







BMJ Open Characteristics associated with COVID-19 vaccine uptake among adults aged 50 years and above in England (8 December 2020–17 May 2021): a population-level observational study

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ABSTRACT

Objective To determine characteristics associated with COVID-19 vaccine coverage among individuals aged 50 years and above in England since the beginning of the programme.

Design Observational cross-sectional study assessed by logistic regression and mean prevalence margins.

Setting COVID-19 vaccinations delivered in England from 8 December 2020 to 17 May 2021.

Participants 30 624 257/61 967 781 (49.4%) and 17 360 045/61 967 781 (28.1%) individuals in England were recorded as vaccinated in the National Immunisation Management System with a first dose and a second dose of a COVID-19 vaccine, respectively.

Interventions Vaccination status with COVID-19 vaccinations.

Main outcome measures Proportion, adjusted ORs and mean prevalence margins for individuals not vaccinated with dose 1 among those aged 50–69 years and dose 1 and 2 among those aged 70 years and above.

Results Of individuals aged 50 years and above, black/African/Caribbean ethnic group was the least likely of all ethnic groups to be vaccinated with dose 1 of the COVID-19 vaccine. However, of those aged 70 years and above, the odds of not having dose 2 was 5.53 (95% CI 5.42 to 5.63) and 5.36 (95% CI 5.29 to 5.43) greater among Pakistani and black/African/Caribbean compared with white British ethnicity, respectively. The odds of not receiving dose 2 was 1.18 (95% CI 1.16 to 1.20) higher among individuals who lived in a care home compared with those who did not. This was the opposite to that observed for dose 1, where the odds of being unvaccinated was significantly higher among those not living in a care home (0.89 (95% CI 0.87 to 0.91)).

Conclusions We found that there are characteristics associated with low COVID-19 vaccine coverage. Inequalities, such as ethnicity are a major contributor to suboptimal coverage and tailored interventions are required to improve coverage and protect the population from SARS-CoV-2.

Strengths and limitations of this study

- This is the first study assessing characteristics associated with COVID-19 vaccine coverage for all individuals aged 50 years and above in England.
- This study uses data from the National Immunisation Management System, which is based on all individuals in England with a registered National Health Service (NHS) number.
- This centralised national system captures individual-level data for both vaccination status and demographic characteristics and allows for linkage to other datasets such as healthcare worker and care home resident status.
- This study does not include those without an NHS number and, therefore, it is possible we have underestimated the number of vaccines delivered and odds of being unvaccinated for characteristics such as ethnic groups where we have seen the greatest impact.
- Residual errors in data entry on the point-of-care applications at the vaccination sites may have also occurred, although these errors are not likely to be widespread.

BACKGROUND

The UK was the world's first country to approve a COVID-19 vaccine for the pandemic, getting a head start on the roll out of its COVID-19 vaccination programme.¹ On 8 December 2020, the UK launched its COVID-19 vaccination programme with the aim of reducing COVID-19 mortality and hospitalisations among those at highest risk. There are currently three vaccines that the Medicines and Healthcare products Regulatory Agency have authorised: the Pfizer/BioNTech vaccine (offered from 8 December 2020), the AstraZeneca (Oxford) vaccine

(offered from 4 January 2021) and the Moderna Tx (offered from 13 April 2021).²⁻⁴

To ensure the reduction of mortality from SARS-CoV-2 infection and to protect the healthcare system, the Joint Committee on Vaccination and Immunisation (JCVI), an independent expert advisory committee that advises UK health departments on vaccination, initially recommended extending the interval between doses to as long as 12 weeks. Its goal was to vaccinate a greater number of people sooner with the first dose of the COVID-19 vaccine.^{5,6} The JCVI also recommended that the vaccination programme be rolled out in phases beginning on 8 December 2021, for those aged 80 years and above and for frontline healthcare workers.⁶ The UK then opened eligibility to others, first among individuals identified as clinically extremely vulnerable, meaning they had been classified as at risk and advised to shield at home, and then in descending age groups.⁷ By 17 March 2021, all adults aged 50 years and above were eligible for their first dose of a COVID-19 vaccine.

NHS England, with support from Public Health England (PHE), the national public health agency, publishes COVID-19 vaccination counts and denominators by region, age, ethnicity and for care home residents using a tracker tool.⁸ Previous research on characteristics for low vaccine coverage in England have shown that deprivation and ethnicity are associated with lower coverage for a range of routine immunisations delivered in England.⁹⁻¹¹ There is little to no data collected on vaccine coverage for routine vaccines such as shingles and influenza for individuals living in care homes, although evidence shows that barriers exist in achieving high influenza uptake in care homes. These barriers include care home size, geographical location and working relationships with primary care and pharmacies.¹² These studies and guidance assess routine vaccines delivered in England, which are primarily delivered through general practices, pharmacies and schools. With the ongoing COVID-19 pandemic, the rapid development of COVID-19 vaccines and the urgency to rapidly roll out the programme in various settings including mass immunisation sites, it is unknown whether the same characteristics associated with vaccine coverage for routine programmes are associated with low coverage for COVID-19 vaccines.

