UK Health Security Agency

COVID-19 vaccine surveillance report

Week 2

12 January 2023

Contents

Executive summary

Rigorous clinical trials have been undertaken to understand the immune response, safety profile and efficacy of all coronavirus (COVID-19) vaccines approved for use in the UK as part of the regulatory process. Ongoing monitoring of the vaccines as they are rolled out in the population is important to continually ensure that clinical and public health guidance on the vaccination programme is built upon the best available evidence.

UK Health Security Agency (UKHSA), formerly Public Health England (PHE), works closely with the Medicines and Healthcare Regulatory Agency (MHRA), NHS England, and other government, devolved administration and academic partners to monitor the COVID-19 vaccination programme. Details of the vaccine surveillance strategy are set on the page COVID-19: vaccine surveillance strategy (1). As with all vaccines, the safety of COVID-19 vaccines is continuously being monitored by the MHRA. They conclude that overall, the benefits of COVID-19 vaccines outweigh any potential risks (2).

Please note that this report is published monthly. The next report will be published on 2 February 2023.

This month's report contains updates on vaccine effectiveness, vaccine coverage, vaccine impact on the proportion of the population with antibodies to COVID-19 and vaccination status by the time of admission through SARI-Watch.

Vaccine effectiveness

Several studies of vaccine effectiveness (VE) have been conducted in the UK against different COVID-19 variants. Vaccine effectiveness against symptomatic disease with the Omicron variant is substantially lower than against the Delta variant, with rapid waning. However, protection against hospitalisation remains high.

Population impact

The impact of the vaccination programme on the population is assessed by taking into account vaccine coverage, evidence on vaccine effectiveness and the latest COVID-19 disease surveillance indicators.

By the end of week one 2023 (week ending 8 January 2023), 64.3% (14,995,236 out of 23,312,691) of all people aged over 50 years old had been vaccinated with an Autumn booster dose since 1 September 2022, For further detail on the vaccine uptake and the current booster campaign, please the flu and COVID-19 weekly surveillance report weekly national influenza and COVID-19 surveillance report.

Vaccine effectiveness

Large clinical trials have been undertaken for each of the COVID-19 vaccines approved in the UK which found that they are highly efficacious at preventing symptomatic disease in the populations that were studied. The clinical trials have been designed to be able to assess the efficacy of the vaccine against laboratory confirmed symptomatic disease with a relatively short follow up period so that effective vaccines can be introduced as rapidly as possible.

Post implementation real world vaccine effectiveness studies are needed to understand vaccine effectiveness against different outcomes (such as severe disease and onward transmission), effectiveness in different subgroups of the population and against different variants as well as to understand the duration of protection. Vaccine effectiveness is estimated by comparing rates of disease in vaccinated individuals to rates in unvaccinated individuals. Below we outline the latest real-world evidence on vaccine effectiveness from studies in UK populations. Where available we focus on data related to the Omicron variant which is currently dominant in the UK.

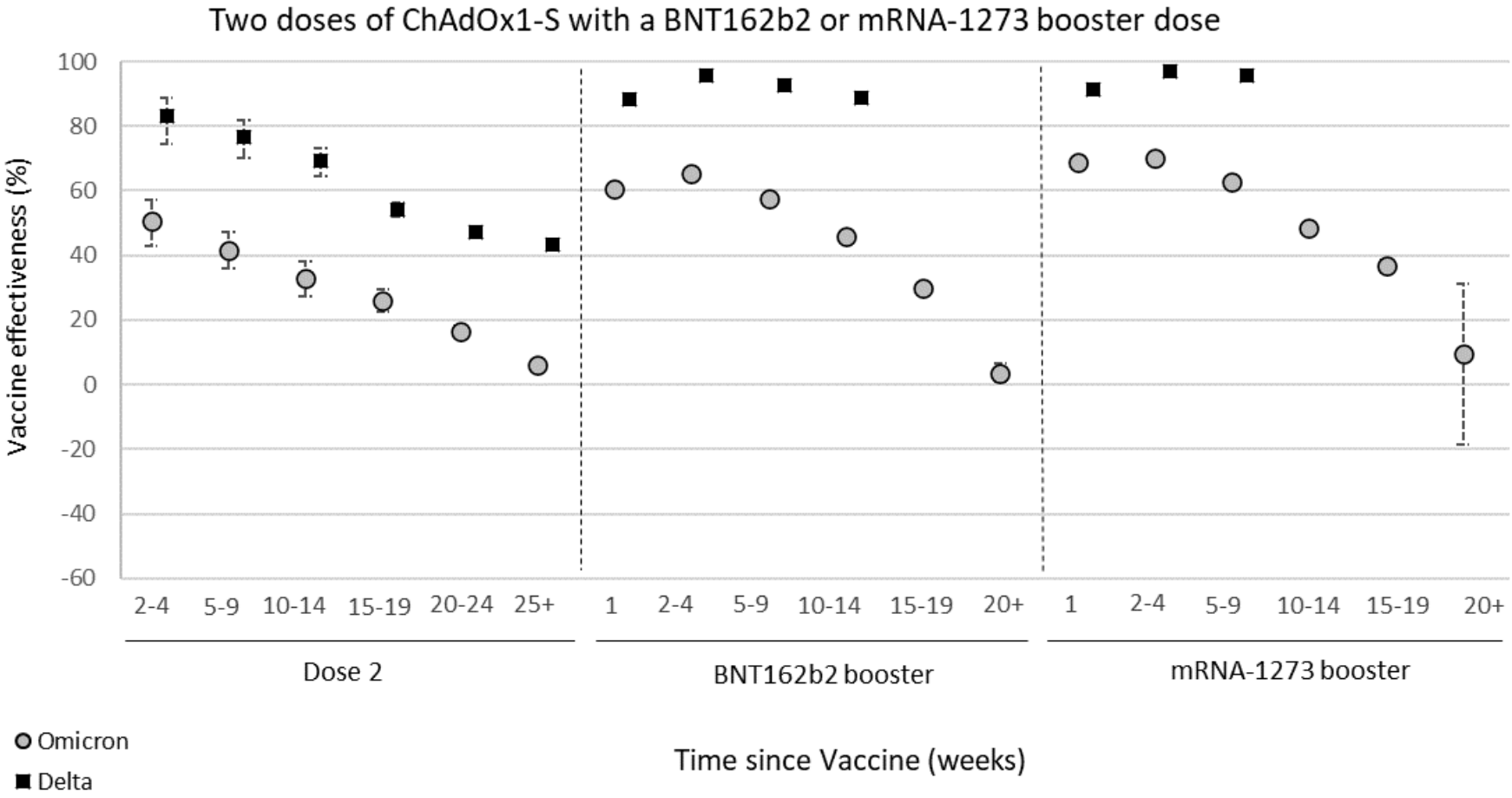
Please note that vaccine effectiveness data will be updated in this report as it becomes available.

Effectiveness against symptomatic disease

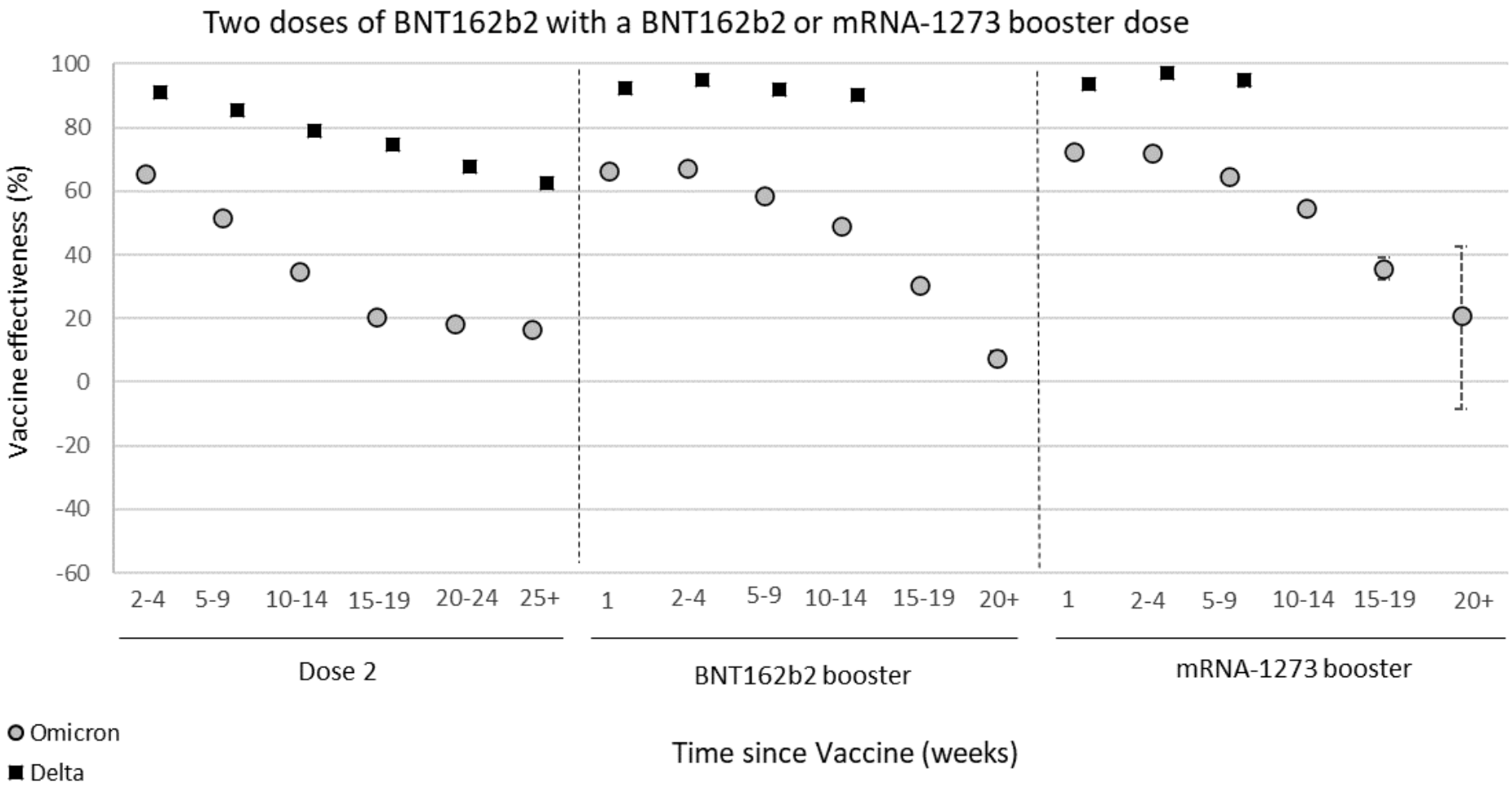
Vaccine effectiveness against symptomatic COVID-19 has been assessed in England based on community testing data linked to vaccination data from the National Immunisation Management System (NIMS), cohort studies such as the COVID-19 Infection Survey and GP electronic health record data. After 2 doses of the AstraZeneca vaccine, vaccine effectiveness against the Omicron variant starts at 45 to 50% then drops to almost no effect from 25 weeks after the second dose. With 2 doses of Pfizer or Moderna effectiveness dropped from around 65 to 70% down to around 15% by 25 weeks after the second dose. For 2 to 4 weeks after a booster dose of either the Pfizer or Moderna vaccine following an AstraZeneca or Pfizer primary course, effectiveness ranges from around 60 to 75%, dropping to almost no effect from 20+ weeks after the booster. Vaccine effectiveness estimates for the booster dose are very similar, irrespective of the primary course received (3). Vaccine effectiveness is generally slightly higher in younger compared to older age groups. After community testing for COVID-19 was reduced in April 2022, we are no longer able to assess vaccine effectiveness against symptomatic disease using this data. However, evidence suggests that effectiveness against symptomatic disease with subsequent sub-lineages of the Omicron variant is also low and wanes rapidly.

Figure 1. Vaccine effectiveness against symptomatic disease by period after the second and booster doses for Delta (black squares) and Omicron (grey circles) for a) recipients of 2 doses of AstraZeneca (ChAdOx1-S) vaccine as the primary course and Pfizer BioNTech (BNT162b2) or Moderna (mRNA-1273) as a booster; b) recipients of 2 doses of Pfizer vaccine as the primary course and Pfizer or Moderna as a booster and c) 2 doses of Moderna as a primary course and Pfizer or Moderna as a booster

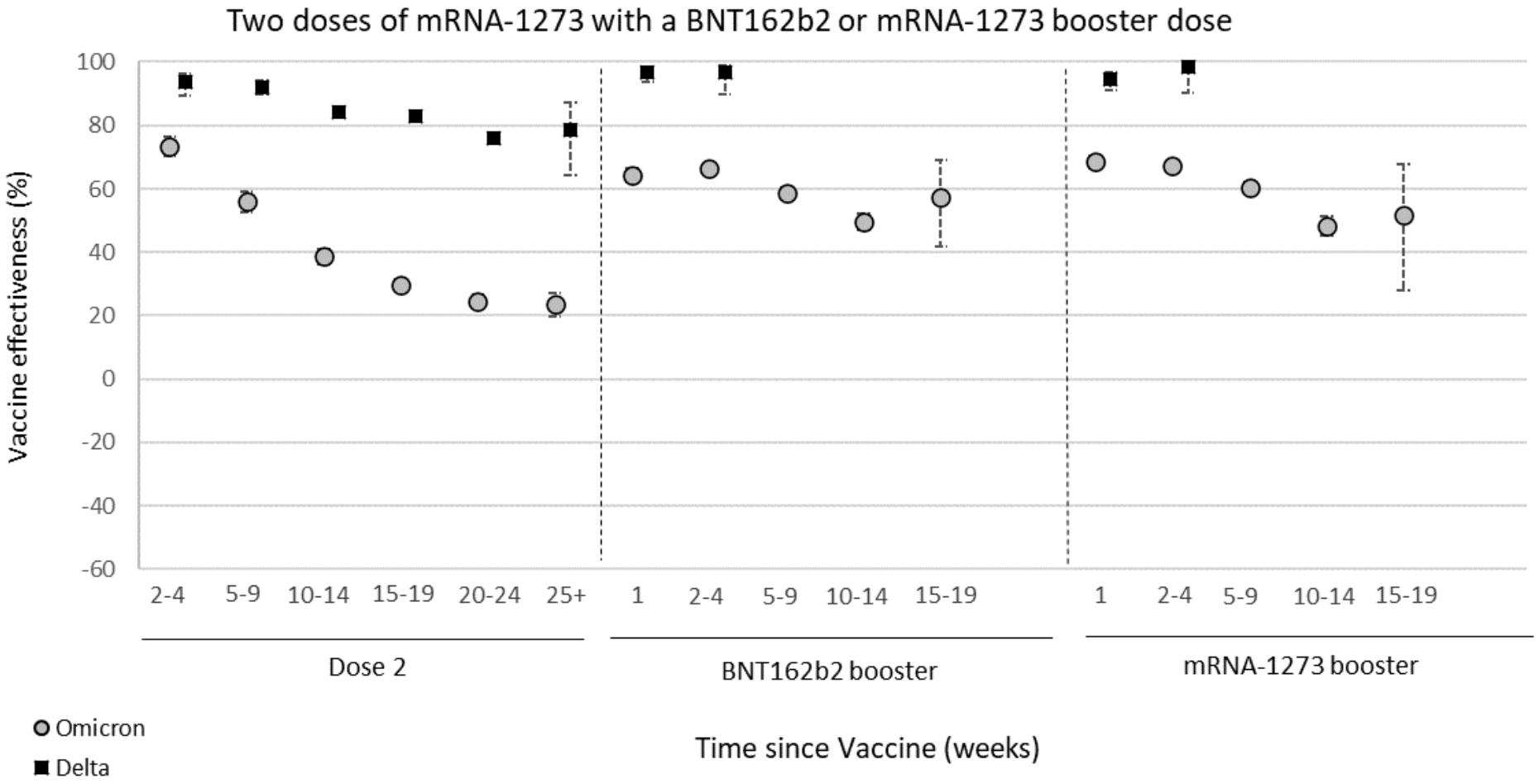
a)



b)


Two doses of BNT162b2 with a BNT162b2 or mRNA-1273 booster dose
Vaccine effectiveness (%)
100
80
60
40
20
0
-20
-40
-60
2-4
5-9
10-14
15-19
20-24
25+
1
2-4
5-9
10-14
15-19
20+
1
2-4
5-9
10-14
15-19
20+
Dose 2
BNT162b2 booster
mRNA-1273 booster
Omicron
Delta
Time since Vaccine (weeks)

c)


Two doses of mRNA-1273 with a BNT162b2 or mRNA-1273 booster dose
Vaccine effectiveness (%)
100
80
60
40
20
0
-20
-40
-60
2-4
5-9
10-14
15-19
20-24
25+
1
2-4
5-9
10-14
15-19
1
2-4
5-9
10-14
15-19
Dose 2
BNT162b2 booster
mRNA-1273 booster
Omicron
Delta
Time since Vaccine (weeks)

Data (based primarily on the Alpha and Delta variants) suggested that in most clinical risk groups, immune response to vaccination is maintained and high levels of VE are seen with both the Pfizer and AstraZeneca vaccines. Reduced antibody response and vaccine effectiveness were seen after one dose of the vaccine among the immunosuppressed group, however, after a second dose, the reduction in vaccine effectiveness is smaller (4). Analyses by dosing interval suggest that immune response to vaccination and vaccine effectiveness against symptomatic disease improves with a longer (greater than 6 week interval) compared to a shorter interval of 3 to 4 weeks (5).

In the UK, standard booster vaccination was either with Pfizer or Moderna regardless of the primary course received. However, a small number of individuals for whom vaccination with both Pfizer and Moderna were clinically contraindicated received the AstraZeneca vaccine.

