

Monitoring sociodemographic inequality in COVID-19 vaccination uptake in England: a national linked data study

Ted Dolby,¹ Katie Finning ,¹ Allan Baker,² Leigh Fowler-Dowd,² Kamlesh Khunti,^{3,4,5} Cameron Razieh,^{1,3,5} Thomas Yates,^{3,5} Vahe Nafilyan ^{1,6}

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¹Health Analysis and Life Events division, Office for National Statistics, Newport, UK

²Population Health Analysis Team, Office for Health Improvement and Disparities, Department of Health and Social Care, London, UK

³NIHR Leicester Biomedical Research Centre, Leicester, UK

⁴University Hospitals of Leicester NHS Trust, Leicester, UK

⁵Diabetes Research Centre, University of Leicester, Leicester, UK

⁶London School of Hygiene & Tropical Medicine, London, UK

Correspondence to

Dr Katie Finning, Office for National Statistics, Newport, Newport, UK; katie.finning@ons.gov.uk

TD and KF contributed equally.

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ABSTRACT

Background The UK began an ambitious COVID-19 vaccination programme on 8 December 2020. This study describes variation in vaccination uptake by sociodemographic characteristics between December 2020 and August 2021.

Methods Using population-level administrative records linked to the 2011 Census, we estimated monthly first dose vaccination rates by age group and sociodemographic characteristics among adults aged 18 years or over in England. We also present a tool to display the results interactively.

Results Our sample included 35 223 466 adults. A lower percentage of males than females were vaccinated in the young and middle age groups (18–59 years) but not in the older age groups. Vaccination rates were highest among individuals of White British and Indian ethnic backgrounds and lowest among Black Africans (aged ≥80 years) and Black Caribbeans (18–79 years). Differences by ethnic group emerged as soon as vaccination roll-out commenced and widened over time. Vaccination rates were also lower among individuals who identified as Muslim, lived in more deprived areas, reported having a disability, did not speak English as their main language, lived in rented housing, belonged to a lower socioeconomic group, and had fewer qualifications.

Conclusion We found inequalities in COVID-19 vaccination uptake rates by sex, ethnicity, religion, area deprivation, disability status, English language proficiency, socioeconomic position and educational attainment, but some of these differences varied by age group. Research is urgently needed to understand why these inequalities exist and how they can be addressed.

INTRODUCTION

The UK began an ambitious vaccination programme to combat the COVID-19 pandemic on 8 December 2020; by 27 September 2021, 89.6% of the UK adult population had received their first dose.¹ Previous research demonstrates that rates of vaccination for a variety of diseases are lower among certain ethnic groups and in areas of higher deprivation,^{2–5} and that rates of COVID-19 vaccination differ by sociodemographic factors, religion, and certain underlying health conditions.^{6,7} However, the evidence for COVID-19 vaccination rates has so far focused on older adults and the clinically vulnerable, who were initially prioritised for vaccination. Less is known about COVID-19 vaccination

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Several studies have reported differences in COVID-19 vaccination uptake by characteristics such as ethnicity and religion, however, these have focused on older adults and the clinically vulnerable who were initially prioritised for vaccination. There is little evidence on sociodemographic inequalities in vaccination uptake among younger adults and evidence is also lacking on uptake by a wider range of characteristics such as sex, disability status, English language proficiency, socio-economic position, and educational attainment.

WHAT THIS STUDY ADDS

⇒ This study provides the first evidence for sociodemographic inequalities in COVID-19 vaccination uptake among the entire adult population in England, using population-level administrative records linked to the 2011 Census. We demonstrated that COVID-19 vaccination rates in adults aged 18 years and over differed by sex, ethnic group, religious affiliation, area deprivation, disability status, English language proficiency, household tenure, socioeconomic classification, and educational attainment. By disaggregating the data by age group, we were able to show for the first time that disparities in uptake by some sociodemographic characteristics differ by age group.

WHAT THIS STUDY ADDS, HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY

⇒ Many of the groups with the lowest rates of COVID-19 vaccination are also the groups that have been disproportionately affected by the pandemic, including severe illness and mortality. Research is urgently needed to understand why these disparities exist and how they can be addressed, for example through public health or community engagement programmes. Since the relationships between sociodemographic characteristics and vaccination uptake may differ by age group, it is important for future research to disaggregate by age group when examining these inequalities.

rates among younger adults, or about differences in the impact of sociodemographic factors across different age groups.