The aim of this study is twofold:

1. To describe the number of individuals eligible for a COVID-19 vaccine in the first phase of the roll out that have been vaccinated with a single or two doses of COVID-19 vaccine by age, sex, geographical location, vaccine type, ethnicity, deprivation, urban or rural setting and programme week.
2. To determine whether there are any characteristics independently associated with low vaccine coverage for dose 1 and dose 2 of COVID-19 vaccines.

METHODS

Data source

A National Immunisation Management System (NIMS) capable of recording any vaccination, regardless of point

of delivery, has been used for the pandemic response to collect information about COVID-19 vaccines delivered across England. Individuals who present to a vaccination site, such as general practice, pharmacy or hospital provider and receive a COVID-19 vaccine will have their vaccine event information recorded on a point-of-care application. PHE receives data that are linked to demographic data obtained from the National Health Service (NHS) (eg, gender, date of birth), using the individual's unique NHS number.¹³ PHE uses these data for monitoring vaccine safety, effectiveness and coverage. All variables for vaccine coverage are described in online supplemental table 1. Age was calculated for all individuals based on their age on 31 March 2021.

Patient and public involvement

No patients were involved in the design or execution of the study.

Study population

NIMS data were extracted on 17 May 2021 to assess vaccination status of all individuals aged 50–69 years for a first dose of COVID-19 vaccine, and of all individuals aged 70 years and above vaccinated with a first and a second dose of a COVID-19 vaccine. The programme was still being rolled out among younger cohorts, so not all aged between 50 and 59 years had been offered a second dose of a COVID-19 vaccine at the time of data extraction. Individuals recorded in the NIMS must have an NHS number in order to link the population denominator and vaccination event files. All individuals with a death recorded were excluded from the analyses for the purpose of calculating coverage in the living resident population aged 50 years and above on 31 March 2021.

Vaccine coverage

Vaccine coverage was calculated by dividing the total number of individuals with a recorded NHS number in the dataset who were vaccinated with one dose and two doses of COVID-19 vaccine since the beginning of the vaccine roll out on 8 December 2020 (numerator) by the total number of individuals with a recorded NHS number in the dataset (denominator).

Proportion of unvaccinated individuals

The proportion of individuals not vaccinated for dose 1 and/or not vaccinated with dose 2 was calculated by dividing the total number of individuals unvaccinated or with a single dose of the COVID-19 vaccine since the beginning of the vaccine roll out on 8 December 2020 (numerator) by the total number of individuals with a recorded NHS number in the dataset (denominator).

Descriptive analyses

The proportion of individuals vaccinated and unvaccinated was described by programme week, starting at week 1 (beginning on 7 December 2020). Cumulative vaccine uptake has been calculated by programme week. Furthermore, the number of and proportion of individuals

unvaccinated were aggregated by age groups, region, rural/urban classification, ethnicity, for individuals clinically extremely vulnerable, for individuals over 65 years living in a care home, for individuals <65 years and a healthcare worker.

Statistical analyses

Statistical analyses were conducted for individuals eligible for a COVID-19 vaccine in England in phase I, at the beginning of the roll out. The analyses were conducted for those vaccinated with dose 1 and dose 2 for individuals aged 70 years and above, and for dose 1 among individuals aged 50–69 years.

To assess the odds of being unvaccinated or being unvaccinated with dose 2, univariable logistic regression models for each characteristic were fitted with the binary outcome of vaccination status (not vaccinated/vaccinated with dose 1 and vaccinated with dose 1/vaccinated with dose 2). A multivariable logistic regression model was conducted adjusting for all other characteristics.

The adjusted mean prevalence margins and 95% CIs of being unvaccinated for each characteristic within the multivariable model fit were calculated using the adjusted ratios. All statistical analyses were conducted using Stata V.15.1.

RESULTS

Descriptive results

From 17 March 2021, all individual aged 50 years and above were eligible for a COVID-19 vaccine. As of 17 May 2021, a total of 30 624 257/61 967 781 (49.4%) and 17 360 045/61 967 781 (28.1%) individuals were vaccinated with a first dose and a second dose of a COVID-19 vaccine, respectively. A total of 90.9% of individuals aged 65 years and older had received at least one dose of the COVID-19 vaccine. The number of individuals vaccinated varied by programme week, plateauing at weeks 11 and 24 for dose 1 and 2 among those aged 70 years and above, and week 23 for dose 1 among those aged 50–69 years (figures 1

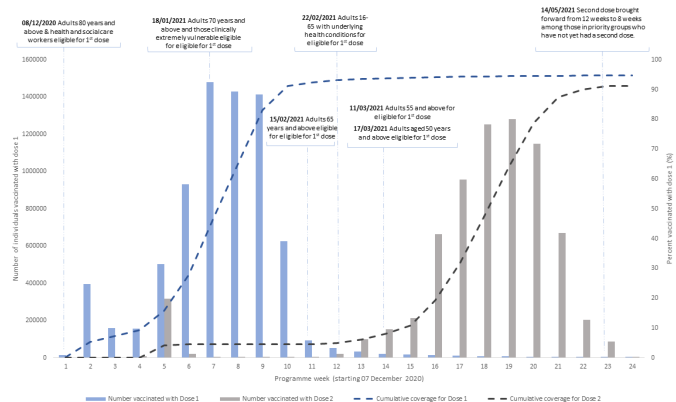


Figure 1 Number of individuals aged 70 years and above vaccinated with dose 1 and dose 2 of the COVID-19 vaccine and cumulative vaccine uptake by programme week (starting the week of 7 December 2020), England.