Effectiveness against hospitalisation

Several studies have estimated vaccine effectiveness against hospitalisation, all of which indicate higher levels of protection against hospitalisation with all vaccines against the Alpha, Delta and Omicron variants (6 to 11). Given that Omicron generally causes milder disease than previous variants (12), in particular among younger individuals, an increasing proportion of individuals hospitalised with a positive COVID-19 test are likely to have COVID-19 as an incidental finding rather than the primary reason for admission (11). We have previously found that using broader definitions of hospitalisation has given lower vaccine effectiveness estimates, reflecting outcome misclassification where cases are likely coincidentally positive whilst in hospital, without this being the primary reason for admission (and therefore these cases cannot be prevented by vaccination). We, therefore, use stricter definitions to define a COVID-19 hospitalisation. Here, a COVID-19 hospitalisation is defined as requiring at least 2 days stay in the hospital and a respiratory code in the primary diagnostic field. To estimate effectiveness against more severe disease we also estimate effectiveness for those requiring oxygen, mechanical ventilation or ICU (Table 1). There are likely still some incidental admissions in our data, in particular among younger adults, which may explain the higher vaccine effectiveness against hospitalisation in 65+ year olds compared to 18 to 64 year olds (Table 1). There appears to be little variation in vaccine effectiveness against hospitalisation after a booster dose according to the type of vaccine used for priming or boost, or between BA.1, BA.2, BA.4 or BA.5 sub-lineages of Omicron (Figure 2).

Vaccine effectiveness against a range of hospitalisation outcomes with the Omicron variant has been estimated using a test-negative case control study design (Table 1,11). Among 18 to 64 year olds, VE after a booster peaked at 83.9% before dropping to 45.5% by 25 to 39 weeks after booster vaccination. VE against the most severe outcome measured (those on oxygen, ventilated or on intensive care) ranged from 92.4% down to 53.7% following a booster vaccine. Among those aged 65 years and older, VE against hospitalisation peaked at 89.5% before waning to 60.7% at 40 weeks or more after receiving a booster vaccine. Protection against hospitalisation requiring oxygen, ventilated or on intensive care ranged from 92.4% down to 66.8% for older adults (Table 1).

A minority of individuals in the UK who were clinically contradicted to receive mRNA vaccines were given AstraZeneca as a booster vaccine after a primary course of AstraZeneca. Amongst those aged 65 years and older, protection against hospitalisation (defined as requiring a stay of 2 or more days with severe respiratory disease) following Omicron infection was 82.3% after one or more weeks after receiving an AstraZeneca booster compared to 90.9% among those who received a Pfizer booster (6). Direct comparison of the AstraZeneca booster with the mRNA vaccines is challenging using data from the UK since those boosted with AstraZeneca were more likely to be in risk groups and from previous studies in the UK, we know that VE is lower in the clinically vulnerable populations (13). Nonetheless, this data provide reassuring evidence for the use of AstraZeneca as a booster for protection against severe disease with COVID-19.

Table 1. vaccine effectiveness against hospitalisation using different definitions of hospitalisations in a) 18 to 64 year olds and b) 65 year olds and over

		At least 2 days stay with a respiratory code in primary diagnosis field	At least 2 days stay with either oxygen, ventilation or ICU and a respiratory code in primary diagnosis field
18 to 64			
	Interval (weeks)	**VE**	**VE**
Dose 1	4+	31.7 (21.6 to 40.4)	59.8 (37.6 to 74.1)
Dose 2	2 to 14	69.5 (58.9 to 77.4)	58.2 (-19.5 to 85.4)
	15 to 24	54.8 (43.7 to 63.8)	61.9 (26.6 to 80.2)
	25 to 39	44.3 (37.1 to 50.7)	66.4 (52.2 to 76.4)
	40+	33.8 (25.2 to 41.4)	42.5 (13.3 to 61.9)
Booster	2 to 4	83.9 (80.4 to 86.8)	92.4 (86.4 to 95.8)
	5 to 9	81.2 (78.3 to 83.6)	91.4 (87.0 to 94.4)
	10 to 14	69.9 (65.9 to 73.4)	79.9 (71.0 to 86.1)
	15 to 19	57.8 (52.0 to 62.8)	67.5 (52.1 to 77.9)
	20 to 24	46.7 (38.9 to 53.4)	54.8 (32.0 to 70)
	25 to 39	45.5 (38.9 to 51.4)	53.7 (28.3 to 70.2)
	40+		
Over 65			
	Interval (weeks)	**VE**	**VE**
Dose 1	4+	47.1 (38.9 to 54.1)	52.6 (25.2 to 69.9)
Dose 2	2 to 14	80.2 (72.9 to 85.6)	86.1 (64.5 to 94.5)
	15 to 24	54.5 (41.1 to 64.8)	83.0 (63.7 to 92.1)
	25 to 39	50.5 (44.7 to 55.8)	60.0 (44.2 to 71.4)
	40+	53.7 (49.1 to 57.9)	65.0 (52.5 to 74.2)
Booster	2 to 4	89.5 (87.8 to 91.0)	92.4 (88.1 to 95.2)
	5 to 9	86.4 (85 to 87.6)	89.0 (85.5 to 91.7)
	10 to 14	83.0 (81.5 to 84.3)	87.0 (83.4 to 89.8)
	15 to 19	78.4 (76.6 to 80.1)	79.1 (73.3 to 83.7)
	20 to 24	71.4 (68.9 to 73.6)	73.0 (65.2 to 79.1)
	25 to 39	63.1 (60.1 to 66.0)	66.8 (57.2 to 74.3)
	40+	60.7 (53.7 to 66.6)	75.4 (47.7 to 88.4)

Effectiveness of the spring 2022 booster

Spring boosters with either Pfizer BioNTech or a half dose (50µg) of Moderna were offered to those at risk and those aged 75 years and older from March 2022. VE was estimated against hospitalisation using a strict definition (at least 2 days stay with a respiratory code in the primary diagnosis field). VE was estimated against the Omicron variant, all sub-lineages (BA.1, BA.2, BA.4 and BA.5) combined since we have not found a big difference in VE between sub-lineages. Since very few individuals remained unvaccinated, VE of the fourth dose was estimated as compared to those who had a waned third dose (25 to 39 weeks past receiving their third vaccine) (Table 2). The incremental VE for the fourth dose is therefore the level of protection that the fourth dose adds in addition to the remaining protection conferred by a third dose. These estimates, therefore, appear lower and are not directly comparable with estimates where VE is calculated relative to the unvaccinated. VE against hospitalisation was enhanced by a fourth dose; the incremental VE after 2 to 4 weeks was 58.8%. This waned to 10.8% at 20 or more weeks after receiving the fourth dose.

Table 2. Vaccine effectiveness against hospitalisation for fourth doses, estimated using those 25 to 39 weeks post their third dose as the baseline group

Dose	Interval (weeks)	Vaccine effectiveness (95% CI)
3	25 to 39 weeks	Baseline
	40+ weeks	-7.1 (-31.0 to 12.5)
4	0 to 6 days	46.5 (37.7 to 54.2)
	7 to 13 days	45.6 (36.4 to 53.4)
	2 to 4 weeks	58.8 (54.1 to 63.0)
	5 to 9 weeks	50.1 (45.6 to 54.2)
	10 to 14 weeks	35.9 (30.2 to 41.1)
	15 to 19 weeks	21.1 (11.6 to 29.5)
	20+ weeks	10.8 (-6.2 to 25.1)

Effectiveness of the autumn 2022 bivalent booster

Bivalent boosters with either Pfizer BioNTech (Original/Omicron BA.1 Comirnaty®) or a Moderna bivalent (Spikevax® bivalent Original/Omicron vaccine) targeting both the ancestral strain and Omicron BA.1 were offered to those in clinical risk groups and those aged 50 years and older from September 2022. VE of the bivalent boosters was estimated against hospitalisation in the period following 5 September 2022 against all Omicron sub-lineages in circulation at the time. Only individuals who had received at least 2 COVID-19 vaccines before 5 September 2022 and with the last of these doses at least 6 months prior to sample date were included in analysis. The effectiveness measured is therefore incremental effectiveness on top of at least 6 months waned protection. The incremental protection conferred by the bivalent

vaccines estimated relative to those with waned immunity was 54% (95% C.I.: 47 to 59%) after 2 weeks, and 53% (95% C.I.: 36 to 66%) after 10 or more weeks.

Table 3. Vaccine effectiveness of the bivalent booster vaccines against hospitalisation in those aged 50 years and older (all vaccine brands combined). VE = vaccine effectiveness, CI = confidence intervals.

Interval after booster dose	Cases	Controls	Odds ratio	VE (95% CI)
2 to 4 weeks	400	1865	0.46 (0.41 to 0.53)	53.5 (47.4 to 59)
5 to 9 weeks	395	2809	0.46 (0.41 to 0.53)	53.8 (47.3 to 59.4)
10+ weeks	54	458	0.47 (0.35 to 0.64)	52.8 (35.6 to 65.5)

Effectiveness against mortality

High levels of protection (over 90%) are also seen against mortality with all 3 vaccines and against both the Alpha and Delta variants with relatively limited waning (7, 14 and 15). Vaccine effectiveness against mortality with the Omicron variant has been estimated for those aged 50 years and older using a test-negative case control study design (all vaccines combined) (Table 4). At 25-plus weeks following the second dose, vaccine effectiveness was around 50%. At 2 or more weeks following booster vaccination, effectiveness was 93.6% against mortality while at 10 or more weeks VE was 87.6%. This analysis is also likely to include some incidental deaths of individuals who died with COVID-19 as opposed to from COVID-19, and we suspect the true VE against mortality is likely higher than the estimates presented here.

Table 4. Vaccine effectiveness against mortality in those aged 50 years and older (all vaccine brands combined). VE = vaccine effectiveness, CI = confidence intervals.

Dose	Interval after dose	Odds ratio	VE (95% CI)
2	40+ weeks	0.48 (0.41 to 0.56)	52.3 (44.5 to 59)
3	2 to 4 weeks	0.15 (0.12 to 0.18)	85.3 (81.5 to 88.3)
3	5 to 9 weeks	0.17 (0.15 to 0.2)	82.9 (80.2 to 85.3)
3	10 to 14 weeks	0.21 (0.18 to 0.24)	79.2 (76.4 to 81.7)
3	15 to 19 weeks	0.25 (0.22 to 0.28)	75.3 (71.9 to 78.2)
3	20 to 24 weeks	0.32 (0.28 to 0.37)	67.7 (63.1 to 71.7)
3	25 to 39 weeks	0.37 (0.32 to 0.43)	63.0 (57.4 to 67.8)

Effectiveness against infection

Although individuals may not develop symptoms of COVID-19 after vaccination, it is possible that they could still be infected with the virus and could transmit it to others. Understanding how effective vaccines are at preventing infection is therefore important to predict the likely impact of the vaccination programme on the wider population. In order to estimate vaccine effectiveness against infection, repeat asymptomatic testing of a defined cohort of individuals is required. Studies have now reported on vaccine effectiveness against infection in healthcare workers, care home residents and the general population with the Alpha and Delta variants (16 to 19). Generally, estimates are similar to or slightly lower than vaccine effectiveness estimates against symptomatic disease and there is evidence of a significant waning in protection against infection over time. Estimates for vaccine effectiveness against infection with the Omicron variant are not yet available.

Effectiveness against transmission

As described above, several studies have provided evidence that vaccines are effective at preventing infection. Uninfected individuals cannot transmit. Therefore, the vaccines also provide some protection against transmission. There may be an additional benefit, beyond that due to prevention of infection, if some of those individuals who become infected despite vaccination are also at a reduced risk of transmitting (for example, because of reduced duration or level of viral shedding). Several studies have provided evidence of reduced risk of household transmission from vaccinated cases compared to unvaccinated cases (20 to 24).

Consensus vaccine effectiveness estimates

Table 5 summarises consensus estimates of vaccine effectiveness against different outcomes that have been reached by the UK Vaccine Effectiveness Expert Panel. These take into account estimates from UK studies by public health agencies and academic groups as well as international data. Table 5a summarises consensus VE estimates compared to unvaccinated individuals. Please note that Table 5b summarises consensus incremental VE estimates of a fourth dose of a COVID-19 vaccine (Pfizer or Moderna) compared to 6 months or more since a third dose. This differs from Table 5a which compares to unvaccinated individuals so data should be interpreted with this in mind.

Table 5a. Consensus estimates of vaccine effectiveness against BA.1 or BA.2 Omicron for 2 doses and 3 doses of COVID-19 vaccine compared to unvaccinated individuals

Vaccine product for primary course	Outcome	Second dose: 0 to 3 months	Second dose: 4 to 6 months	Second dose: 6 to 8 months	Second dose: 9+ months	Booster dose: All periods	Booster dose: 0 to 3 months	Booster dose: 4 to 6 months	Booster dose: 6 to 8 months	Booster dose: 9+ months
AstraZeneca	**All infection**	30% (20 to 40%)	0 to 30% (range only)	0% (0 to 10%)	Insufficient data	See individual periods	40% (30 to 50%)	20% (10 to 30%)	0% (0 to 10%)	0% (0 to 10%)
	Symptomatic	40% (30 to 50%)	20% (5 to 30%)	5% (0 to 5%)	Insufficient data	See individual periods	60% (50 to 70%)	40% (30 to 50%)	10% (0 to 20%)	0% (0 to 10%)
	Hospitalisation	80% (70 to 90%)	55% (45 to 70%)	50% (40 to 65%)	Insufficient data	See individual periods	90% (85 to 95%)	85% (85 to 95%)	60% (40 to 75%)	Insufficient data
	Mortality	80% (70 to 95%)	60% (50 to 80%)	50% (40 to 70%)	Insufficient data	See individual periods	85% (70 to 95%)	75% (65 to 90%)	60% (50 to 80%)	Insufficient data
	Transmission	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Moderna	**All infection**	30% (20 to 40%)	0 to 30% (range only)	30% (10 to 50%)	Insufficient data	See individual periods	40% (30 to 50%)	20% (10 to 30%)	0% (0 to 10%)	0% (0 to 10%)
	Symptomatic	55% (35 to 75%)	30% (15 to 35%)	15% (10 to 20%)	Insufficient data	See individual periods	65% (55 to 75%)	40% (30 to 50%)	10% (0 to 20%)	0% (0 to 10%)
	Hospitalisation	80% (70 to 90%)	55% (45 to 70%)	50% (40 to 65%)	50% (40 to 60%)	See individual periods	85 to 95% (range only)	Insufficient data	60% (40 to 75%)	60% (40 to 75%)
	Mortality	80% (70 to 95%)	60% (50 to 80%)	50% (40 to 70%)	Insufficient data	Insufficient data	85% (70 to 95%)	75% (65 to 90%)	60% (50 to 80%)	Insufficient data
	Transmission	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Pfizer	**All infection**	30% (20 to 40%)	0 to 30% (range only)	20% (10 to 30%)	Insufficient data	See individual periods	40% (30 to 50%)	20% (10 to 30%)	0% (0 to 10%)	0% (0 to 10%)
	Symptomatic	50% (30 to 65%)	20% (15 to 30%)	15% (10 to 15%)	Insufficient data	See individual periods	65% (55 to 75%)	45% (35 to 55%)	10% (0 to 20%)	0% (0 to 10%)
	Hospitalisation	80% (70 to 90%)	55% (45 to 70%)	50% (40 to 65%)	50% (40 to 60%)	See individual periods	90% (85 to 95%)	85% (85 to 95%)	60% (40 to 75%)	60% (40 to 75%)
	Mortality	80% (70 to 95%)	60% (50 to 80%)	50% (40 to 70%)	Insufficient data	See individual periods	85% (70 to 95%)	75% (65 to 90%)	60% (50 to 80%)	Insufficient data
	Transmission	Insufficient data	Insufficient data	Insufficient data	Insufficient data	0 to 25% (range only)	Insufficient data	Insufficient data	Insufficient data	Insufficient data

Booster data is based on use of the Moderna or Pfizer vaccines as a booster.
This table provides overall estimates but there may be variation by age group or other clinical or demographic factors.

Table 5b. Consensus estimates of relative vaccine effectiveness against BA.1 or BA.2 Omicron for a fourth dose of COVID-19 vaccine compared to 6+ months since the third dose*

Vaccine product of fourth dose (second booster)	Outcome	Fourth dose: all periods	Fourth dose: 0 to 3 months	Fourth dose: 4 to 6 months	Fourth dose: 6+ months
Any*	**All infection**	Insufficient data	40% (30 to 50%)	10% (0 to 30%)	0% (0 to 10%)
Any*	**Symptomatic**	Insufficient data	40% (30 to 50%)	10% (0 to 30%)	Insufficient data
Any*	**Hospitalisation**	Insufficient data	50% (40 to 60%)	25% (15 to 35%)	Insufficient data
Any*	**Mortality**	Insufficient data	Insufficient data	Insufficient data	Insufficient data

* Note: This table is relative VE of fourth doses against 6+ months since the third dose.
** Any refers to Pfizer or Moderna only.

High confidence	Evidence from multiple studies which is consistent and comprehensive
Medium confidence	Evidence is emerging from a limited number of studies or with a moderately level of uncertainty
Low confidence	Little evidence is available at present and results are inconclusive

Effectiveness against BA.4 and BA.5

The Omicron sub-lineages BA.4 and BA.5 were designated Variants of Concern (VOC) on 18 May 2022 and are now dominant in the UK (25). Modelling shows that BA.4 and BA.5 demonstrate a growth advantage over BA.2. Vaccine effectiveness against symptomatic disease following BA.2 infection is reported elsewhere (23).

A test-negative case-control (TNCC) study design to investigate VE against hospitalisation for BA.4, BA.5 and BA.2 (Figure 2). Incremental VE was estimated in those vaccinated with either a third or fourth dose as compared to individuals with waned immunity who had received their second dose at least 25 weeks prior.

There was no evidence of reduced VE against hospitalisation for BA.4 or BA.5 as compared to BA.2 (Figure 2). In those who had received their third or fourth dose 2 to 14 weeks ago, the incremental VE as compared to those who were 25 or more weeks post their second dose was 60.9% (95% C.I.; 42.2 to 73.5%) and 62.1% (95% C.I.; 54.4 to 68.4%) for BA.4 and BA.5, respectively, and 50.1% (95% C.I.; 40.7 to 58.0%) for BA.2 (Figure 2). Incremental VE waned to 16.2% (95% C.I.; -18.7 to 40.9%), 23.8% (95% C.I.; 9.8 to 35.6%) and 9.0% (95% C.I.; -6.8 to 22.4%) for BA.4, BA.5 and BA.2 at 25 or more weeks.