Understanding which sociodemographic, economic and cultural factors are associated with lower vaccination rates across the whole adult population has major implications for the design of policies that help to maximise coverage of the vaccination campaign. Achieving a high rate of vaccination in the population and not just in those at the highest risk is critical to slow infection, reduce hospital admissions, and help healthcare systems and countries recover from the pandemic.⁸ Understanding socio-demographic inequalities in vaccination rates may also provide insights into how the vaccination programme could be tailored to improve uptake among certain groups. This is especially important given that inequalities in the social determinants of health, such as occupation and access to healthcare, have been particularly influential during the COVID-19 pandemic and disproportionately impact some of the same groups for whom vaccination rates are reported to be low.⁹

This study investigates inequality in vaccination rates by age group and sociodemographic characteristics among adults aged 18 years or over in England, using population-level administrative records linked to the 2011 Census. This dataset enables examination of a wide range of sociodemographic characteristics lacking in previously published studies including age, sex, ethnicity, religious affiliation, area deprivation, disability status, English language proficiency, socioeconomic classification and educational attainment.

METHODS

Data

We linked vaccination data from the National Health Service (NHS) England and NHS Improvement's National Immunisation Management System (NIMS) to the Office for National Statistics (ONS) Public Health Data Asset (PHDA) based on NHS number (a unique identifier). The ONS PHDA is a linked dataset that includes the 2011 Census, mortality records, and the General Practice Extraction Service (GPES) data for pandemic planning and research. To obtain NHS numbers for the 2011 Census, we linked the 2011 Census to the 2011–2013 NHS Patient Registers using deterministic and probabilistic matching, with an overall linkage rate of 94.6%. All subsequent linkages were performed based on NHS numbers. The study population consisted of adults aged 18 years or over, alive on 8 December 2020, who were resident in England, registered with a general practitioner, and enumerated at the 2011 Census. Of 38 066 935 adults aged 18 years or over who received a first dose of a COVID-19 vaccine in NIMS, 30 505 356 (80.1%) were linked to the ONS PHDA.

Outcome

The outcome was having received at least one dose of any COVID-19 vaccine as recorded in NIMS on 15 September 2021. To calculate cumulative rates, vaccination status was assessed on the last day of each month from December 2020 to August 2021.

Exposures

This dataset contains comprehensive sociodemographic information from the 2011 Census and geographical information from GPES. Demographic and socioeconomic characteristics including age, sex, ethnicity, religion, socioeconomic status and self-reported disability status were based on the 2011 Census. We used a 10-category ethnic group classification (white British, Bangladeshi, black African, black Caribbean, Chinese, Indian,

mixed, other, Pakistani, white other). Region, urban/rural status and area deprivation (Index of Multiple Deprivation, IMD¹⁰) were derived from the 2019 GPES. We also considered English language proficiency, educational attainment, the National Statistics Socio-Economic Classification (NS-SEC) and household tenure, all of which were drawn from the 2011 Census. All variables included in this analysis and their source are listed in online supplemental table S1.

Statistical analyses

Descriptive statistics were used to calculate monthly first dose vaccination rates by age group and demographic and socioeconomic characteristics. For every month between December 2020 and August 2021 and for each age group, we estimated the proportion of people who had received at least a first dose of a COVID-19 vaccination by the end of the month, restricting the sample to people alive at the end of the month. Plots were produced to provide a visual summary of vaccination uptake over time by demographic and socioeconomic characteristics. Analyses were conducted using R V.3.5; code is available via GitHub (katiefinling1/Vaccine uptake.txt).

Data sharing statement

All data used in this paper are displayed on the COVID-19 Health Inequalities Monitoring for England (CHIME) tool.¹¹

RESULTS

Characteristics of sample

Table 1 summarises the characteristics of the sample, of which 52.4% were female, 82.4% identified as White British, 60.5% identified as Christian and 14.5% reported having a disability and being limited a little (8.8%) or a lot (5.7%) in their daily activities.

Inequality in vaccination uptake

When examining all age groups combined, vaccination uptake was higher among females compared with males (figure 1). When stratified by age group this difference was pronounced among younger adults, particularly the 18–29, 30–39, 40–49 and, to a lesser extent, 50–59 years old age groups. Among those aged 60 years and over, vaccination rates were approximately equivalent for males and females. The sex difference observed in the younger age groups was widest in the earlier months of vaccination roll-out and has since narrowed but has not been eliminated (figure 1). As at the end of August 2021, 24% of females aged 18–29 years and 21% of females aged 30–39 years had not received their first vaccination, compared with 29% and 25% of males in the same age groups, respectively.