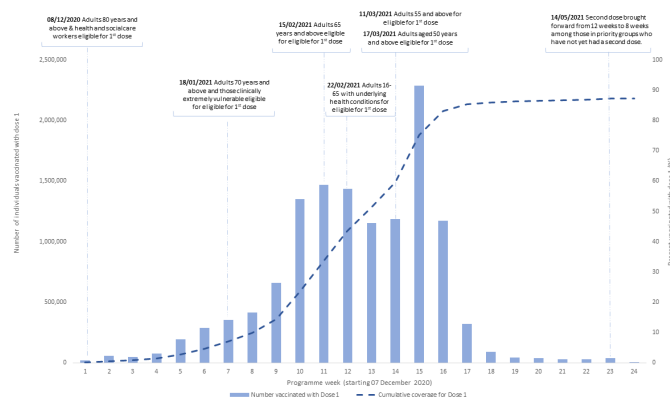


Figure 2 Number of individuals aged 50–69 years vaccinated with dose 1 of the COVID-19 vaccine and cumulative vaccine uptake by programme week (starting the week of 7 December 2020), England.

and 2). Those aged 50–69 years were still eligible for their second dose and had not yet plateaued at the time the data were extracted.

The proportion of individuals unvaccinated varied by age, dose and region; London consistently had the highest proportion of individuals being unvaccinated (figure 3). Among the total population aged 50 years and older, the North East of England had the lowest proportion of unvaccinated individuals (figure 3).

Individuals aged 70 years and above unvaccinated

Of individuals aged 70 years and above, all characteristics were significantly associated with being unvaccinated in both the univariable and multivariable logistic regression analyses.

The odds of being unvaccinated was higher among male population and those aged 75–79 and 80 years and above than the baseline of 70–74 years old (table 1). The odds of being unvaccinated with one or two doses was higher in urban areas, particularly in London with an increased odds of 2.30 (95% CI 2.27 to 2.33) and 1.96 (95% CI 1.94

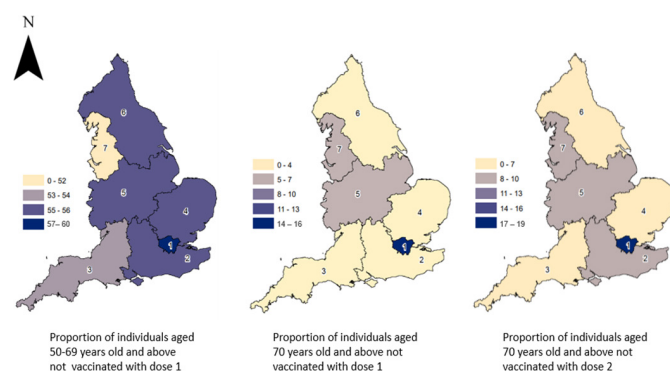


Figure 3 Proportion of individuals aged (A) 50–69 years not vaccinated with dose 1, (B) 70 years and above not vaccinated with dose 1 and (C) 70 years and above not vaccinated with dose 2 of COVID-19 vaccine (1: London; 2: South East; 3: South West; 4: East of England; 5: Midlands; 6: North East and Yorkshire; 7: North West).

Table 1 Number and proportion of individuals aged 70 years and above not vaccinated for dose 1 and dose 2 of the COVID-19 vaccine between 8 December 2020 and 17 May 2021 in England and the odds of being unvaccinated from a multivariable logistic regression and mean adjusted prevalence from the model fit