Effectiveness against BA.4.6

BA.4.6 is a sub-lineage of Omicron BA.4, first identified as part of horizon scanning in August 2022. We estimated VE of BA.4.6 as compared to BA.4 (excluding BA.4.6) and BA.5 together since we previously found there was no difference in the effectiveness of the vaccines against hospitalisation with BA.4 and BA.5 (Figure 2). As before, incremental VE was estimated in those vaccinated with either a third or fourth dose as compared to individuals with waned immunity who had received their second dose at least 25 weeks prior. Overall, there was no evidence of reduced VE against hospitalisation for BA.4.6 as compared to other BA.4 or BA.5 sub-lineages (Figure 3).

Figure 2. Incremental VE against hospitalisation with BA.4, BA.5 and BA.2 in England, estimated using individuals who received a second dose at least 25 weeks prior as the baseline

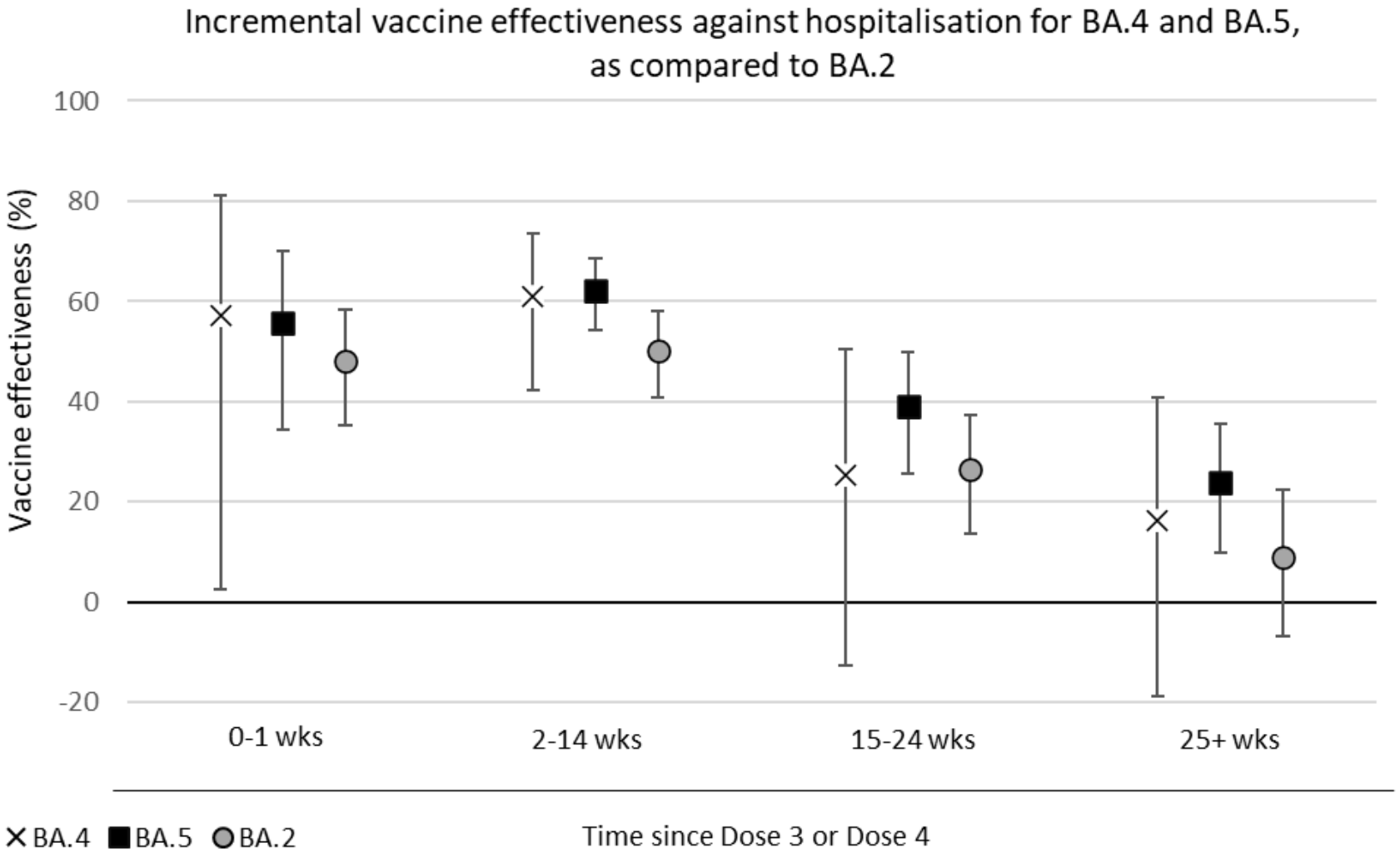
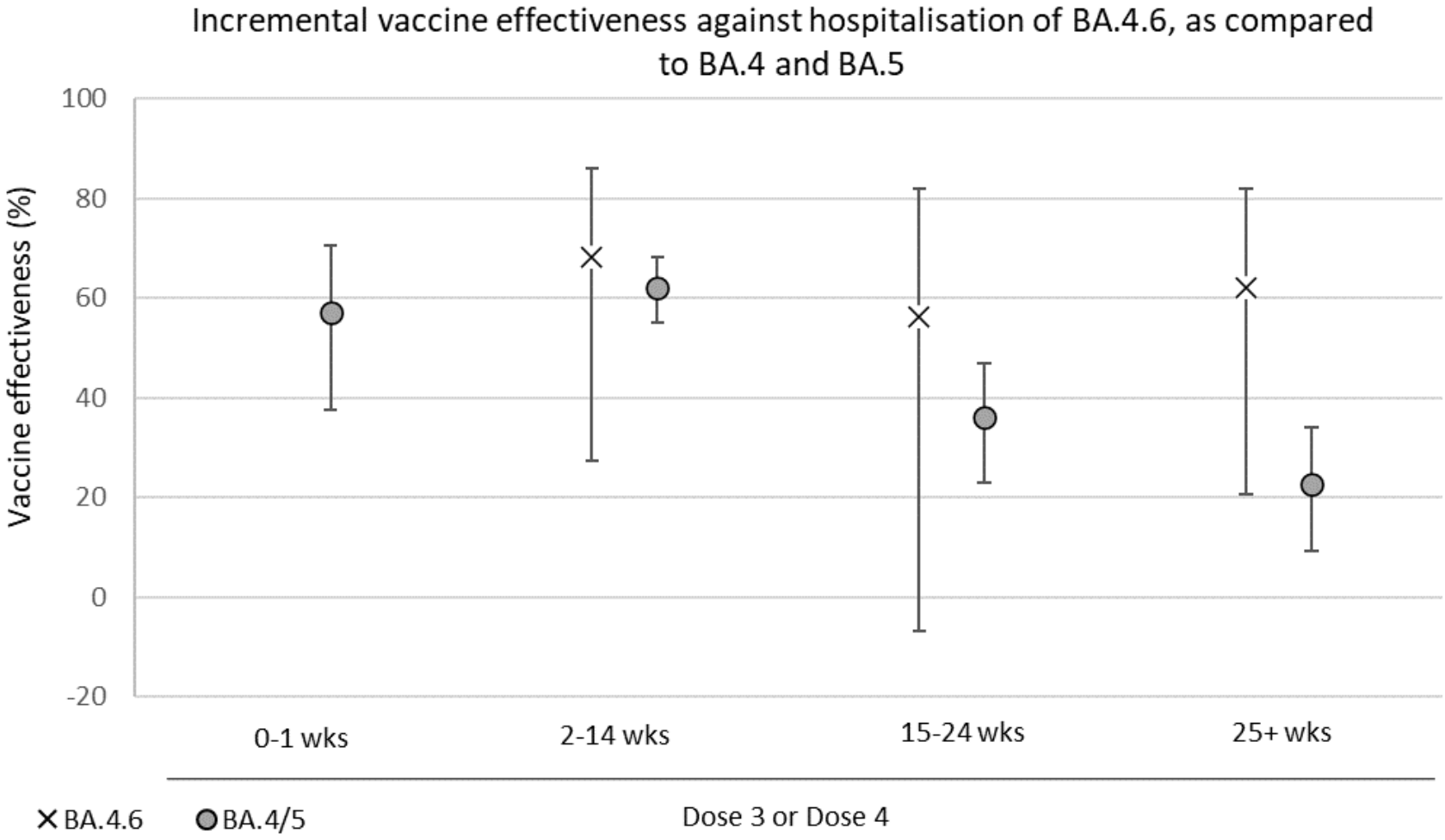


Figure 3. Incremental VE against hospitalisation with BA.4.6 and BA.4/5 in England, estimated using individuals who received a second dose at least 25 weeks prior as the baseline



Vaccine effectiveness publications

UKHSA and collaborators have published a significant amount of research into vaccine effectiveness, which is summarised on pages 4 to 19. The publications listed in Table 6 provide further results and details on the methods used.

Table 6. UKHSA publications on the effectiveness of COVID-19 vaccination

Publication	Subject
Effectiveness of the COVID-19 vaccines against severe disease with Omicron sub-lineages BA.4 and BA.5 in England	The latest evidence shows that vaccine effectiveness against hospitalisation is similar for the BA.4/5 variants as it is for BA.2. In somebody who received their second dose around 6 months previously, a booster dose increases protection against hospitalisation by 50 to 60%. This is the most comprehensive analysis of vaccine effectiveness against hospitalisation for BA.4/5 undertaken to date.
Effectiveness of AstraZeneca COVID-19 booster vaccination against the Omicron and Delta variants	This study estimates the effectiveness of booster vaccination with AstraZeneca against symptomatic disease and hospitalisation in individuals who were not able to receive mRNA vaccines in the UK.
COVID-19 Vaccine Effectiveness against the Omicron BA.2 variant in England	This study estimates the effectiveness of booster vaccination against symptomatic disease caused by the BA.2 sub-lineage of the Omicron (B.1.1.529) variant.
Vaccine effectiveness against hospitalisation with the Omicron variant	This study estimates vaccine effectiveness against hospitalisation with the Omicron variant and investigates the impact of using different hospitalisation outcome definitions
Effectiveness of COVID-19 vaccines against hospitalisation with the Omicron variant in adults aged 75 years and older	This study reports on vaccine effectiveness against hospitalisation with the Omicron variant in adults aged 75 years and older.
Effectiveness of BNT162b2 and ChAdOx1 against SARS-CoV-2 household transmission: a prospective cohort study in England	This study reports on vaccine effectiveness against transmission of COVID-19 with the Alpha and Delta variants.
Effectiveness of 3 doses of COVID-19 vaccines against symptomatic COVID-19 and hospitalisation in adults aged 65 years and older	Updated analysis on the effectiveness of 3 doses of COVID-19 vaccines against symptomatic COVID-19 and hospitalisation in adults aged 65 years and older.

Publication	Subject
Effectiveness of BNT162b2 COVID-19 booster vaccine against COVID-19 related symptoms and hospitalisation in England	This study provides real world evidence of significantly increased protection from the booster vaccine dose against symptomatic disease and hospitalisation irrespective of the primary course.
Effectiveness of COVID-19 vaccines against the Omicron (B.1.1.529) variant of concern	This study reports on the vaccine effectiveness against symptomatic disease with 2 dose courses of BNT1622 and ChAdOx1-S as well as booster doses of BNT162b2 following a primary course of either BNT1622 or ChAdOx1-S.
Effectiveness of BNT162b2 (Comirnaty, Pfizer-BioNTech) COVID-19 booster vaccine against COVID-19 related symptoms in England: test negative case-control study	Results from the first UK real-world study by UKHSA show significantly increased protection against symptomatic disease from a booster dose of the Pfizer-BioNTech vaccine in those aged 50 years and older.
Duration of Protection against Mild and Severe Disease by COVID-19 Vaccines	This study reports on the vaccine effectiveness and duration of protection of Comirnaty, Vaxzevria and Spikevax against mild and severe COVID-19 in the UK.
Serological responses and vaccine effectiveness for extended COVID-19 vaccine schedules in England	This study investigates the impact of different dosing schedules on immune response and vaccine effectiveness.
Pfizer-BioNTech and Oxford AstraZeneca COVID-19 vaccine effectiveness and immune response among individuals in clinical risk groups	This study reports on the immune response and clinical effectiveness of COVID-19 vaccine among individuals in clinical risk groups. A supplementary appendix is also available to download.
Effectiveness of COVID-19 vaccines against hospital admission with the Delta (B.1.617.2) variant	This study reports on the effectiveness of COVID-19 vaccines on hospitalisation disease with the Delta variant. A supplementary appendix is also available to download.
Effectiveness of COVID-19 Vaccines against the B.1.617.2 (Delta) Variant	This study reports on the effectiveness of COVID-19 vaccines on symptomatic disease with the Delta variant.
Effectiveness of BNT162b2 mRNA and ChAdOx1 adenovirus vector COVID-19 vaccines on risk of hospitalisation among older	A study using the SARI watch surveillance system of COVID-19 hospitalisations found high levels of protection against

Publication	Subject
adults in England: an observational study using surveillance data	hospitalisation after both a single dose and 2 doses of COVID-19 vaccines.
Effectiveness of BNT162b2 mRNA vaccine and ChAdOx1 adenovirus vector vaccine on mortality following COVID-19	A study on deaths with COVID-19 indicates that COVID-19 vaccines offer high levels of protection against mortality.
Effect of Vaccination on Household Transmission of SARS-CoV-2 in England	Impact of vaccination on household transmission of SARS-COV-2 in England is an analysis to determine whether individuals who have received vaccine, but still become infected with SARS-COV-2 up to 60 days after the first dose, are less likely than unvaccinated cases to transmit to their unvaccinated household contacts.
Vaccine effectiveness of the first dose of ChAdOx1 nCoV-19 and BNT162b2 against SARS-CoV-2 infection in residents of Long-Term Care Facilities (VIVALDI study)	The VIVALDI study found evidence that COVID-19 vaccines were associated with a substantially reduced risk of infection in care home residents.
Effectiveness of BNT162b2 and ChAdOx1 nCoV-19 COVID-19 vaccination at preventing hospitalisations in people aged at least 80 years: a test-negative, case-control study	The Avon CAP study, conducted in 2 hospitals in Bristol, found evidence of high levels of protection against hospitalisation in 80+ year olds with a single dose of either vaccine.
COVID-19 vaccine coverage in health-care workers in England and effectiveness of BNT162b2 mRNA vaccine against infection (SIREN): a prospective, multicentre, cohort study	Early data from UKHSA's SIREN study shows a promising impact on infection in healthcare workers aged under 65. Healthcare workers in the study are tested for COVID-19 every 2 weeks – whether or not they have symptoms.
Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on COVID-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study	Early data from routine COVID-19 testing in older adults shows that vaccines are effective at preventing COVID-19 disease and severe outcomes.
Impact of COVID-19 vaccination programme on seroprevalence in blood donors in England, 2021	Report on the impact of COVID-19 vaccination programme on seroprevalence in blood donors in England, 2021.

Population impact

Vaccines typically have both direct effects on those who are vaccinated and indirect effects on the wider population due to a reduced probability that people will come into contact with an infected individual. The overall impact of the vaccination programme may therefore extend beyond that estimated through vaccine effectiveness analysis.

Estimating the impact of a vaccination programme is challenging as there is no completely unaffected control group. Furthermore, the effects of the vaccination programme need to be differentiated from that of other interventions (for example, lockdowns or outbreak control measures), changes in behaviour and any seasonal variation in COVID-19 activity.

UKHSA and other government and academic partners monitor the impact of the of the vaccination programme on levels of COVID-19 antibodies in the population and different disease indicators, including hospitalisations and mortality. This is done through population-based testing and through modelling which combines vaccine coverage rates in different populations, estimates of vaccine effectiveness and disease surveillance indicators.

Vaccine coverage

Please note that data on vaccine coverage is now available weekly in the national flu and COVID-19 surveillance report.

Vaccination in pregnancy

Vaccination of pregnant women alongside their peers is recommended in the UK and other countries as an important way to protect pregnant women and their unborn children against COVID-19 disease. Vaccination of pregnant women is strongly recommended by the Royal College of Obstetricians and Gynaecologists and the Royal College of Midwives.

Increased severity of COVID-19 disease in pregnant and recently pregnant women was reported after the first SARS-CoV-2 wave in England (26, 27) and in Scotland (28,29). It is not yet clear what impact the currently circulating Omicron strains may have had, although disease is generally reported to be milder during the Omicron period with reduced risk of complications in pregnant women when compared to the Delta period (30, 31). Omicron has also been associated with higher rates of infection in pregnant women when compared to Delta (31). Pregnant women who develop severe disease have increased rates of admission to ICU, need for invasive ventilation and pre-term delivery. Data from the US Centers for Disease Control and Prevention (CDC) found that pregnant women were around 3 times more likely to be admitted to ICU and nearly 3 times more likely to require invasive ventilation compared to non-pregnant women with COVID-19 disease and 25% more likely to die (32).

From 16 April 2021, the Joint Committee on Vaccination and Immunisation (JCVI) advised that pregnant women be offered COVID-19 vaccines at the same time as people of the same age or risk group (33). Therefore, any pregnant women not in a high-risk group would likely have received their first dose from mid-April 2021 as part of the general adult population programme in those aged under 50 years. This was offered by decreasing age group (33). As part of the ongoing review of the programme, the JCVI met on 2 December 2021 and considered further data on severity of SARS-CoV-2 infection in pregnant women and their pregnancies together with data on vaccine safety. As a result, pregnant women were added to the UK's priority COVID-19 vaccine list (34). The booster dose, made available to all individuals with severe immunosuppression from September 2021 and then extended to all eligible adults in England from 30 November 2021, is important to confer high levels of protection against Omicron strains (see report section Vaccine effectiveness). Pregnant women are included as one of the priority groups to be offered the Autumn 2022 COVID-19 booster dose.