In all age groups combined, vaccination rates were highest among White British and Indian ethnic groups, and lowest among black Caribbean, black African, mixed and Pakistani ethnic groups (figure 2). However, these ethnic differences varied according to age group. For example, among those aged 18–29 years, vaccination rates were highest for those identifying as Indian followed by Chinese and white British; whereas in the 80 years and over age group, uptake was greatest for those identifying as white British followed by Indian and white other. In the 80 years and over age group uptake was lowest for individuals of Black African ethnic background, but among all other age groups uptake was lowest for individuals of black Caribbean ethnic background. Differences in vaccination uptake by ethnic group emerged as soon as vaccination roll-out began and tended to widen over time (figure 2). At the end of August 2021, 57% of

Table 1 Characteristics of the study population

Characteristic	Level	No (%)	
Sex	Female	18 455 496 (52.4)	
	Male	16 767 970 (47.6)	
Age (years)	18–29	6 024 663 (17.1)	
	30–39	5 196 626 (14.8)	
	40–49	5 561 817 (15.8)	
	50–59	6 430 167 (18.3)	
	60–69	5 234 144 (14.9)	
	70–79	4 263 033 (12.1)	
Ethnicity	80+	2 513 016 (7.1)	
	Bangladeshi	270 035 (0.8)	
	Black African	538 586 (1.5)	
	Black Caribbean	378 063 (1.1)	
	Chinese	187 646 (0.5)	
	Indian	946 289 (2.7)	
	Mixed	584 822 (1.7)	
	Other	858 255 (2.4)	
	Pakistani	708 387 (2.0)	
	White British	29 024 719 (82.4)	
	White other	1 726 664 (4.9)	
	Religion	Buddhist	146 584 (0.4)
		Christian	21 309 133 (60.5)
		Hindu	537 242 (1.5)
Jewish		159 557 (0.5)	
Muslim		1 598 295 (4.5)	
Sikh		292 093 (0.8)	
Other religion		162 467 (0.5)	
No religion		8 808 882 (25.0)	
Religion not stated		2 209 213 (6.3)	
Disability status		Not limited	30 095 777 (85.4)
	Limited a little	31,101,61 (8.8)	
	Limited a lot	2 017 528 (5.7)	
Index of Multiple Deprivation Quintile	1 (Most deprived)	6 487 968 (18.4)	
	2	6 875 573 (19.5)	
	3	7 186 492 (20.4)	
	4	7 325 184 (20.8)	
	5 (Least deprived)	7 348 249 (20.9)	
Household tenure	Owned	24 190 067 (68.7)	
	Private rented	4 991 430 (14.2)	
	Social rented	5 183 538 (14.7)	
	Other	556 343 (1.6)	
	Not classified	302 088 (0.9)	
English Language Proficiency	Main language	32 762 210 (93.0)	
	Not main language	2 461 256 (7.0)	
Educational Attainment	Level 4+	8 866 351 (30.4)	
	Level 3	3 608 197 (12.4)	
	Apprenticeship	1 061 770 (3.6)	
	Level 2	4 326 004 (14.8)	
	Level 1	4 065 820 (13.9)	
	Other	1 593 068 (5.5)	
	No qualification	5 677 593 (19.4)	
	National Statistics Socio-Economic Classification	1 Higher managerial, administrative and professional occupations	4 957 652 (14.1)
2 Lower managerial, administrative and professional occupations		8 210 886 (23.3)	
3 Intermediate occupations		3 687 464 (10.5)	

Continued

Table 1 Continued

Characteristic	Level	No (%)
	4 Small employers and own account workers	4 651 919 (13.2)
	5 Lower supervisory and technical occupations	3 086 562 (8.8)
	6 Semi-routine occupations	4 454 670 (12.6)
	7 Routine occupations	4 150 251 (11.8)
	8 Never worked and long-term unemployed	1 209 877 (3.4)
	Not classified	814 185 (2.3)

Note: Adults aged 18 years and over living in England, alive on 8 December 2020.

adults in England identifying as black Caribbean had received at least one dose of COVID-19 vaccination, compared with 90% of adults identifying as white British and 88% of those identifying as Indian.

Vaccination rates also varied across religious groups (figure 3). When all age groups were combined, individuals identifying as Muslim had markedly lower vaccination rates than other religious groups, while those belonging to Hindu and Christian religious groups had the highest vaccination uptake. When stratified by age group, adults identifying as Christian had the highest rates of vaccination among those aged 70–79 and 80 years and over, but in the younger age groups uptake among Christians was comparatively lower and was greatest among those identifying as Hindu (figure 3). At the end of August 2021, 71% of adults identifying as Muslim had received at least one dose of COVID-19 vaccination, compared with 90% of adults identifying as Hindu or Christian.