Characteristics	Dose 1			Dose 2			Dose 2 predictive margins (%) and 95% CI*
	Dose 1 not vaccinated n/N (%)	multivariable regression OR and 95% CI	Dose 1 predictive margins	Dose 2 not vaccinated n/N (%)	multivariable regression OR and 95% CI*	Dose 2 not vaccinated those with dose 1 n/n (%)	
Age (years)							
70–74	169 173/2 877 391 (5.9%)	Baseline	5.42% (5.39 to 5.44)	271 998/2 877 391 (9.5%)	Baseline	102 825/271 998 (37.8%)	9.14% (9.11 to 9.17)
75–79	100 478/2 086 215 (4.8%)	0.86 (0.85 to 0.87)	4.74% (4.72 to 4.77)	161 503/2 086 215 (7.7%)	0.82 (0.82 to 0.83)	61 025/161 503 (37.8%)	7.76% (7.72 to 7.79)
>80	140 785/2 830 943 (5.0%)	1.00 (1.00 to 1.01)	5.44% (5.41 to 5.46)	247 875/283 0943 (8.8%)	0.98 (0.97 to 0.98)	107 090/247 875 (43.2%)	8.95% (8.92 to 8.98)
Urban/Rural status							
Urban areas	348 992/5 906 988 (5.9%)	Baseline	5.46% (5.44 to 5.47)	571 598/5 906 988 (9.7%)	Baseline	222 606/571 598 (38.9%)	9.00% (8.98 to 9.02)
Rural areas	60 218/188 0742 (3.2%)	0.77 (0.76 to 0.77)	4.31% (4.28 to 4.35)	108 020/1 880 742 (5.7%)	0.81 (0.80 to 0.81)	47 802/108 020 (44.3%)	7.50% (7.45 to 7.54)
Other/Unknown	1226/6819 (18.0%)	–	–	1758/6819 (25.8%)	–	532/1758 (30.3%)	–
Clinically extremely vulnerable							
Not clinically extremely vulnerable	333 971/6 158 381 (5.4%)	Baseline	5.75% (5.73 to 5.77)	523 938/6 158 381 (8.5%)	Baseline	189 967/523 938 (36.3%)	8.93% (8.91 to 8.95)
Clinically extremely vulnerable	76 464/1 636 167 (4.7%)	0.61 (0.61 to 0.62)	3.72% (3.70 to 3.75)	157 437/1 636 167 (9.6%)	0.88 (0.87 to 0.89)	80 973/157 437 (51.4%)	8.01% (7.97 to 8.05)
Care home status							
Not in a care home	404 206/7 578 254 (5.3%)	Baseline	5.25% (5.24 to 5.27)	663 275/7 578 254 (8.8%)	Baseline	259 069/663 275 (39.1%)	8.67% (8.65 to 8.69)
In a care home	6230/216 295 (2.9%)	0.89 (0.87 to 0.91)	4.74% (4.63 to 4.85)	18 101/216 295 (8.4%)	1.18 (1.16 to 1.20)	11 871/18 101 (65.6%)	10.00% (9.86 to 10.13)
IMD deprivation decile							
Most deprived	44 759/515 973 (8.7%)	Baseline	9.47% (9.39 to 9.56)	76 750/515 973 (14.9%)	Baseline	31 991/76 750 (41.7%)	15.13% (15.03 to 15.23)
	47 804/567 221 (8.4%)	0.75 (0.74 to 0.76)	7.44% (7.38 to 7.50)	77 905/567 221 (13.7%)	0.76 (0.76 to 0.77)	30 101/77 905 (38.6%)	12.19% (12.11 to 12.27)
	47 565/627 241 (7.6%)	0.64 (0.64 to 0.65)	6.54% (6.49 to 6.60)	77 343/627 241 (12.3%)	0.66 (0.66 to 0.67)	29 778/77 343 (38.5%)	10.85% (10.78 to 10.93)
	45 373/722 661 (6.3%)	0.57 (0.57 to 0.58)	5.93% (5.87 to 5.98)	73 905/722 661 (10.2%)	0.59 (0.58 to 0.59)	28 532/73 905 (38.6%)	9.75% (9.69 to 9.82)
	42 635/796 652 (5.4%)	0.51 (0.5 to 0.52)	5.34% (5.29 to 5.39)	70 283/796 652 (8.8%)	0.52 (0.52 to 0.53)	27 648/70 283 (39.3%)	8.84% (8.78 to 8.9)
	40 935/858 303 (4.8%)	0.46 (0.45 to 0.46)	4.84% (4.79 to 4.88)	67 766/858 303 (7.9%)	0.47 (0.46 to 0.47)	26 831/67 766 (39.6%)	8.06% (8.00 to 8.12)
	38 086/894 485 (4.3%)	0.42 (0.41 to 0.43)	4.48% (4.44 to 4.52)	63 503/894 485 (7.1%)	0.43 (0.43 to 0.44)	25 417/63 503 (40.0%)	7.48% (7.42 to 7.53)
	36 684/918 054 (4.0%)	0.39 (0.39 to 0.4)	4.21% (4.16 to 4.25)	61 723/918 054 (6.7%)	0.41 (0.4 to 0.41)	25 039/61 723 (40.6%)	7.09% (7.04 to 7.14)
	33 833/934 779 (3.6%)	0.35 (0.34 to 0.35)	3.77% (3.73 to 3.81)	56 910/934 779 (6.1%)	0.36 (0.36 to 0.37)	23 077/56 910 (40.5%)	6.40% (6.35 to 6.44)
Least deprived	30 264/947 216 (3.2%)	0.31 (0.30 to 0.31)	3.40% (3.36 to 3.43)	51 417/947 216 (5.4%)	0.32 (0.32 to 0.33)	21 153/51 417 (41.1%)	5.79% (5.75 to 5.84)
Unknown	2498/11 964 (20.9%)	–	–	3871/11 964 (32.4%)	–	1373/3871 (35.5%)	–
Ethnicity							
White	204 842/6 555 567 (3.1%)	Baseline	3.23% (3.21 to 3.24)	409 220/6 555 567 (6.2%)	Baseline	204 378/409 220 (49.9%)	6.43% (6.41 to 6.45)
Mixed/Multiple ethnic	5446/34 247 (15.9%)	4.38 (4.25 to 4.52)	12.44% (12.12 to 12.75)	7612/34 247 (22.2%)	3.25 (3.17 to 3.34)	2166/7612 (28.5%)	17.87% (17.50 to 18.25)
Indian	11 881/121 720 (9.8%)	2.19 (2.14 to 2.23)	6.73% (6.61 to 6.85)	18257/121 720 (15.0%)	1.82 (1.79 to 1.85)	6376/18 257 (34.9%)	11.02% (10.87 to 11.18)
Pakistani	10 528/52 518 (20.0%)	5.26 (5.14 to 5.38)	14.47% (14.21 to 14.74)	18 530/52 518 (35.3%)	5.53 (5.42 to 5.63)	8002/18 530 (43.2%)	26.63% (26.28 to 26.97)
Other Asian or Asian	13 706/82 251 (16.7%)	3.72 (3.65 to 3.79)	10.80% (10.62 to 10.98)	19 797/82 251 (24.1%)	3.04 (2.99 to 3.09)	6091/19 797 (30.8%)	16.93% (16.70 to 17.16)
Black/African/Caribbean	29 981/103 294 (29.0%)	6.69 (6.58 to 6.79)	17.58% (17.37 to 17.79)	41 162/103 294 (39.8%)	5.36 (5.29 to 5.43)	11 181/41 162 (27.2%)	26.06% (25.81 to 26.31)
Other ethnic group	10 227/58 524 (17.5%)	4.16 (4.07 to 4.25)	11.89% (11.66 to 12.12)	13 907/58 524 (23.8%)	3.14 (3.07 to 3.2)	3680/13 907 (26.5%)	17.36% (17.09 to 17.64)
Not stated/Unknown	123 825/786 428 (15.7%)	6.00 (5.95 to 6.04)	16.12% (16.03 to 16.2)	152 891/786 428 (19.4%)	3.69 (3.66 to 3.71)	29 066/152 891 (19%)	19.73% (19.64 to 19.82)