Prior to 16 April 2021, COVID-19 vaccine was delivered to priority groups, based on clinical risk and risk of exposure, and delivered in order of priority. On 22 December 2020, JCVI advised that vaccine could be offered to pregnant and breast-feeding women who were in these risk categories. The Pfizer vaccine was rolled out from early December 2020, AstraZeneca vaccine was used from 4 January 2021 and the Moderna vaccine became available from April 2021. From 17 April 2021 pregnant women have been offered the Pfizer-BioNTech or Moderna (mRNA) vaccines where available for their first dose due to reassuring global safety data (35).

There is evidence of high levels of protection against SARS-CoV-2 infection in pregnant women after COVID-19 vaccination (36 to 38) and evidence that vaccination induces higher antibody levels than after disease (38). There is also evidence from a recent US study that 2-doses of mRNA COVID-19 vaccination during pregnancy might help prevent COVID-19 hospitalisations in young infants under 6 months of age (39). Between February and September 2021, 0.4% of 1,714 pregnant women with COVID-19 symptoms who required hospital treatment in the UK had received 2 doses of COVID-19 vaccine and, of 235 pregnant women who were admitted to intensive care with COVID-19 disease in that period, none had received 2 doses of vaccine (40). Similar findings have been reported from Scotland with the report that 90.9% (748 out of 823; 95% CI 88.7−92.7) of SARS-CoV-2 associated with hospital admission, 98% (102 out of 104; 95% CI 92.5−99.7) of SARS-CoV-2 associated with critical care admission and all baby deaths, occurred in pregnant women who were unvaccinated at the time of their COVID-19 diagnosis (29, 41). The researchers also found a higher extended perinatal mortality rate for women who gave birth within 28 days of a COVID-19 diagnosis compared to rates across the pandemic period and in women vaccinated and going on to give birth within 28 days.

COVID-19 vaccines used in the UK programme do not contain live SARS-CoV-2 virus and therefore cannot infect a pregnant woman or her unborn child with the virus. Whilst as is commonly the case in trials of medicinal products, pregnant women were excluded from the original COVID-19 vaccine trials, there is accumulating experience and evidence of the safe and effective use of mRNA vaccines (such as the Pfizer-BioNTech or Moderna) in pregnant women. In Scotland, COVID-19 vaccine had been administered to more than 30,000 pregnant women to the end of March 2022 (28). In the USA data collected by the US Centre for Disease Control

indicated that around 71% of pregnant people were fully vaccinated before or during pregnancy in week ending 20 August 2022 (42).

No safety concerns relating to COVID-19 vaccination of pregnant women have been found in published studies to date (42 to 46). The rate of vaccine side-effects appears to be similar in pregnant and non-pregnant populations (42). Studies from Norway, the USA and Scotland have found no association between COVID-19 vaccination and risk of miscarriage (44 to 47).

This report presents data on vaccine coverage and outcomes for women delivering up to the end of June 2022 and updates the early data on COVID-19 vaccination in pregnant women published in the COVID-19 vaccine surveillance report – weeks 47 of 2021, 4, 8, 12, 16, 19 and 35 of 2022. Findings continue to be provisional and are not directly comparable between reports as data is updated through the complete time period under consideration.

Vaccine coverage

COVID-19 vaccine coverage in women before they give birth has increased as more women have become eligible for vaccination. In November 2021, 48.7% of women giving birth had received at least one dose of vaccine before they delivered. This increased to 53.7% of women who gave birth in December 2021, to 65.9% of women by February 2022 and has stabilised at approximately 73% from May 2022. Of women who gave birth in December 2021, 43.4% had received 2 doses of the vaccine before they gave birth increasing to 57.9% of women giving birth in February 2022 and 67.3% of women who gave birth in June 2022 (see Table 7).

In the 18 month period between January 2021 and June 2022, a total of 755,030 women gave birth with linked records on vaccination status for 752,252 (99.6%) of them. Of all women who gave birth over this period, 258,639 (34.3%) were known to have received at least one dose of COVID-19 vaccine prior to delivery, 208,993 (27.7%) received at least 2 doses and 83,433 (11.1%) women had received at least 3 doses but not all would have been eligible during their pregnancy.

There were 121,726 women who received their first dose prior to pregnancy and went on to conceive and deliver by June 2022. There were 61,787 women who received at least one dose in the first trimester, 89,949 women received at least one dose in the second and 71,390 received at least one dose in the third trimester (women may be vaccinated in more than one trimester). In addition, 45,663 women were known to have received dose one before giving birth but without enough information to establish which trimester. Of these women, 26,401 were known to have received this dose in pregnancy, and 19,262 around the start of pregnancy.

Of all vaccinated women giving birth, 155,563 had received one or more doses of Pfizer vaccine only; 9,270 one or more doses of only Moderna; 18,509 one or more doses of only AstraZeneca. The remaining 75,297 vaccinated women with known vaccine manufacturer received a mixture of doses: 39,568 received a combination of Pfizer and Moderna and 35,693 received AstraZeneca with Pfizer or Moderna.

Table 7. Overall vaccine coverage in women giving birth, by month of delivery[1]

Month	Women giving birth	One or more doses by time of delivery	Two or more doses by time of delivery	Unvaccinated at delivery	Unvaccinated who went on to receive doses after pregnancy to 26 August 2022
January 2021	41,949	18 (0.0%)	1 (0.0%)	41,774 (99.6%)	32,271 (77.3%)
February 2021	40,093	83 (0.2%)	0 (0.0%)	39,882 (99.5%)	30,833 (77.3%)
March 2021	44,589	296 (0.7%)	25 (0.1%)	44,173 (99.1%)	33,931 (76.8%)
April 2021	42,467	493 (1.2%)	93 (0.2%)	41,825 (98.5%)	31,850 (76.2%)
May 2021	43,964	1,261 (2.9%)	309 (0.7%)	42,542 (96.8%)	31,625 (74.3%)
June 2021	43,723	4,369 (10.0%)	656 (1.5%)	39,219 (89.7%)	27,832 (71.0%)
July 2021	47,393	7,717 (16.3%)	2,203 (4.6%)	39,497 (83.3%)	26,493 (67.1%)
August 2021	46,149	10,486 (22.7%)	6,129 (13.3%)	35,488 (76.9%)	22,208 (62.6%)
September 2021	46,710	15,101 (32.3%)	10,519 (22.5%)	31,433 (67.3%)	17,992 (57.2%)
October 2021	46,196	19,211 (41.6%)	14,655 (31.7%)	26,801 (58.0%)	13,689 (51.1%)
November 2021	42,917	20,896 (48.7%)	16,482 (38.4%)	21,860 (50.9%)	8,864 (40.5%)
December 2021	41,578	22,372 (53.8%)	18,048 (43.4%)	19,033 (45.8%)	5,634 (29.6%)
January 2022	39,331	23,449 (59.6%)	19,971 (50.8%)	15,739 (40.0%)	2,776 (17.6%)
February 2022	36,348	23,938 (65.9%)	21,043 (57.9%)	12,254 (33.7%)	1221 (10.0%)
March 2022	38,702	26,936 (69.6%)	23,957 (61.9%)	11,625 (30.0%)	611 (5.3%)
April 2022	37,539	26,961 (71.8%)	24,324 (64.8%)	10,426 (27.8%)	330 (3.2%)
May 2022	38,345	28,023 (73.1%)	25,645 (66.9%)	10,187 (26.6%)	199 (2.0%)
June 2022	37,037	27,029 (73.0%)	24,933 (67.3%)	9,855 (26.6%)	96 (1.0%)

[1] 2,778 women could not be matched with a NIMS record. Their vaccine status is therefore unknown and they are excluded from these coverage figures.

Table 8. Vaccine coverage by ethnicity, for women giving birth April to June 2022 (latest 3 months)[2]

Ethnicity	Women giving birth in April to June 2022	One or more doses by time of delivery	Two or more doses by time of delivery	Unvaccinated at delivery	Unvaccinated who went on to receive doses after pregnancy to 25 August 2022
Asian	15,229	11,627 (76.3%)	10,315 (67.7%)	3,602 (23.7%)	242 (6.7%)
Black	5,909	2,999 (50.8%)	2,496 (42.2%)	2,910 (49.2%)	72 (2.5%)
Mixed	2,824	1,656 (58.6%)	1,478 (52.3%)	1,168 (41.4%)	17 (1.5%)
Other	4,843	3,062 (63.2%)	2,717 (56.1%)	1,781 (36.8%)	35 (2.0%)
White	79,459	59,868 (75.3%)	55,333 (69.6%)	19,591 (24.7%)	235 (1.2%)
Unknown	4,657	2,801 (60.1%)	2,563 (55.0%)	1,416 (30.4%)	24 (1.7%)

Table 9. Vaccine coverage by quintile of deprivation of the small area in which the woman lived, for women giving birth April to June 2022 (latest 3 months)[3]

Quintile of deprivation	Women giving birth in April to June 2022	One or more doses by time of delivery	Two or more doses by time of delivery	Unvaccinated at delivery	Unvaccinated who went on to receive doses after pregnancy to 25 August 2022
1 – most deprived	28,379	17,289 (60.9%)	14,710 (51.8%)	11,090 (39.1%)	196 (1.8%)
2	24,727	17,049 (68.9%)	15,421 (62.4%)	7,678 (31.1%)	174 (2.3%)
3	21,912	16,674 (76.1%)	15,461 (70.6%)	5,238 (23.9%)	122 (2.3%)
4	19,214	15,602 (81.2%)	14,671 (76.4%)	3,612 (18.8%)	84 (2.3%)
5 – least deprived	16,919	14,516 (85.8%)	13,837 (81.8%)	2,403 (14.2%)	47 (2.0%)
Unknown	1,770	883 (49.9%)	802 (45.3%)	447 (25.3%)	2 (0.4%)

[2] 440 women could not be matched with a NIMS record. Their vaccine status is therefore unknown and they are excluded from these figures.
[3] 440 women could not be matched with a NIMS record. Their vaccine status is therefore unknown and they are excluded from these figures.

Table 10. Vaccine coverage by age of mother, for women giving birth April to June 2022 (latest 3 months)[4]

Age	Women giving birth in April to June 2022	One or more doses by time of delivery	Two or more doses by time of delivery	Unvaccinated at delivery	Unvaccinated who went on to receive doses after pregnancy to 25 August 2022
Under 20	2,062	808 (39.2%)	532 (25.8%)	1,254 (60.8%)	19 (1.5%)
20 to 24	11,957	6,741 (56.4%)	5,451 (45.6%)	5,216 (43.6%)	88 (1.7%)
25 to 29	27,373	18,177 (66.4%)	16,046 (58.6%)	9,196 (33.6%)	206 (2.2%)
30 to 34	38,891	30,144 (77.5%)	28,110 (72.3%)	8,747 (22.5%)	179 (2.0%)
35 to 39	25,193	20,486 (81.3%)	19,407 (77.0%)	4,707 (18.7%)	109 (2.3%)
40 and above	7,002	5,657 (80.8%)	5,356 (76.5%)	1,345 (19.2%)	24 (1.8%)

[4] 440 women could not be matched with a NIMS record. Their vaccine status is therefore unknown and they are excluded from these figures. An additional 3 women of unknown age were unvaccinated at delivery and are excluded from Table 9.

In the most recent 3-month period (April to June 2022), there were 112,921 women whose vaccination record was linked and who gave birth, of whom 82,013 (72.6%) were vaccinated with at least one COVID-19 vaccine dose before they gave birth. There were differences in vaccine coverage by both ethnicity (Table 8) and by quintile of deprivation (Table 9). Overall, 50.8% of black women, 76.3% of Asian women and 75.3% of white women had received at least one dose of COVID-19 vaccine before they delivered, with a modest coverage increase in each of these groups of women compared to the 3 month period between December 2021 and February 2022 (coverage of 48.7%, 74.6% and 74.4% respectively). Of women who were unvaccinated when they gave birth in the most recent 3-month period, 2.1% went on to be vaccinated post-partum. This included 2.5% of Black women, 6.7% of Asian women and 1.2% of white women. In line with increased coverage before delivery, the proportions of unvaccinated women of these ethnicities who were immunised post-partum was lower than that previously reported.

Whilst increases in coverage were observed in all groups, women of black ethnicity and women living in the most deprived areas in England (in whom at least one dose coverage increased slightly from 59.3% to 60.9% in the most recent 3-month period) continue to be least likely to have been vaccinated with one or 2 doses of COVID-19 vaccine before they gave birth. Coverage increased as levels of deprivation decreased (Table 9). Vaccine coverage at birth increased with increasing age group with uptake exceeding 80% for one dose and 75% for 2 doses in women aged 35 years or older (Table 10).

Methods

Data on COVID-19 vaccination status together with details of each vaccine administered is recorded in a central data set called the NIMS[5]. In addition, NHS Digital manages the Hospital Episode Statistics (HES) data sets, containing information about hospital activity in England.

Records of women giving birth (‘delivery records’) in the months since 1 January 2021 were identified in HES. De-duplication of delivery records resulted in a data set of women who had given birth with one record per woman, identified by her NHS Number, and the latest ‘delivery episode’ associated with her. An ‘earliest’ and ‘latest’ likely pregnancy start date were assigned to each woman’s record, using the known delivery date and further information from her record, where available:

1. Where a valid gestational age was recorded (GESTAT_1 between 24 and 42), the woman’s earliest pregnancy start date was calculated by taking the number of weeks away from the delivery date, and then calculating an additional earlier week, to account for GESTAT_1 recording completed weeks of pregnancy. In a similar way, latest pregnancy start date was calculated by taking the number of weeks of GESTAT_1 away from the delivery date.
2. Where no valid GESTAT_1 was available, the first 12 diagnostic codes were

[5] NIMS Data controllers are NHSEI and NHSD. The NIMS IT software is commissioned by NHSEI via South Central West CSU and is provided by the System C and Graphnet Care Alliance.

examined to identify any with a code suggesting delivery at term (O60.2). In this case, the gestational age at delivery was assumed to be between 37 and 42 completed weeks of pregnancy, and a similar method was used to establish earliest and latest pregnancy start dates.

3. Where no valid GESTAT_1 was available and there were no codes suggesting term delivery, the first 12 diagnoses codes were examined to identify any suggesting pre-term delivery (O60.1 or O60.3). In this case, the gestational age at delivery was assumed to be between 24 and 36 completed weeks of pregnancy, and these values were used to establish earliest and latest pregnancy start dates.
4. In the absence of any additional information in the woman's record (or in conflicting cases where diagnostic codes suggesting both term and pre-term delivery appeared in the same record), the gestational age at delivery was assumed to be between 24 and 42 completed weeks of pregnancy, and these values were used to establish earliest and latest pregnancy start dates.

Earliest and latest dates for the start of each trimester were established in a similar way, using the windows of trimester 1: day 0 to day 97 (where day 0 is the earliest or latest pregnancy start date, as established using the method above), trimester 2: day 98 to day 195 and trimester 3: day 196 to delivery. Each woman's delivery record was linked to her record(s) in the NIMS using the NHS Number, establishing her vaccine status as either having had one or more doses before delivery (including any prior to becoming pregnant) or not having had any doses of the vaccine prior to delivery, using the NIMS vaccine records.

For each vaccine dose (this analysis considered doses 1 to 4) the woman was known to have received, the following information was ascertained:

Dose administered pre-pregnancy	Dose administered before the earliest pregnancy start date
Dose administered in pregnancy	Dose administered after the latest pregnancy start date and before the delivery date
Dose administered post-pregnancy	Dose administered on or after the delivery date based on NIMS records extracted on 28 September 2022
Dose in pregnancy: unknown	Dose administered around the start or pregnancy: after the earliest pregnancy start date and before the latest pregnancy start date
Unvaccinated	No vaccine records exist for the woman, based on NHS number

And the following information about trimester:

Dose administered pre-pregnancy	Dose administered before the earliest pregnancy start date
Dose administered in trimester 1	Dose administered after the latest pregnancy start date and before the earliest pregnancy start date +97 days

Dose administered in trimester 2	Dose administered after the latest pregnancy start date +98 days and before the earliest pregnancy start date +195 days
Dose administered in trimester 3	Dose administered after the latest pregnancy start date + 196 days and before the delivery date
Dose administered post-pregnancy	Dose administered on or after the delivery date based on NIMS records extracted on 28 September 2022
Dose in trimester unknown	Dose administered in the 'gap' between trimesters, because of inaccuracy in establishing pregnancy start date
Unvaccinated	No vaccine records exist for the woman, based on NHS number

The ethnicity, residence and age information used to generate Tables 7 to 9 was taken from the NIMS record. The analysis within this section was carried out on 28 September 2022. The latest HES data available was for June 2022, and all HES data since April 2021 is considered provisional.

Pregnancy outcomes

The following figures present rates of women in England who:

1. Gave birth to one or more live-born babies at term without low birthweight; that is, they experienced none of the following adverse outcomes considered (outcomes 2 to 4), according to their delivery record.
2. Gave birth to a stillborn baby (based on recorded diagnoses).
3. Gave birth to a baby with low birthweight (less than 2,500g) or a very low birthweight (less than 1,500g). The babies with a very low birthweight are therefore a subset of the low birthweight babies.
4. Gave birth prematurely (less than 37 weeks gestation), very prematurely (less than 32 weeks gestation) and extremely prematurely (less than 28 weeks gestation). The very premature and extremely premature are therefore a subset of women who gave birth prematurely.

These analyses assess whether rates were different in women giving birth between January 2021 and June 2022, who received one or more COVID-19 vaccination doses during their pregnancy compared with those who did not (either because they were unvaccinated or had only received vaccine doses prior to pregnancy). The analyses do not take other factors that might affect these outcomes into account, such as age (except for outcome 1 above) and whether the woman was categorised as clinically at risk. However, women who gave birth on or after 17 April 2021 without the reported complications (outcome 1 above), were also reviewed with vaccinations given from 16 April 2021 onwards. This is a more homogenous group of pregnant women who were eligible for vaccination based solely on age and not because they

were considered at high risk of exposure or severe disease. Therefore, data is also presented for women giving birth between 17 April 2021 and 30 June 2022 for comparison.

