model adjustments.

The decrease in VE over three months after the third dose that is observed for the overall population is not seen in those aged 65 to 79 years and those aged 80 years and over, and therefore may be because of the effects of confounding rather than vaccine waning. Other sources of a decrease in VE after vaccination could include the healthy vaccine effect where people who are unwell delay vaccination, increasing VE shortly after vaccination, and confounding by indication, where people vaccinated earlier were more likely to be clinically vulnerable.

VE against COVID-19 mortality follows broadly similar trends to the non-age stratified VE among the older age groups (those aged 30 to 64 years, those aged 65 to 79 years, and those aged 80 years and over), with protection also seen in those aged 16 to 29 years for all except the "over three months after the first dose" category but with higher uncertainty because of lower counts.

For those aged 80 years and over, VE after the first dose is not significantly different from zero. However, the uncertainty is large, probably because most of those aged 80 years and over received the first dose towards the beginning of the vaccination campaign before our study period begins, therefore resulting in low numbers for this group.

Figure 2: Vaccine effectiveness for older age groups is consistent with that for all ages

Vaccine effectiveness against coronavirus (COVID-19) hospitalisation and death involving COVID-19, by age group, England, 21 March 2021 to 20 March 2022

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