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Table 1 Continued

Characteristics	Dose 1			Dose 2		
	Dose 1 not vaccinated n/N (%)	multivariable regression OR and 95% CI†	Dose 1 predictive margins	Dose 2 not vaccinated n/N (%)	Dose 2 vaccinated/ those with dose 1 n/n (%)	Dose 2 predictive multivariable regression OR and 95% CI†
Region						
East of England	42 261/97 1824 (4.3%)	Baseline	4.73% (4.69 to 4.78)	72 699/971 824 (7.5%)	30 438/72 699 (41.9%)	Baseline
London	108 877/792 575 (13.7%)	2.30 (2.27 to 2.33)	9.77% (9.70 to 9.83)	153 166/792 575 (19.3%)	44 289/153 166 (28.9%)	1.96 (1.94 to 1.98)
Midlands	69 371/1 515 414 (4.6%)	0.97 (0.96 to 0.98)	4.60% (4.57 to 4.63)	120 989/1 515 414 (8.0%)	51 618/120 989 (42.7%)	0.97 (0.96 to 0.98)
North East and Yorkshire	45 147/1 232 540 (3.7%)	0.77 (0.76 to 0.78)	3.74% (3.71 to 3.78)	83 505/1 232 540 (6.8%)	38 358/83 505 (45.9%)	0.80 (0.79 to 0.81)
North West	45 973/973 704 (4.7%)	0.95 (0.93 to 0.96)	4.51% (4.47 to 4.55)	82 655/973 704 (8.5%)	36 682/82 655 (44.4%)	0.97 (0.96 to 0.98)
South East	59 447/1 334 389 (4.5%)	1.11 (1.09 to 1.12)	5.18% (5.14 to 5.22)	102 275/1 334 389 (7.7%)	42 828/102 275 (41.9%)	1.10 (1.09 to 1.11)
South West	36 862/962 139 (3.8%)	0.90 (0.89 to 0.91)	4.30% (4.26 to 4.35)	62 216/962 139 (6.5%)	25 354/62 216 (40.8%)	0.88 (0.87 to 0.89)
Unknown	2498/11 964 (20.9%)	–	–	3 871/11 964 (32.4%)	1373/3871 (35.5%)	–
Sex						
Female	217 583/4 279 458 (5.1%)	Baseline	4.95% (4.93 to 4.97)	372 475/4 279 458 (8.7%)	154 892/372 475 (41.6%)	Baseline
Male	192 285/3 510 687 (5.5%)	1.16 (1.15 to 1.16)	5.62% (5.59 to 5.64)	305 672/3 510 687 (8.7%)	113 387/305 672 (37.1%)	1.03 (1.02 to 1.03)
Unknown	568/4404 (12.9%)	0.94 (0.84 to 1.04)	4.67 (4.24 to 5.09)	3229/4404 (73.3%)	2661/3229 (82.4%)	21.72 (19.92 to 23.69)

*The odds of having a complete course of COVID-19 vaccine compared with having an incomplete (one dose) or zero vaccines.

†The per cent vaccinated may fall outside the range of the predictive margins, as they are based on the effect of the adjusted multivariable model.

‡ Index of multiple deprivation (IMD)

to 1.98) odds for being unvaccinated for both dose 1 and dose 2, respectively (table 1).

Among those clinically extremely vulnerable, the odds of being unvaccinated was reduced (OR 0.61 (95% CI 0.61 to 0.62)) and (OR 0.88 (95% CI 0.87 to 0.89)) for dose 1 and dose 2, respectively compared with those with no significant underlying health conditions.