Figure 4. Women giving birth January 2021 to June 2022 to live-born babies at term without low birthweight

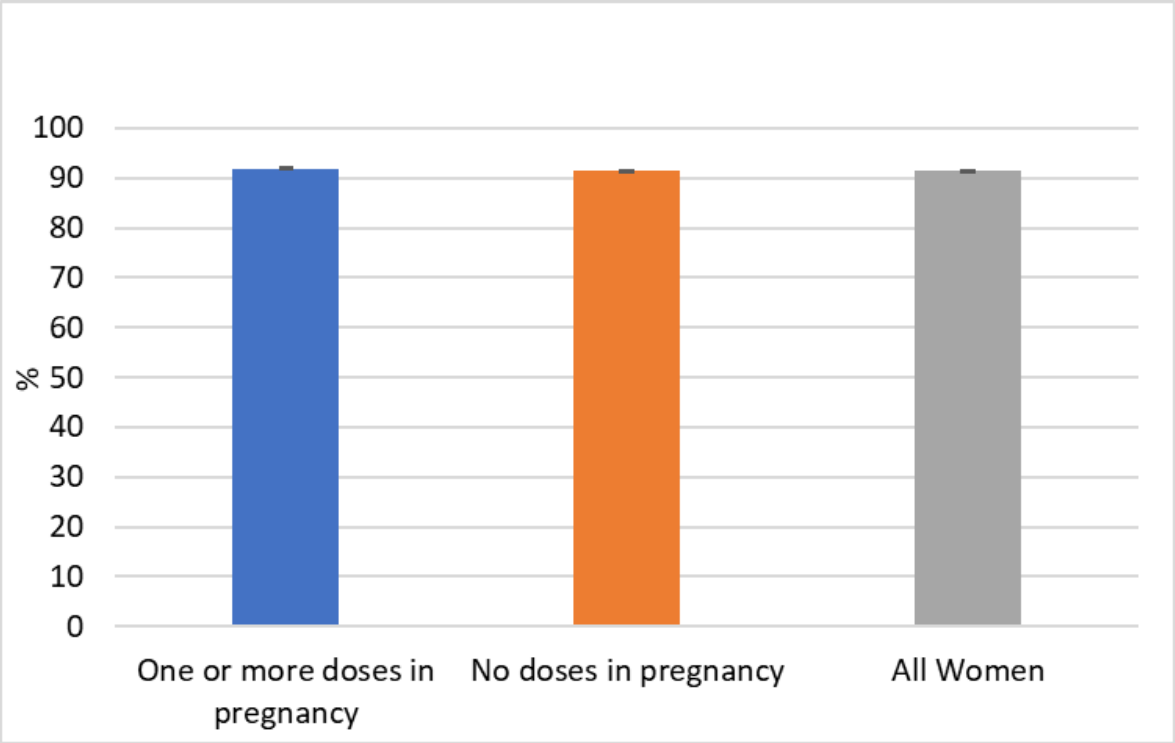


Figure 5. Women giving birth January 2021 to June 2022 to live-born babies at term without low birthweight, by age

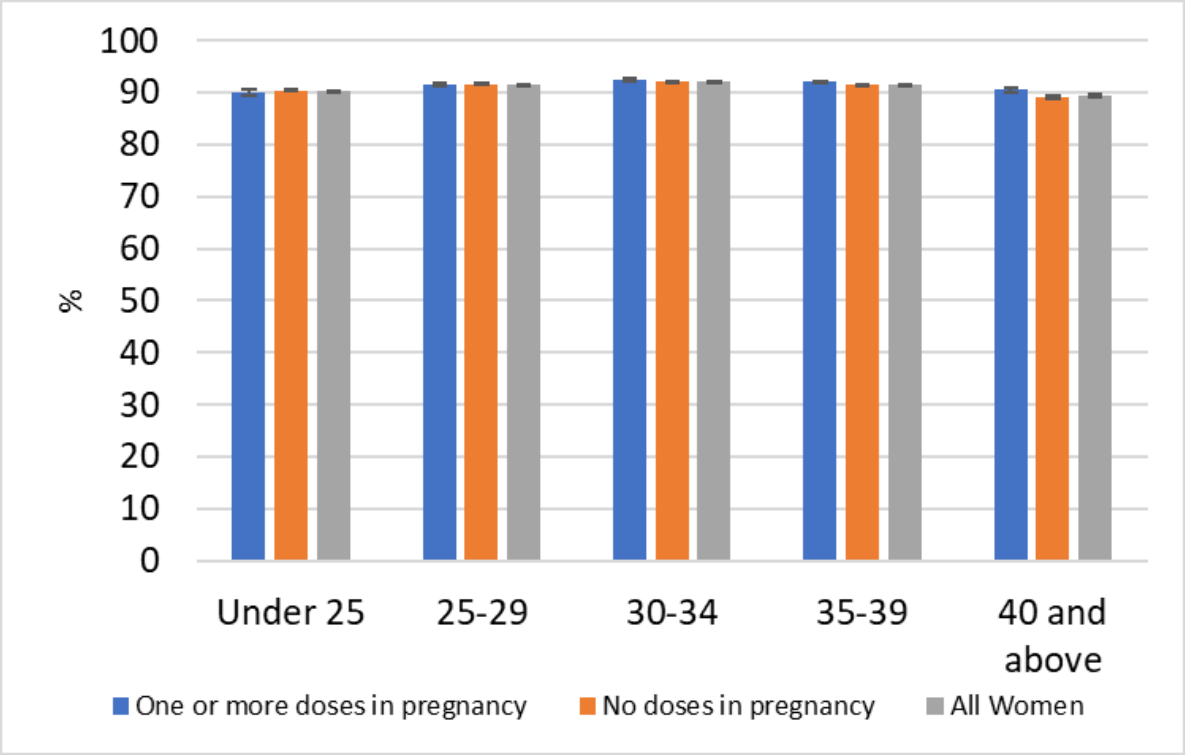


Figure 6. Women giving birth April 2021 to June 2022 to live-born babies at term without low birthweight

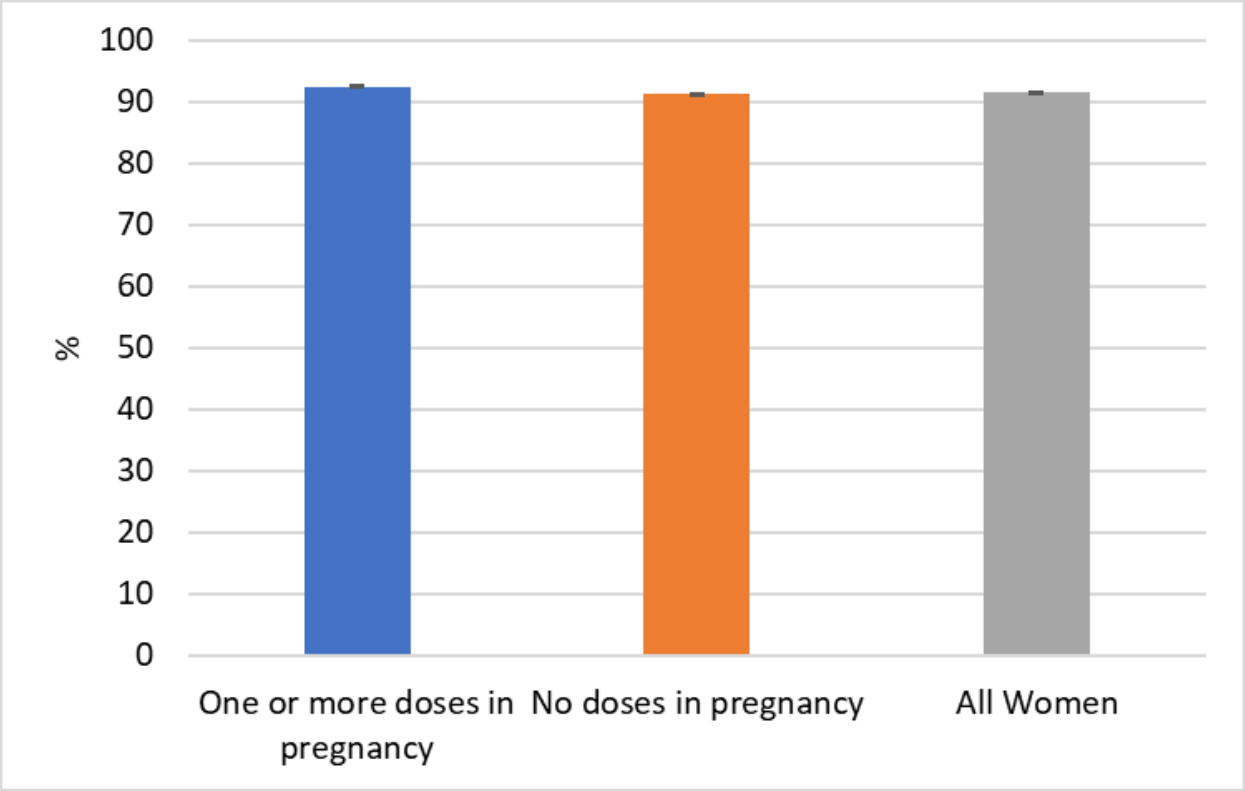


Figure 7. Women giving birth April 2021 to June 2022 to live-born babies at term without low birthweight, by age group

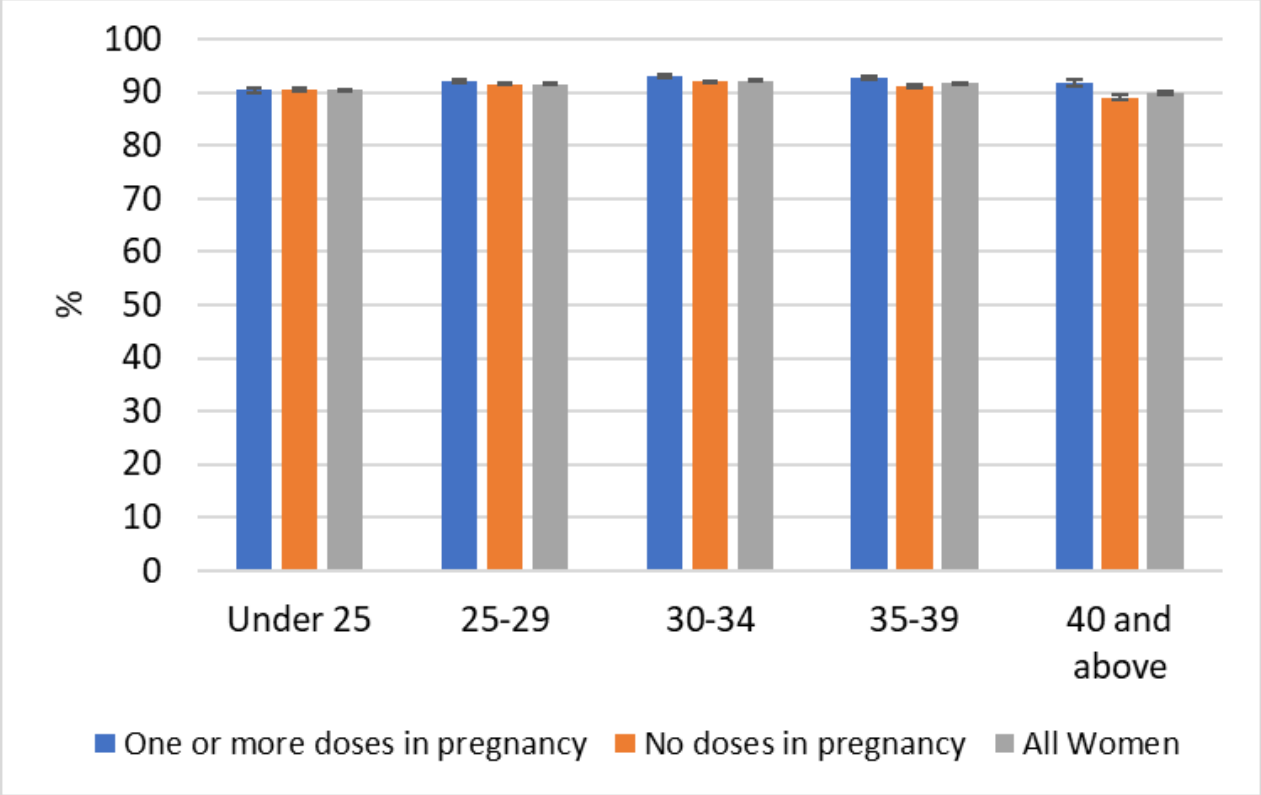


Figure 8. Stillbirths experienced by women giving birth January 2021 to June 2022

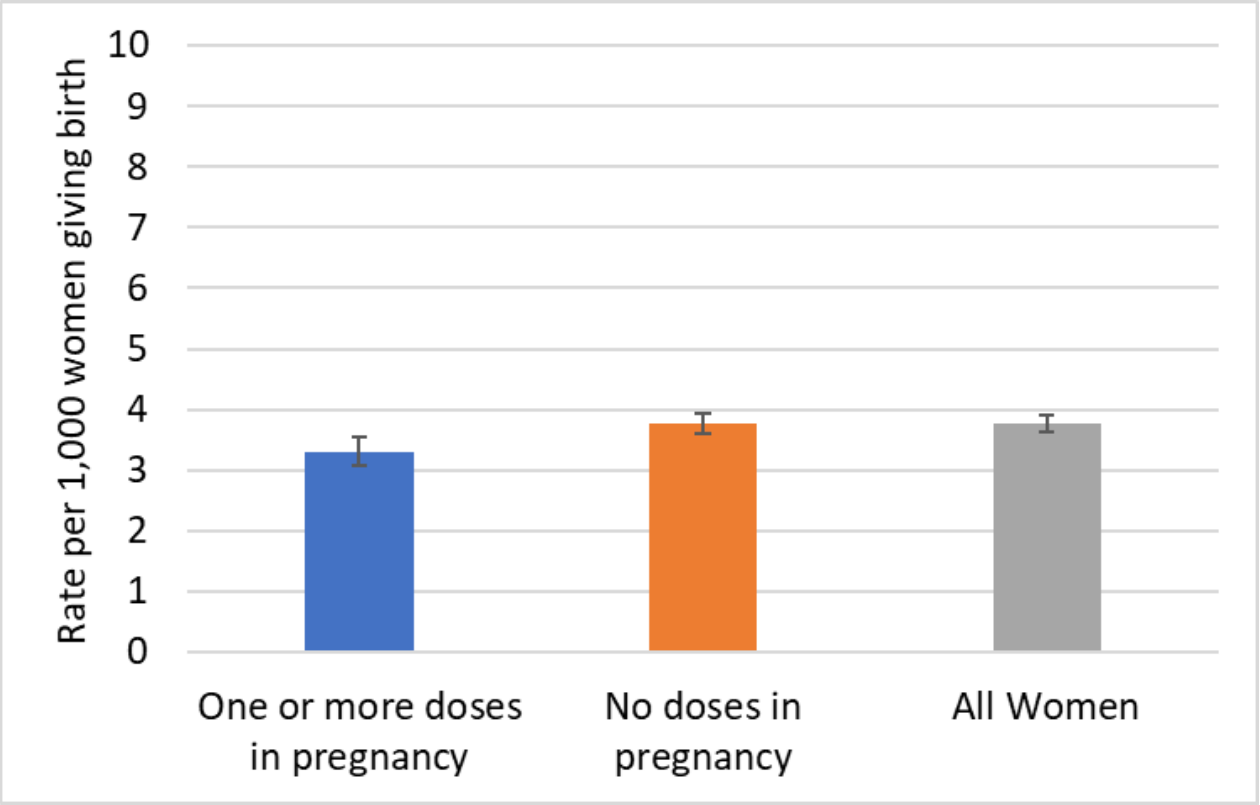


Figure 9. Low birthweight experienced by women giving birth January 2021 to June 2022

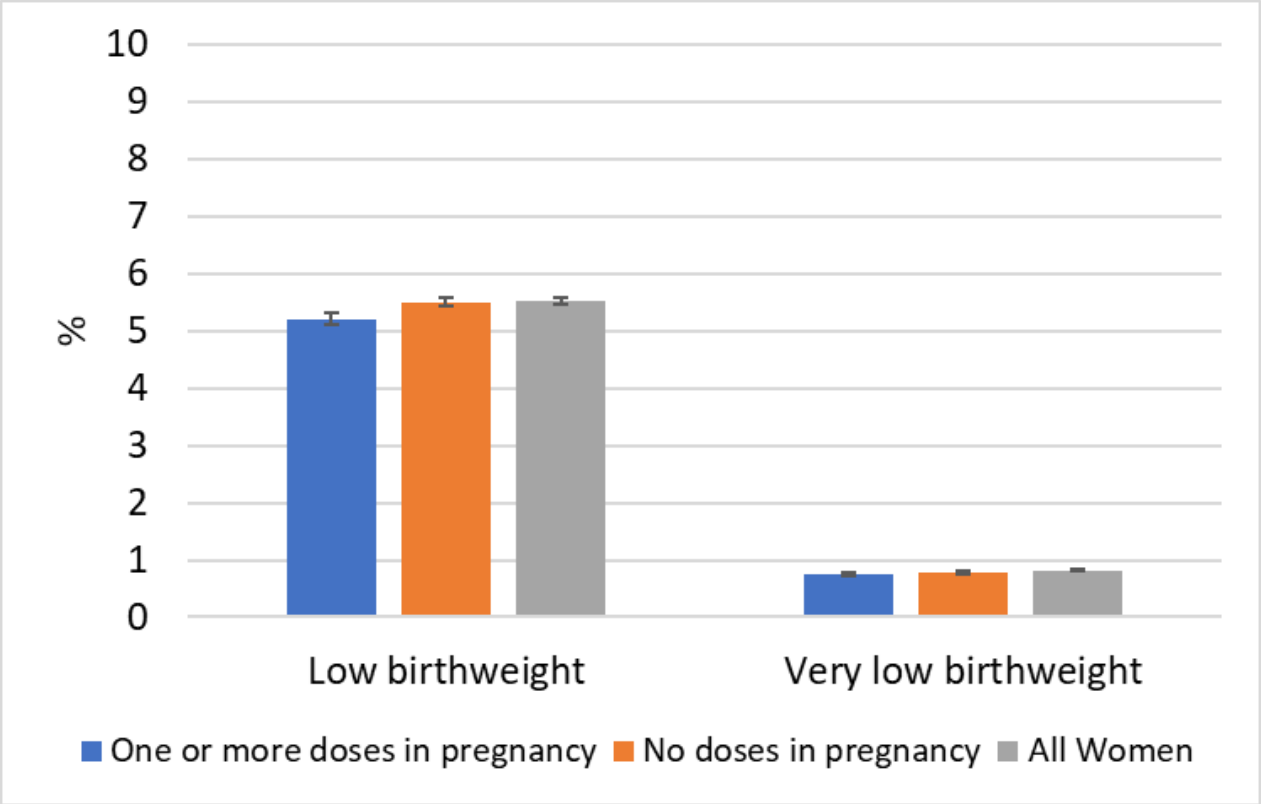
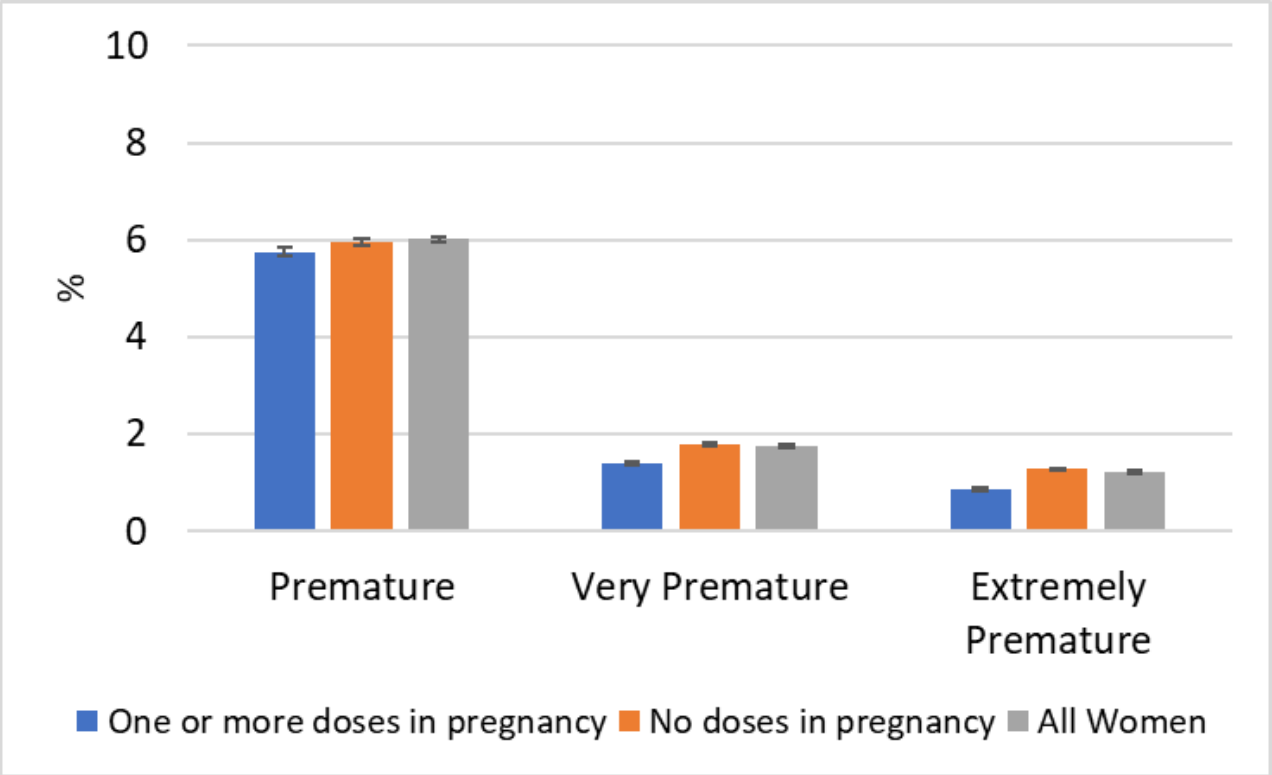


Figure 10. Women giving birth prematurely January 2021 to June 2022



The proportion of women giving birth between January 2021 and June 2022 to live-born babies at term without low birthweight (that is, with no specified adverse outcomes) having received one or more doses in pregnancy (91.9% 95%CI 91.8 to 92.0) is higher than the proportion in women who did not receive any doses in pregnancy (91.4% 95%CI 91.3 to 91.5) (Figure 4). These positive outcomes were similar across all age groups in vaccinated and unvaccinated women (Figure 5). For the more recent period (women vaccinated from 16 April and delivering from 17 April 2021), when all pregnant women were routinely offered vaccination on the basis of age, women who had received at least one dose of COVID-19 vaccine during their pregnancy were more likely to give birth without any of the reported adverse outcomes than women who had not been vaccinated in pregnancy (92.5% 95%CI 92.4 to 92.6 compared with 91.3% 95%CI 91.2 to 91.4) (Figure 6). This difference was more apparent in those aged 30 years and older (Figure 7).

The stillbirth rate for women who gave birth having received one or more doses in pregnancy (3.30 per 1,000, 95%CI 3.07 to 3.56) was lower than the rate for those who had not received any doses in pregnancy (3.76 per 1,000, 95%CI 3.60 to 3.94) giving birth between January 2021 and June 2022 (Figure 8). In the same period, the proportion of women who had received one or more doses in pregnancy giving birth to babies with low birthweight (5.21%, 95%CI 5.11 to 5.30) was lower than those who had not received any doses in pregnancy (5.50%, 95%CI 5.44 to 5.57) (Figure 9). There was no statistically significant difference between the 0.76% (95%CI 0.72 to 0.79) of women who had received one or more doses in pregnancy and 0.78% (95%CI 0.75 to 0.80) of those who had not, who gave birth to a very low birthweight baby (Figure 9).

The proportion of women who received one or more doses in pregnancy having premature births was 5.76% (95%CI 5.66 to 5.86), compared with 5.95% (95%CI 5.88 to 6.02) in those who had not (Figure 10). The proportion of women with very premature births was 1.40% (95%CI 1.35 to 1.45) in those who received one or more dose in pregnancy, lower than the 1.79% (95%CI 1.75 to 1.83) with a very premature birth who had not been vaccinated during pregnancy. The proportion of women with extremely premature births was 0.86% (95%CI 0.82 to 0.90) in those who received one or more dose in pregnancy: lower than the 1.27% (95%CI 1.24 to 1.31) in those who had not.

Interpretation and limitations

The first women to be offered COVID-19 vaccine were those who were categorised as at risk of severe disease and women of older age who are at increased risk of the 3 adverse outcomes presented here (given the medical conditions that placed them in this category), together with healthcare professionals at higher risk of COVID-19 exposure. Women with underlying conditions that put them at very high risk of serious complications of COVID-19 will thus account for a relatively high proportion of early deliveries in women who had received one or more doses of the vaccine before 16 April 2021. It is therefore very reassuring that women who had received at least one dose of the vaccine in pregnancy were more likely to deliver live born babies at term without low birthweight and had no overall increased risk of any adverse outcome through January 2021 to June 2022 and that their rate of stillbirth was lower than that observed in women who were not vaccinated during pregnancy.

These findings continue to support the conclusions on vaccine safety from earlier COVID-19 vaccine surveillance reports from week 47 2021 onwards COVID-19 vaccine weekly surveillance reports (weeks 39 to 40, 2021 to 2022) and from analyses published by Public Health Scotland Outputs and information for the public – the University of Edinburgh.

More detailed statistical analyses are planned (see COVID-19 vaccination in pregnancy surveillance protocol. There are recognised limitations of the data sets including the level of completeness of the relevant fields. The adverse pregnancy outcomes considered are routinely reported as official statistics annually by ONS, (see Coronavirus (COVID-19) hospital admissions by vaccination and pregnancy status, England – Office for National Statistics), however HES data was used to monitor outcomes more quickly than ONS data allows.

Methods

The same methods as used to establish coverage figures were used to group records of deliveries into those who had received at least one dose of the vaccine during their pregnancy and those who had not. The definition of this second group includes any women who received dose(s) only prior to pregnancy and those who received their first dose after delivery, as well as those unvaccinated as of 28 September 2022. Outcomes are also presented by age at delivery, using the woman's date of birth as recorded in NIMS.

To identify deliveries where adverse outcomes were experienced; the following criteria were applied. The outcomes are related: for example, babies born prematurely are more likely to be born with low birthweight, and therefore a delivery may have more than one adverse outcome. Stillbirths were identified as records where any one or more of the first 12 diagnoses was the following: Z37.1: Single stillbirth; Z37.3 Twins, one liveborn and one stillborn; Z37.4 Twins, both stillborn; Z37.6: Other multiple births, some liveborn; Z37.7: Other multiple births, all stillborn. Low birthweight and very low birthweight deliveries were identified as records where any of the first 4 babies born had a known birthweight between 500g and 2,499g (1,499g or lower for very low birthweight).

Premature deliveries were identified as records where the gestational length was less than 37 weeks (less than 32 weeks for very premature, and less than 28 weeks for extremely premature).

Low birthweight is by convention presented as a percentage of all deliveries with known birthweights, and prematurity is usually presented as a percentage of all deliveries with known gestational length. However here they are presented as percentages of all deliveries, to reduce the chance of significant findings arising from a change in the overall success of recording these fields during the pandemic. Figures will therefore differ from official statistics and should be considered for surveillance purposes only.

Confidence intervals were calculated using the Wilson Score method (48). A confidence interval is a range of values that is used to quantify the imprecision in the estimate of a particular indicator. Specifically, it quantifies the imprecision that results from random variation in the measurement of the indicator. A wider confidence interval shows that the indicator value presented is likely to be a less precise estimate of the true underlying value.

Main findings

COVID-19 vaccination is the safest and most effective way for women to protect themselves and their pregnancies against severe COVID-19 disease. The JCVI has advised that women who are pregnant are considered to be in a clinical risk group within the COVID-19 vaccine programme. Unvaccinated women who become pregnant are strongly encouraged to come forward for vaccination. Women who are pregnant and have previously been vaccinated should be offered a booster dose this autumn (Joint Committee on Vaccination and Immunisation (JCVI) updated statement on the COVID-19 vaccination programme for autumn 2022).

COVID-19 vaccine coverage in pregnant women at delivery has increased as more women have become eligible for vaccination, stabilising from May 2022. 73.0% of women who gave birth in June 2022 had received one or more dose before their baby was born. In Scotland, 74% of the women delivering in March 2022 had received at least one dose of COVID-19 vaccine prior to delivery, with 65% having received at least 2 doses and 41% having received 3 doses (49). In Wales estimated coverage at time of delivery for 2,018 women with delivery dates

during July 2022 was 81% for at least one dose, 77% for at least 2 doses and 45% for at least one booster dose (data provided by Public Health Wales).

As in the previous report, however, coverage increased with decreasing levels of deprivation (with increasing affluence) and women of black ethnicity had the lowest vaccine coverage. Coverage also increased with increasing age group.

Whilst uptake improved between February and May 2022 as presented in the week 35 2022 report, across all groups, it appears to have now largely stabilised. Reported coverage continues to highlight inequalities consistent with those seen across the entire COVID-19 vaccination programme. Coverage of at least one dose increased from 5.5% in women of black ethnicity who delivered between June and August 2021 to 30.5% between November 2021 and January 2022 and to 50.8% between April and June 2022. The difference in coverage between black and white women was 24.5 percentage points in the most recent 3-month period (and 25.5 percentage points between black and Asian women), similar to the 25.7 percentage point difference reported between March and May 2022. In women living in the most deprived areas in England coverage increased from 25.5% to 38.9% to 60.9% in the same periods. A difference of 24.9 percentage points persists in those living between the most deprived and most affluent areas. Few women who were unvaccinated at delivery are still being vaccinated post-partum.

It is very reassuring that women who had received at least one dose of the vaccine in pregnancy were more likely to deliver live born babies at term without low birthweight as women who were not vaccinated in pregnancy, though the difference was very small. In addition, the group of women who were most likely to be immunised on the basis of their age group alone (vaccinated from 16 April 2021 and giving birth from 17 April 2021) were significantly more likely to deliver live born babies at term without low birthweight than women giving birth in the same period who were not vaccinated in pregnancy.

The specific outcomes that were considered (stillbirth, low birthweight and premature delivery) were similar or lower in women who were vaccinated whilst pregnant compared to women who were not vaccinated during their pregnancy, without taking other factors into account.

The next update on COVID-19 vaccination in pregnancy will focus on the Autumn boost. This will be published in early 2023 to allow some time for women eligible for the vaccine in pregnancy to begin to deliver.

Vaccination status in cases, deaths and hospitalisations

Data on the vaccination status of COVID-19 cases, and deaths and hospitalisations with COVID-19, was previously published to help understand the implications of the pandemic to the NHS, for example understanding workloads in hospitals, and to help understand where to prioritise vaccination delivery.

From 1 April 2022, the UK Government ended provision of free universal COVID-19 testing for the general public in England, as set out in the plan for living with COVID-19. Such changes in testing policies affect the ability to robustly monitor COVID-19 cases by vaccination status, therefore, from the week 14 report onwards this section of the report will no longer be published. For further context and previous data, please see previous vaccine surveillance reports and our blog post.

Vaccine effectiveness is measured in other ways as detailed in the vaccine effectiveness section of this report.

Vaccine impact on proportion of population with antibodies to COVID-19

Seroprevalence

The results from testing samples provided by healthy adult blood donors aged 17 years and older, supplied by the NHS Blood and Transplant (NHS BT collection) between weeks 35 2020 and week 50 2022 are summarised. As of week 44 2020, approximately 250 samples from each geographic NHS region are tested each week.

The COVID-19 vaccination campaign began on 8 December 2020 (week 50) with a phased roll out by age and risk group. From the beginning of September 2021, a third dose was offered to individuals with severe immunosuppression. A booster dose was introduced from 16 September 2021 for individuals aged 50 years and over, frontline health and social care staff, individuals aged 16 to 49 with certain underlying health conditions and household contacts of immunosuppressed individuals. Eligibility for booster doses was extended to individuals aged 40 years and over from 22 November and from December to those aged 18 to 39 in a phased rollout by age group. Booster doses are generally given at least 6 months after the second dose, although the minimum interval was reduced to at least 3 months from the second or third dose in an effort to accelerate the roll out with the emergence of the Omicron variant. A second booster (spring booster) was introduced from 21 March 2022 for individuals aged 75 years and older, older residents in care homes and individuals with severe immunosuppression. The spring booster was offered 3 to 6 months after the last dose. An autumn booster was introduced from 7 September 2022 for individuals aged 50 years and over, those in care homes, individuals aged 5 years and over in clinical risk groups, frontline health and social care staff, those who care for vulnerable individuals and families of individuals with weakened immune systems, with those at highest risk being vaccinated first. The autumn booster is offered at least 3 months after the last dose.

Please note that this section will be updated monthly. This update was published on 12 January 2023.

Seroprevalence in blood donors aged 17 years and older

The results presented here are based on testing samples with Roche nucleoprotein (N) and Roche spike (S) antibody assays.

Nucleoprotein (Roche N) assays only detect post-infection antibodies, whereas spike (Roche S) assays will detect both post-infection antibodies and vaccine-induced antibodies. Thus, changes in seropositivity for the Roche N assay reflect the effect of natural infection. Increases in

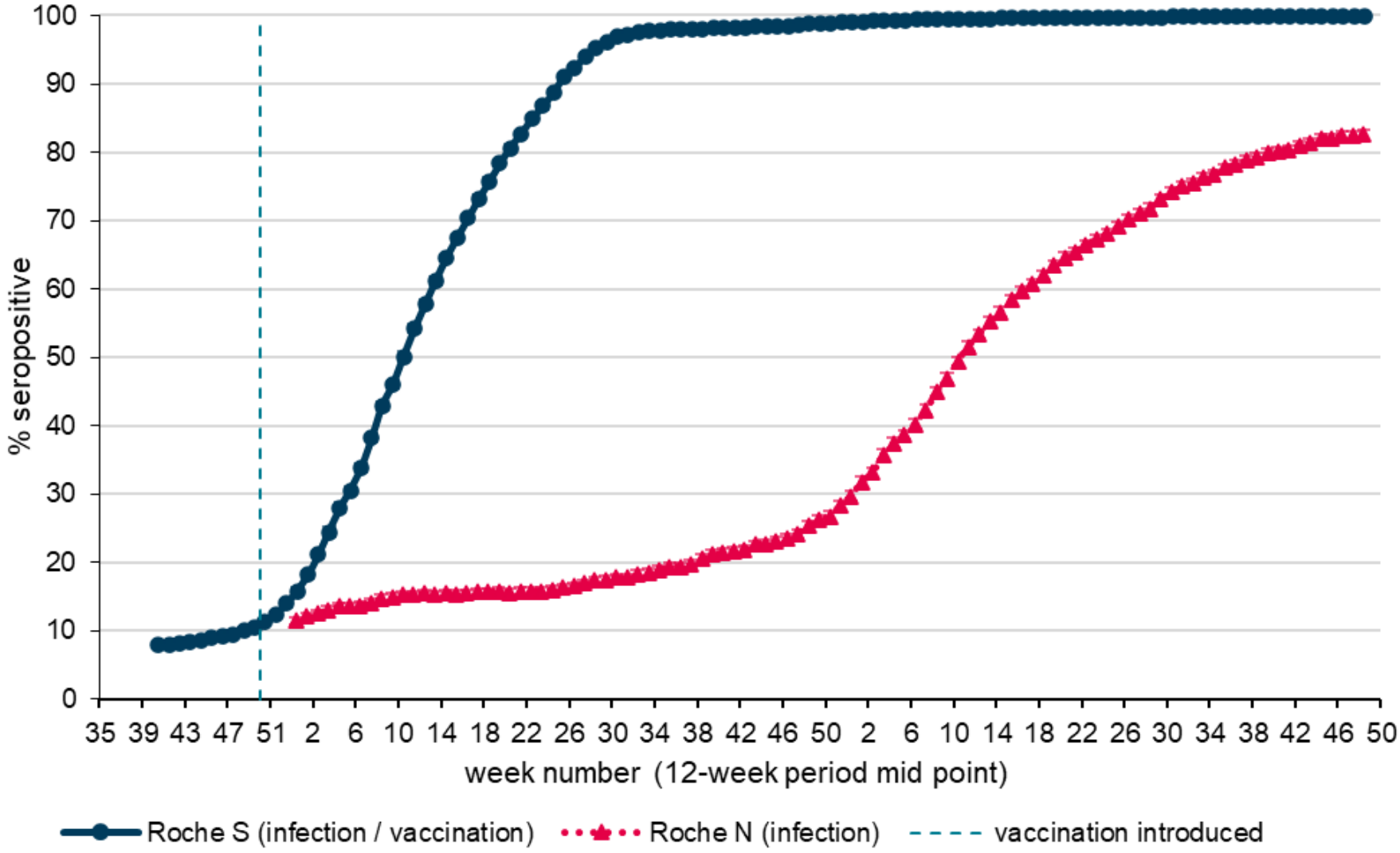
seropositivity as measured by S antibody reflect both infection and vaccination. Antibody responses to both targets reflect infection or vaccination occurring at least 2 to 3 weeks previously given the time taken to generate a COVID-19 antibody response. Currently donors are asked to defer donations for at least 48 hours post vaccination (previously 7 days), and for at least 10 full days after a positive COVID-19 test as well as 7 days following resolution of any symptoms (previously 28 days, changes were implemented during January 2022).