The odds of being unvaccinated among those living in a care home was also reduced for dose 1 (OR 0.89 (95% CI 0.87 to 0.91)) compared with those not living in a care home. However, the odds of being unvaccinated for dose 2 was 1.18 (95% CI 1.16 to 1.20) greater.

The greatest odds of being unvaccinated among those aged 70 years was among those living in the most deprived areas and among black/African/Caribbean ethnicities. Among the black/African/Caribbean ethnicity, the odds of not having a first dose was 6.69 (95% CI 6.58 to 6.79) greater than white British ethnicity. The odds of being unvaccinated with a second dose was 5.53 (95% CI 5.42 to 5.63) greater among the Pakistani ethnicity, followed by the black/African/Caribbean ethnicity with an odds of 5.36 (95% CI 5.29 to 5.43).

The mean prevalence of being unvaccinated for each characteristic within the adjusted multivariable model showed increased prevalence among the characteristics with the highest odds of being unvaccinated. The highest prevalence was among the black/African/Caribbean ethnic group for dose 1 with a mean prevalence of 17.6% unvaccinated. The prevalence among those unvaccinated with dose 1 was 26.6% and 26.1% among the Pakistani and black/African/Caribbean ethnicities, although the 95% CIs do overlap between the two ethnicities (table 1).

Individuals aged 50–69 years unvaccinated

Of those aged 50–69 years, all the characteristics were significantly associated with being unvaccinated in both the univariable and multivariable logistic regression analyses.

Similarly to those aged 70 years and above, the odds of being unvaccinated was higher among male population and increased in the younger population (table 1). The odds of being unvaccinated was higher in urban areas and particularly in London where there was an increased odds of 1.85 (95% CI 1.84 to 1.86) (table 2).

The greatest odds of being unvaccinated with dose 1 among 50–69 years age group was highest among those with an unknown or not stated ethnicity and black/African/Caribbean ethnicity which had a 3.40 (95% CI 3.38 to 3.41) and 3.32 (95% CI 3.29 to 3.34) increased odds of being unvaccinated compared with those of white British ethnicity (table 2).

Both the clinically extremely vulnerable/at-risk and healthcare workers had decreased odds of being unvaccinated than those that were not in these groups (OR 0.59 (95% CI 0.59 to 0.59) and 0.34 (95% CI 0.34 to 0.35), respectively) (table 2), showing a protective effect among those at highest risk of SARS-CoV-2 disease.

The highest predictive margin for being unvaccinated after adjusting for all variables in the multivariable logistic regression model was among the unknown/not stated and black/African/Caribbean ethnic groups with a prevalence of 24.7% and 23.9% unvaccinated, respectively (table 2).

DISCUSSION

As of 17 May 2021, 49.4% of the population aged 50 years and above in England had received a first dose of the COVID-19 vaccine and 28.1% had their second dose. Vaccine coverage for dose 1 among those aged 50 years, and for dose 2 for those aged 70 years and above, have plateaued. A significant increase in the number of individuals aged 50–69 years occurred in week 15 of the programme (the week commencing the 15 March 2021), when those aged 50–69 years became eligible for the vaccine.^{14 15} Individuals aged 50–69 years vaccinated in earlier weeks were most likely to have been healthcare workers, individuals clinically extremely vulnerable/cohort 6 at risk for SARS-CoV-2 disease.¹⁶

The overall proportion of individuals eligible for the vaccine but not vaccinated was highest in London, followed by the Midlands and East of England areas. These results coincide with findings from studies assessing predictors associated with influenza and shingles vaccine coverage, prior to mass immunisation,^{9 10 17} which offered vaccines to individuals in similar populations, such as elderly individuals and those at risk, in which lower coverage in London and in urban areas is observed, despite differences in delivery of the programmes. For example, the shingles vaccine is delivered opportunistically in GP practices, while influenza vaccines are more widely available, including in pharmacies. Overall vaccine coverage for the first dose of a COVID-19 vaccine among those aged 65 years and older was higher for COVID-19 than for seasonal influenza vaccines delivered in the 2020/2021 winter season (90.9% vs 80.9%).¹⁸

Results from the multivariable logistic regression model and the predictive margins for two doses among those aged 70 years and above, and for one dose among those aged 50–69 years, indicate increased odds and predicted margins of being unvaccinated with lower age groups. Should lower coverage among younger adults continue to be observed as the programme continues to roll out, efforts must be made to address this. Moreover, after adjusting for all variables in the multivariable models, the odds of being unvaccinated was higher among male compared with female population, in urban areas compared with rural areas and highest in London compared with other regions in England among individuals aged 50 years and above. Reduced odds of being unvaccinated was observed among those clinically extremely vulnerable/at risk aged 50 years and above, and among healthcare workers aged 50–69 years. These individuals were all eligible for the vaccine early in the programme.