This report presents Roche N and Roche S seropositivity estimates on the same set of samples, using a 12-week rolling prevalence for national, age group and regional estimates. Seropositivity estimates are plotted using the mid-point of a 12-weekly rolling period that reduces to 8 weeks in the most recent weeks to allow for a more representative current estimate of seropositivity. However, this also means the data will reflect seroprevalence several weeks previously. Seroprevalence estimates reported are based on seropositivity which are unadjusted for the sensitivity and specificity of the assays used.

National prevalence

Overall population weighted (by age group, sex and NHS region) antibody prevalence among blood donors aged 17 years and older in England was 82.5 % (95% CI 81.8% to 83.2%) using the Roche N assay and 99.9% (95% CI 99.8% to 99.9%) using the Roche S assay for the period 26 October to 16 December (weeks 43 to 50 2022). 11,478 out of 13,967 were Roche N positive and 13,917 out of 13,937 samples were Roche S positive. This compares with 78.2% (95% CI 77.6% to 78.8%) Roche N seropositivity and 99.8% (95% CI 99.8% to 99.9%) Roche S seropositivity for the period of 10 August to 21 October (weeks 31 to 42 2022). Seropositivity (weighted by region, age group and sex) varies over time. Figure 11 shows the overall 12-weekly rolling proportion seropositive over time for the Roche N and Roche S assays. Seropositivity estimates are plotted weekly using the mid-point of a rolling 12-weekly period.

Figure 11. Overall 12-weekly rolling SARS-CoV-2 antibody seroprevalence (% seropositive) in blood donors



Regional prevalence of infection over time

Seropositivity (weighted by age group and sex) using the Roche N assay which detects infection only, varies by region (Figure 12).

Figure 12. 12-weekly rolling SARS-CoV-2 antibody seroprevalence (% seropositive) in blood donors by region, using Roche N test; error bars show 95% confidence intervals

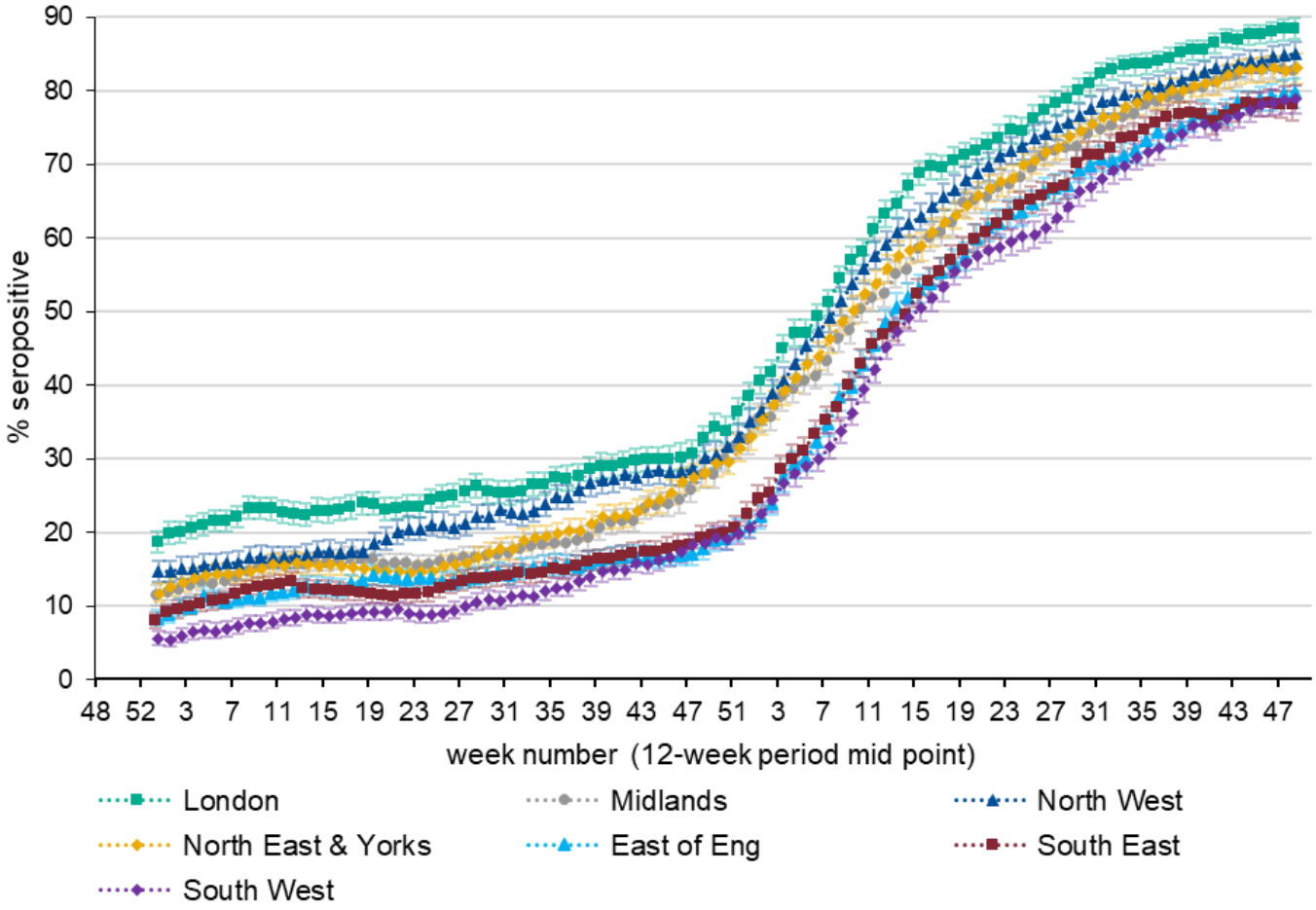


Table 11. Roche N seropositivity (95% CI) estimates by NHS region

NHS region	Weeks 31 to 42 2022	Weeks 43 to 50 2022
East of England	74.5% (72.8% to 76.2%)	79.8% (77.8% to 81.8%)
London	84.0% (82.6% to 85.3%)	88.5% (87.0% to 89.9%)
Midlands	78.5% (77.0% to 80.0%)	82.7% (80.8% to 84.4%)
North East and Yorkshire	79.2% (77.5% to 80.8%)	83.2% (81.0% to 85.2%)
North West	80.6% (78.9% to 82.2%)	85.0% (83.2% to 86.7%)
South East	75.7% (74.0% to 77.3%)	78.1% (76.0% to 80.1%)
South West	72.3% (70.5% to 74.0%)	78.9% (76.9% to 80.8%)

Increases in Roche N seropositivity have recently been observed across all regions (Table 11) compared to the previous 12-week period with the largest increases in the South West and East of England regions

Seropositivity has consistently been lowest in the South West with the difference between other regions narrowing over time, whilst the highest seropositivity has consistently been observed in London, closely followed by the North West.

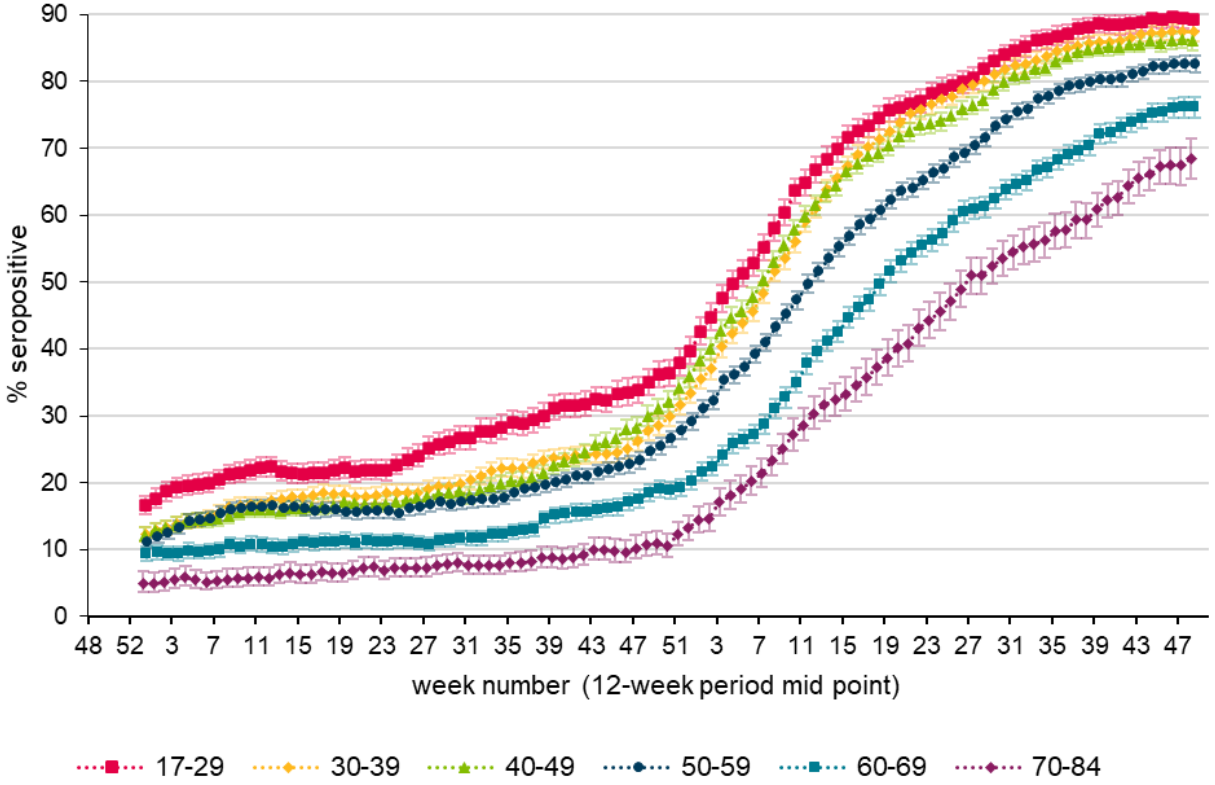
Overall COVID-19 case rates through Pillar 1 were increasing in week 50 in all regions. Overall Pillar 1 positivity increased compared to the previous week. (Weekly national Influenza and COVID-19 surveillance report week 47 2022).

Pillar 1 testing is undertaken by NHS hospitals and UKHSA labs for those with a clinical need and some health and social care workers. Testing recommendations have been updated and routine asymptomatic testing through NHS settings has been paused since the end of August 2022, which will have an impact on Pillar 1 case rates and positivity rates. Changes in testing practices is likely to influence a range of surveillance indicators highlighting the importance of maintaining the serosurveillance programme to provide consistent data on exposure to infection and vaccine impact in the population over time.

Prevalence by age group

Seropositivity estimates by age group using the Roche N assay are presented below.

Figure 12. Population weighted 12-weekly rolling SARS-CoV-2 antibody seroprevalence (% seropositive) in blood donors from the Roche N assay by age group



Based on testing samples using the Roche N assay (Figure 12) as a marker of infection, the highest seropositivity continues to be observed in those aged 17 to 29 and the lowest in those aged 70 to 84.

Table 12. Roche N seropositivity (95% CI) estimates by age group

Age group	Weeks 31 to 42 2022	Weeks 43 to 50 2022
17 to 29	87.2% (85.7% to 88.5%)	89.4% (87.5% to 91.0%)
30 to 39	84.9% (83.7% to 86.0%)	87.4% (86.0% to 88.7%)
40 to 49	83.7% (82.6% to 84.8%)	86.0% (84.6% to 87.3%)
50 to 59	79.3% (78.2% to 80.4%)	82.6% (81.3% to 83.8%)
60 to 69	69.1% (67.6% to 70.5%)	76.1% (74.5% to 77.7%)
70 to 84	57.8% (55.2% to 60.3%)	68.5% (65.4% to 71.4%)

Increases in N seropositivity have recently been observed across all age groups (Table 12) compared to the previous 12-week period. In the most recent period, the largest increase in seropositivity was observed in individuals aged 70 to 84 years and 60 to 69 years.

In England, Pillar 1 COVID-19 case rates for week 50 2022, were increasing across all age groups with the highest rates currently seen in individuals aged 70 years and older (Weekly national Influenza and COVID-19 surveillance report week 47 2022).

Roche S seropositivity in blood donors has plateaued and is now over 99% across all age groups. Seropositivity estimates for S antibody in blood donors are likely to be higher than would be expected in the general population and this probably reflects the fact that donors are more likely to be vaccinated. Seropositivity estimates for N antibody will underestimate the proportion of the population previously infected due to (i) waning of the N antibody response over time and (ii) observations from UK Health Security Agency (UKHSA) surveillance data that N antibody levels are lower in individuals who acquire infection following vaccination. These lower N antibody responses in individuals with breakthrough infections (post-vaccination) compared to primary infection likely reflect the shorter and milder infections in these patients. Patients with breakthrough infections do have significant increases in S antibody levels consistent with boosting of their antibody levels.

Vaccination has made an important contribution to the overall Roche S increases observed since the roll out of the vaccination programme. The impact of the booster vaccination programmes can be assessed by monitoring Roche S antibody levels across the population over time.

Roche S levels by age group and month

The Roche S assay that the UK Health Security Agency (UKHSA) uses for serological surveillance is fully quantitative, meaning that it measures the level of antibodies in a blood sample; an antibody level above 0.8 au/ml (approximately 1 IU/ml using the WHO standard) is deemed positive. The UKHSA surveillance since Autumn 2021 has found that over 99% of the population of blood donors test positive for S-antibodies, which may have resulted from either

COVID-19 infection or vaccination. With such high seropositivity, it is important to look at population antibody levels in order to assess the impact of the vaccination booster programmes.

Figure 13 shows monthly categorised Roche S levels in N-antibody negative individuals by age group over the past year. In January 2022 antibody levels were high in the younger age groups following rollout of the accelerated booster programme due to the emergence of the Omicron variant in late 2021. However, the decreasing profile of antibody levels among 17 to 69 year olds from February through to August shows signs of waning. From April 2022 the proportion of donors, aged 70 to 84 years, with very high antibody levels of 25,000+ au/ml increased following the introduction of the spring booster for ages 75 and older. Antibody levels in this older age group have remained consistent from May to September 2022. A further increase in highest antibody levels can be seen in October following the Autumn booster in those aged 40 to 84, with the highest increase seen in those aged 70 to 84. In November 2022 the proportion of donors aged 70 to 84 with very high antibody levels of 25,000+ au/ml remained high and the proportion of donors aged 50 to 69 years with very high antibody levels increased. By the end of week 50, 64.1% of all individuals aged 50 years and older had been vaccinated with an autumn booster dose (Weekly national Influenza and COVID-19 surveillance report week 47 2022).

Figure 14 shows categorised Roche S levels in N-antibody positive individuals, those likely to have experienced past infection. Pre-vaccination antibody levels will be influenced by time since infection, variant and severity of infection, as well as individual factors such as underlying health conditions and age. In January 2022 more than half of donors aged 70 to 84 years had very high antibody levels of 25,000+ au/ml. The proportion of donors with very high antibody levels of 25,000+ au/ml remained stable during February and March 2022. Since April 2022 the proportion of donors with very high antibody levels of 25,000+ au/ml decreased across all age groups except for those aged 70 to 84 where increases were observed in April and May 2022; however decreases were observed between June and September 2022. Increases of the highest antibody levels are being seen across those aged 60 to 84 in October following rollout of the Autumn booster. In those aged 17 to 59 very little change has been observed between June and October 2022. In November 2022 increases in the proportion of donors with very high antibody levels of 25,000+ au/ml continued to be observed in donors aged 60 to 84 years and also in those aged 50 to 59 years.

Comparing Figure 13 with Figure 14, the overall higher profile of antibody levels in those who have experienced past infection is evident; both vaccination post infection and breakthrough infection following vaccination are expected to boost existing antibody levels.

Whilst it is thought that there is no threshold antibody level that offers complete protection against infection, higher antibody levels are likely to be associated with lower probability of infection.