Table 2 Number and proportion of individuals aged 50–69 years not vaccinated for dose 1 of the COVID-19 vaccine between 8 December 2020 and 17 May 2021 in England and the odds of being unvaccinated from a multivariable logistic regression and mean adjusted prevalence from the model fit

Characteristics		Dose 1 not vaccinated n/N (%)	Dose 1 multivariable regression OR and 95% CI	Dose 1 predictive margins (%) and 95% CI*
Age (years)	50–54	3 018 263/4 214 965 (71.6%)	Baseline	15.07% (15.04 to 15.10)
	55–64	4 485 055/7518 324 (59.7%)	0.81 (0.81 to 0.82)	12.82% (12.8 to 12.85)
	65–69	561 755/2 891 288 (19.4%)	0.51 (0.51 to 0.51)	8.72% (8.68 to 8.75)
Urban/Rural status	Urban areas	6 418 686/11 552 097 (55.6%)	Baseline	13.17% (13.15 to 13.19)
	Rural areas	1 632 703/3 052 642 (53.5%)	0.75 (0.74 to 0.75)	10.39% (10.35 to 10.43)
	Other/Unknown	13 684/19 838 (69.0%)	–	–
Clinically extremely vulnerable/at risk (cohort 6)	Not at risk	6 501 682/10 368 328 (62.7%)	Baseline	14.18% (14.16 to 14.20)
	At risk	156 339/1 425 249 (36.7%)	0.59 (0.59 to 0.59)	9.25% (9.22 to 9.28)
Healthcare worker	Not healthcare worker	8 003 303/14 162 182 (56.5%)	Baseline	12.94% (12.93 to 12.96)
	Healthcare worker	61 770/462 395 (13.4%)	0.34 (0.34 to 0.35)	5.22% (5.16 to 5.28)
IMD deprivation decile	Most deprived	760 885/1 290 391 (59.0%)	Baseline	20.57% (20.50 to 20.65)
		782 255/1 339 803 (58.4%)	0.74 (0.74 to 0.75)	16.52% (16.46 to 16.58)
		795 155/1 383 303 (57.5%)	0.66 (0.65 to 0.66)	15.00% (14.95 to 15.06)
		803 307/1 437 917 (55.9%)	0.59 (0.59 to 0.60)	13.88% (13.82 to 13.93)
		806 095/1 479 989 (54.5%)	0.53 (0.53 to 0.53)	12.69% (12.64 to 12.74)
		816 104/1 522 404 (53.6%)	0.47 (0.47 to 0.48)	11.60% (11.55 to 11.65)
		815 712/1 528 345 (53.4%)	0.43 (0.43 to 0.43)	10.72% (10.67 to 10.77)
		816 165/1 543 302 (52.9%)	0.40 (0.39 to 0.40)	9.97% (9.93 to 10.02)
		814 550/1 530 600 (53.2%)	0.36 (0.35 to 0.36)	9.14% (9.10 to 9.19)
	Least deprived	830 441/1 534 627 (54.1%)	0.32 (0.31 to 0.32)	8.23% (8.19 to 8.28)
	Unknown	24 404/33 896 (72.0%)	–	–
Ethnicity	White	5 532 177/10 821 112 (51.1%)	Baseline	9.07% (9.05 to 9.08)
	Mixed/Multiple ethnic	84 371/135 124 (62.4%)	2.60 (2.57 to 2.64)	19.97% (19.77 to 20.16)
	Indian	152 271/325 697 (46.8%)	1.19 (1.18 to 1.20)	10.55% (10.45 to 10.64)
	Pakistani	130 526/197 437 (66.1%)	2.48 (2.46 to 2.51)	19.26% (19.10 to 19.42)
	Other Asian or Asian	177 291/305 023 (58.1%)	1.56 (1.54 to 1.57)	13.24% (13.13 to 13.35)
	Black/African/Caribbean	306 972/450 853 (68.1%)	3.32 (3.29 to 3.34)	23.87% (23.75 to 23.98)
	Other ethnic group	139 813/217 886 (64.2%)	2.61 (2.59 to 2.64)	20.01% (19.86 to 20.16)
	Not stated/Unknown	1 541 652/2 171 445 (71.0%)	3.40 (3.38 to 3.41)	24.27% (24.21 to 24.32)
Region	East of England	966 550/1 721 713 (56.1%)	Baseline	11.86% (11.81 to 11.91)
	London	1 197 210/2 056 938 (58.2%)	1.85 (1.84 to 1.86)	19.14% (19.09 to 19.19)
	Midlands	1 508 576/2 758 546 (54.7%)	0.98 (0.98 to 0.99)	11.69% (11.66 to 11.73)
	North East and Yorkshire	1 245 671/2 284 027 (54.5%)	0.80 (0.79 to 0.81)	9.85% (9.81 to 9.89)
	North West	967 344/1 865 618 (51.9%)	0.99 (0.98 to 1.00)	11.77% (11.73 to 11.81)
	South East	1 321 417/2 353 321 (56.2%)	1.05 (1.05 to 1.06)	12.37% (12.32 to 12.41)
	South West	833 901/1 550 518 (53.8%)	0.88 (0.88 to 0.89)	10.70% (10.65 to 10.76)
	Unknown	24 404/33 896 (72.0%)	–	–

Continued

Table 2 Continued

Characteristics		Dose 1 not vaccinated n/N (%)	Dose 1 multivariable regression OR and 95% CI	Dose 1 predictive margins (%) and 95% CI*
Sex	Female	3 659 928/7 229 063 (50.6%)	Baseline	11.45% (11.42 to 11.47)
	Male	4 388 976/7 376 483 (59.5%)	1.27 (1.27 to 1.28)	13.87% (13.84 to 13.89)
	Unknown	16 169/19 031 (85.0%)	0.78 (0.75 to 0.81)	9.33% (9.01 to 9.65)

*The per cent vaccinated may fall outside the range of the predictive margins, as they are based on the effect of the adjusted multivariable model.

Individuals aged 70 years and above living in care homes had reduced odds of being unvaccinated for dose 1 compared with those not living in a care home. In contrast, care home residents had increased odds of being unvaccinated for the second dose compared with those living in a care home. The delivery of COVID-19 vaccines to care homes was primarily carried out by mobile teams that required a lot of logistics and coordination.¹⁹ The delivery of second doses of COVID-19 vaccinations in care homes may be lower because it was difficult to follow-up on individuals who were not vaccinated or partially vaccinated and moved into a care home after or between mobile vaccination unit visits. It is important to further investigate the increased odds of being unvaccinated with dose 2 in care homes, as residents have been disproportionately affected by SARS-CoV-2.²⁰ It is unlikely that the death rates are associated with low coverage because deaths are recorded in a timely manner in the NIMS,²¹ although it is possible that care home residents might have had COVID-19 or another illness at the time of offer, thus causing a lag in the number of second doses received.

Both the highest odds and the predictive margins for being unvaccinated for dose 1 among all individuals in the study and for dose 2 among those aged 70 years and above were observed in the most deprived and among the black/African/Caribbean ethnicity. This coincides with findings assessing COVID-19 vaccine coverage for those aged 70 years and above using the 2011 Office for National Statistics (ONS) denominator population estimates²² and using general practice records for population estimates based on registrations for two of the three GP IT System Suppliers in England.²³ Furthermore, among those aged 70 years and above, the odds and prevalence of being unvaccinated among those of Pakistani ethnicity further increased for dose 2.

Our findings highlight the structural and complex interplay of ethnicity and deprivation, which has also been observed with findings on SARS-CoV-2 infection, hospitalisations and mortality.^{24 25} This also concurs with a study assessing households in the UK that found individuals of an ethnic minority and a lower socioeconomic status were associated with greater COVID-19 vaccine hesitancy.²⁶

Strengths and limitations of this study

Our study has several strengths. This is the first study assessing characteristics associated with COVID-19 vaccine coverage for all individuals aged 50 years and above in England, and one of the first studies globally assessing COVID-19 vaccine coverage. Our study also uses data from the NIMS, which is likely to be more complete than other datasets used to estimate COVID-19 vaccine coverage because it is based on all individuals in England with a registered NHS number. Furthermore, immunisation registers have proven to be fundamental when assessing and protecting the population, can be used for linkage to health-outcome databases and can play a key role in the delivery of a national immunisation programme.^{27–29} This is the first time England has developed a centralised national system capturing individual-level data for both vaccination status and demographic characteristics. Previous studies assessing factors influencing vaccine coverage in England have been based on aggregate general practice-level data, in which estimates such as deprivation were based on the general practice postcode. Having individual-level data for front-line healthcare workers, care home residents and others allowed us to link individual NHS numbers to properly account for factors relating to these individuals. Such granular data are not available in similar studies or in general practice records.

We are unable to capture details on the total number of individuals without an NHS number and, of those who had not received a vaccine. Therefore, it is possible we have underestimated the number of vaccines delivered and odds of being unvaccinated for characteristics such as ethnic groups in which we have seen the greatest impact. The proportion of individuals aged 50 years and above with no NHS number is expected to be marginal. The NIMS population estimates are larger compared with the 2020 ONS mid-year population estimates (online supplemental figure 1), thus possibly overestimating population estimates. However, ONS estimates are based on the 2011 census and do not take into account any changes or movements throughout the pandemic, which may be reflected in NHS records.³⁰ Furthermore, it is possible that there could be residual errors in data entry on the point-of-care applications at the vaccination sites, although these errors

are not widespread. Although the NIMS was rapidly set up for monitoring COVID-19 vaccinations, it was piloted with influenza vaccinations delivered in the 2020/21 influenza season and the trends observed in our study align with other immunisation programmes.

CONCLUSIONS

This study provides evidence that in England, being male, being in a younger age group, belonging to certain minority groups, living in urban setting or being a care home resident were associated with low COVID-19 vaccine coverage. The largest odds of being unvaccinated was observed among those of black/African/Caribbean ethnicity and those in the most deprived decile. It is of utmost importance to reduce inequalities in vaccine coverage, particularly among black, Asian and minority ethnic groups, and care home residents who have been most impacted by the SARS-CoV-2 infection. The delivery of the COVID-19 vaccination programme should continue to be investigated. Delivery strategies, such as the use of mass immunisation sites and mobile vaccination units for populations where vaccine coverage is lower, should be evaluated to determine whether it could be applied to routine immunisations. As vaccine coverage increases in England, tailored strategies that consider barriers specific to undervaccinated groups, such as vaccine hesitancy,³¹ should be designed and implemented to improve COVID-19 vaccine coverage.

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