Figure 13. Categorised Roche S antibody levels by age group and month in N negative samples, December 2021 to November 2022

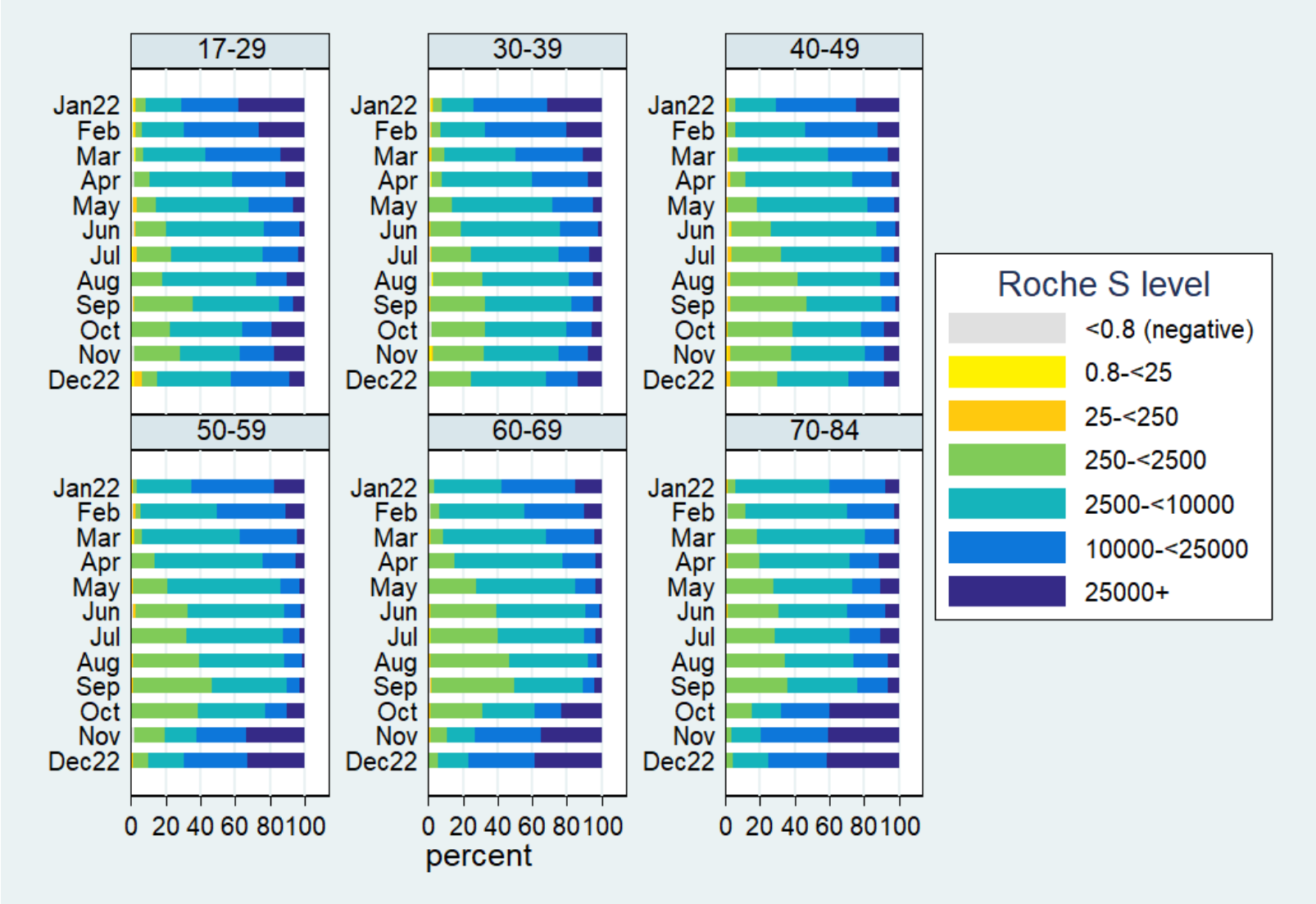
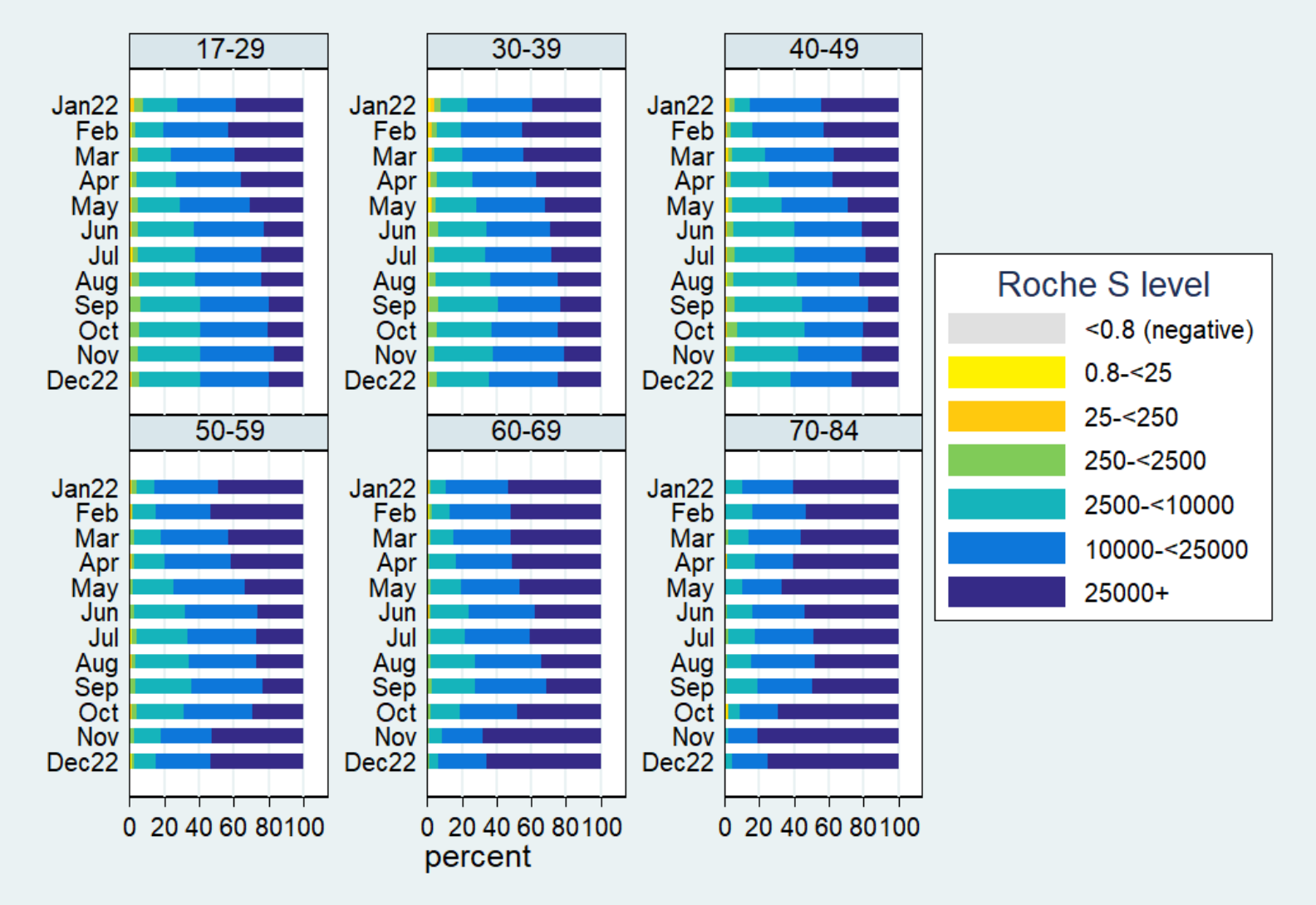


Figure 14. Categorised Roche S antibody levels by age group and month in N positive samples, December 2021 to November 2022



SARI-Watch surveillance data

SARI-Watch is a national surveillance system in England that captures aggregate and individual data on laboratory confirmed COVID-19 hospitalisations (to all level of care) and ICU or HDU admissions. The individual level data is based on hospitalisations for laboratory confirmed COVID-19 submitted by a sentinel network of acute NHS trusts.

The analyses presented are based on individual level data from the sentinel collection in England. The analysis uses data from 1 September 2022 to 1 January 2023 inclusive submitted by 10 acute NHS trusts. 1 September was the official roll out of the Autumn 2022 booster campaign. The data was up to 1 January 2023 as this was last date of ISO week 52 2022. To obtain vaccine history for admitted persons, the SARI-Watch data was linked to the National Immunisation Management Service (NIMS) on 6 January 2023 using key personal identifiers. NIMS captures data on vaccination history of people in England. Data on vaccination history was used to group admissions into 4 categories. Please note that vaccination status on admission does not represent vaccine effectiveness against hospitalisation. Vaccination is highly protective against hospitalisation as VE studies show (see vaccine effectiveness section in this report) but does not completely eliminate the risk of being hospitalised. Hence those that get hospitalised even if vaccinated tend to be the vulnerable elderly population or those with significant underlying health issues. Other caveats are that London trusts are currently under-represented in sentinel data and the most recent data is typically subject to retrospective updates after submission.

Vaccination status by time of admission by age group

Vaccination status on hospital admission was grouped into 4 categories:

- ‘Unvaccinated’ – no evidence of previous vaccination at the time of admission
- ‘D1’ comprising only one dose of the primary course by the time of admission
- ’D2’ comprising only 2 doses of the primary course by the time of admission
- ‘D3 comprising 3 doses or more by the time of admission. This includes 3 doses of primary course only or 2 doses of the primary course plus any or all of the boosters (either Autumn 2021, Spring 2022 or Autumn 2022 booster)

The unlinked group represents hospitalised cases that could not be matched to NIMS data either due to incorrect or missing personal identifiers. This accounted for <1% of data in the 1 September 2022 to 1 January 2023 period.

Table 13 shows vaccination status by the time of admission and age group among admitted cases from 1 September 2022 to 1 January 2023 inclusive (n=4,088 admissions).

Those aged 75 years or more had the lowest proportion that were unvaccinated by the time of admission at 3.5% in this period. The highest proportion that were unvaccinated by time of admission was in <40y at 53.2% (Table 13).

Those in the category '≥3 doses' by time of admission accounted for 91.5% of admitted cases aged 75 years or more (Table 13). This compares with 25.5% in those aged <40 years.

Table 13. Vaccination status at time of admission by age group for admissions from 1 September 2022 to 1 January 2023, sentinel data, England

Age group		Unvaccinated	1 dose (primary)	2 doses (primary)	≥3 doses	Unlinked	Total
Under 40	Number	202	18	57	97	6	380
	%	53.2	4.7	15.0	25.5	1.6	
40 to 49	Number	24	7	24	73	1	129
	%	18.6	5.4	18.6	56.6	0.8	
50 to 64	Number	51	15	44	345	1	456
	%	11.2	3.3	9.6	75.7	0.2	
65 to 74	Number	40	11	37	579	4	671
	%	6.0	1.6	5.5	86.3	0.6	
Over 75	Number	87	19	92	2244	10	2452
	%	3.5	0.8	3.8	91.5	0.4	

Rate of hospitalisation for COVID-19 in vaccinated people by time since vaccination and age group

Using linked sentinel data, admissions from 5 December 2022 to 1 January 2023 inclusive were analysed as this represented the last 4 weeks in 2022 (ISO weeks 49 to 52). This period will match the ISO week system used in the aggregate collection (ISO weeks 49 to 52 2022, used in second step of the calculation – see next paragraph). First, time since last vaccination at the time of admission was calculated based on time in days between the last vaccination and hospital admission date. In this time period 10 sentinel acute NHS trusts contributed data. The last vaccination is irrespective of any dose whether from the primary or the booster schedule. The interval for each admitted case was grouped into <6 months, 6 months to under 9 months, 9 months to under 12 months and 12 months and over since last vaccination. Each month comprises 30 days. The proportion by time since last vaccination is calculated per age group.

The proportion by time since last vaccination and age group obtained from sentinel data was then applied to the corresponding age group for cases from the aggregate collection. Cases from the aggregate collection was used as this is a mandatory surveillance system based on wider national reporting. The mandatory surveillance is based on weekly data (based on ISO week system from Monday to Sunday). As described, the last 4 weeks of 2022 were used from the aggregate data (ISO weeks 49 to 52). Due to approximately 69% trust coverage in the

period of study (5 December 2022 to 1 January 2023) in the aggregate collection, a corrective factor was applied to the second step of the calculation (the second step is where the proportions by age group and time since vaccination from sentinel data are applied to the cases from the aggregate collection in same age group. The corrective factor would approximate the true total cases if there was 100% coverage.

To estimate rates of hospitalisation among vaccinated people by time since last vaccination and age group, the NIMS denominator is needed. Using NIMS data, the time since last vaccination in days was calculated from vaccination date (any dose) capped to 1 January 2023. The time in days was grouped in the same intervals described. The same age/time since vaccination groups are used for SARI-Watch and NIMS, with the former being the numerator and latter being the denominator. The rate of hospitalisation is calculated for each age/time since last vaccination group, expressed as hospitalised cases in the study period (5 December 2022 to 1 January 2023) per 100,000 vaccinated people in England.

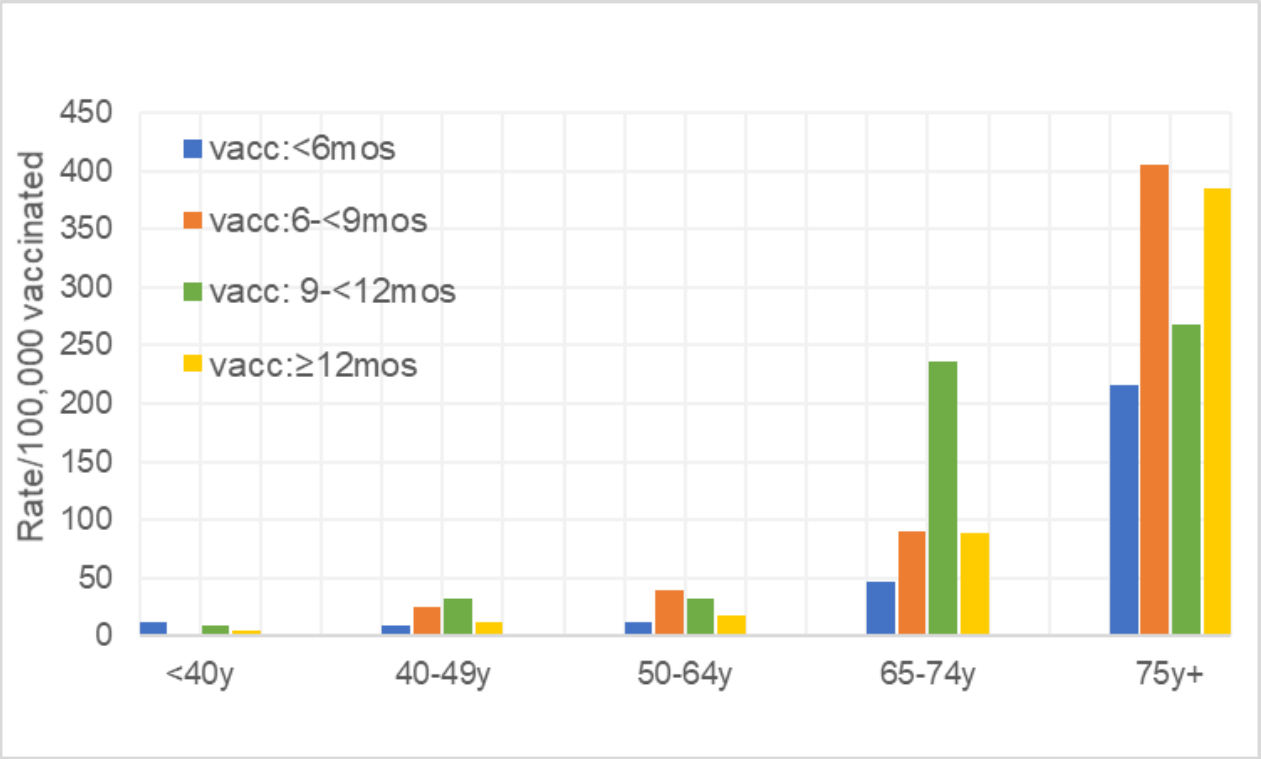
Figure 15 shows that the highest hospitalisation rates were in those aged 75 years and over for every time since last vaccination interval compared to corresponding intervals in other age groups. Also, for every age group except those aged under 40 years, the lowest rate of hospitalisation was in those who were vaccinated in the 6 months prior to hospitalisation.

For example, among people aged 75 years or more, the lowest hospitalisation rate was in the shortest interval of <6 months (216.4/100,000). This rate is noted to be high as it coincided with 3 Omicron waves in this interval (in July, October and December 2022). However, recency of vaccination pulled the rate downwards; the NIMS data shows that nationally 83.5% (4,497,458/5,386,271) of people aged 75 years or more had their last vaccination within 6 months of 1 January 2023, reflecting the expansion of the Autumn 2022 booster programme in this age group. The hospitalisation rate in this age group peaked at 404.7/100,000 for those whose last vaccination was between 6 months to less than 9 months prior to hospital admission. The increase for intervals 6 months and above may be partly due to these periods coinciding with Omicron cycles. There have been 5 Omicron cycles in 2022 alone, with the impact on hospitalisations usually highest in those aged 75 years or more. Although the rate dropped in subsequent intervals (last vaccination 9 months or more prior to admission) these were higher than the rate for the shortest interval.

The rates in younger age groups were much lower and declined with age reflecting progressively lower risk of hospitalisation. For those aged 40 to 49 years, 50 to 64 years 65 to 74 years, the rates by time since last vaccination had a broadly similar pattern to the one seen for those aged 75 years and over. The rate in the 65- to 74-year age group was lowest for the shortest interval of <6 months (47.4/100,000). This is reflected in population level vaccination coverage where 75.6% (4,358,890/5,765,128) of people in this age group had their last vaccination (any dose) within 6 months of 1 January 2023. The rate peaked in the interval 9 to <12 months to 235.5/100,000 (likely coinciding with the Omicron wave due to the BA.1 and BA.2 sub lineages) before dropping in the interval 12 months and over. Across all 3 age groups, the rates for longer intervals exceeded the rate for the shortest interval.

The rates in <40 years requires careful interpretation as the time since last vaccination percentages derived from linked data was based on small volumes for the period under study. Based on available data, for people aged <40 years, the rate was highest in the <6 months interval (12.6/100,000). It is possible that the clinical risk factors that make younger adults eligible for the Autumn 2022 booster vaccination may also make them more pre-disposed to hospital admissions than the general age-matched population. For example, patients with immunosuppression in whom the vaccine may be less effective. The combined effect of these factors may have elevated the risk in the shortest interval.

Figure 15. Estimated rate of hospitalisation for COVID-19 per 100,000 vaccinated people by time since last vaccination (any dose) and age group, admissions from 5 December 2022 to 1 January 2023 inclusive (ISO weeks 49 to 52 2022), England



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