In the early months of vaccination roll-out for each age group, uptake rates followed similar trajectories for individuals in different IMD groups, but differences emerged in later months, with uptake lowest among those living in the most deprived areas (IMD quintile 1) and highest among those in the least deprived areas (IMD quintile 5) (figure 4). These differences were greater among the younger age groups. At the end of August 2021, 40% of individuals aged 18–29 years living in the most deprived areas had not been vaccinated, compared with 17% of adults of the same age living in the least deprived areas. For individuals aged 80 years and over these percentages were 5% and 2%, respectively.

Across most age groups, vaccination rates were initially higher for individuals with a disability compared with those with no disability (figure 5). However, vaccination rates among those with no disabilities increased in later months, and once uptake plateaued within each age group the overall proportion of people vaccinated was marginally lower among those with disabilities (figure 5).

Vaccination rates also differed by English language proficiency, household tenure, NS-SEC and educational attainment (see online supplemental figure S1–S4). In all age groups a greater proportion of individuals who speak English as their main language had been vaccinated compared with those who did not speak English as their main language (online supplemental figure S1). Among all age groups vaccination uptake was highest for adults who own their own home (online supplemental figure S2). Uptake was lowest in those living in social rented housing among the 18–29 and 30–39 year old age groups and lowest in those living in private rented housing among the 50 years and over age groups. Vaccination rates were highest among adults in NS-SEC group 1 (higher managerial, administrative and

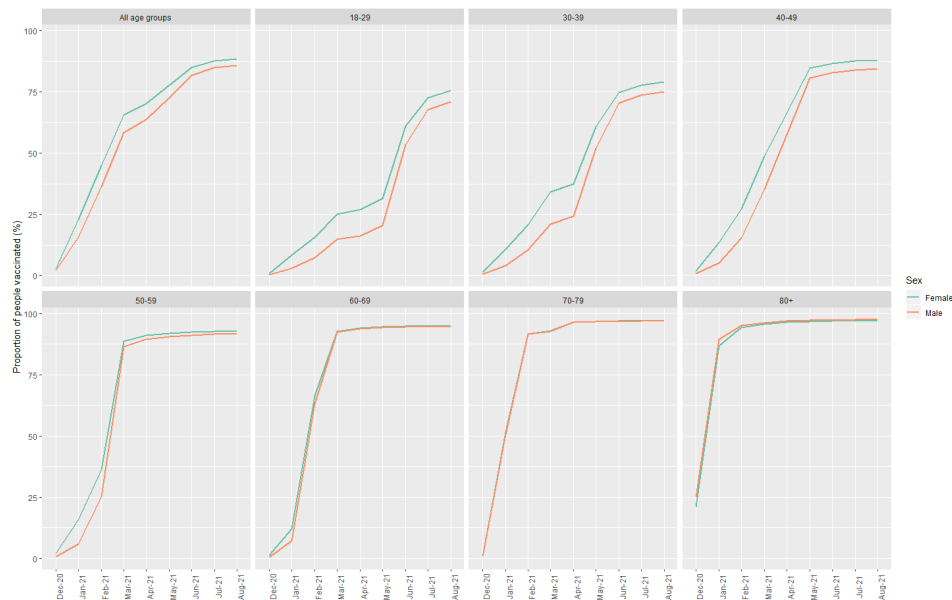


Figure 1 Proportion of people who received at least one dose of COVID-19 vaccination over time, by sex and age group.

professional occupations) and lowest among those in NS-SEC group 8 (never worked and long-term unemployed) (online supplemental figure S3). As at the end of August 2021, 92% of adults in NS-SEC group 1 had received at least their first dose of COVID-19 vaccination compared with 70% of adults in NS-SEC group 8. Finally, there were differences in vaccination uptake by educational attainment, although this varied according to age group (online supplemental figure S4). In the youngest age groups individuals in attainment categories level 3 (A-level or equivalent) and level 4+ (degree or equivalent) had the highest vaccination rates, whereas in the 50–59 and older age groups vaccination rates were highest among those with an apprenticeship. Among all age groups vaccination uptake was lowest in those with ‘other’ qualifications, and as at the end of August 2021, 83% of adults in England whose highest qualification was

‘other’ had been vaccinated compared with 93% of adults with an apprenticeship and 91% of those with a degree or equivalent.

DISCUSSION

Main findings of this study

Using whole population level linked data in England, our analysis demonstrated that first dose vaccination rates in adults aged 18 years and over differed by sex, ethnic group, religious affiliation, area deprivation, disability status, English language proficiency, household tenure, NS-SEC and educational attainment. In addition, some of these differences varied by age group.

What is already known on this topic

Lower rates of vaccination among ethnic minority groups, particularly Black ethnic groups, have been reported for a variety of

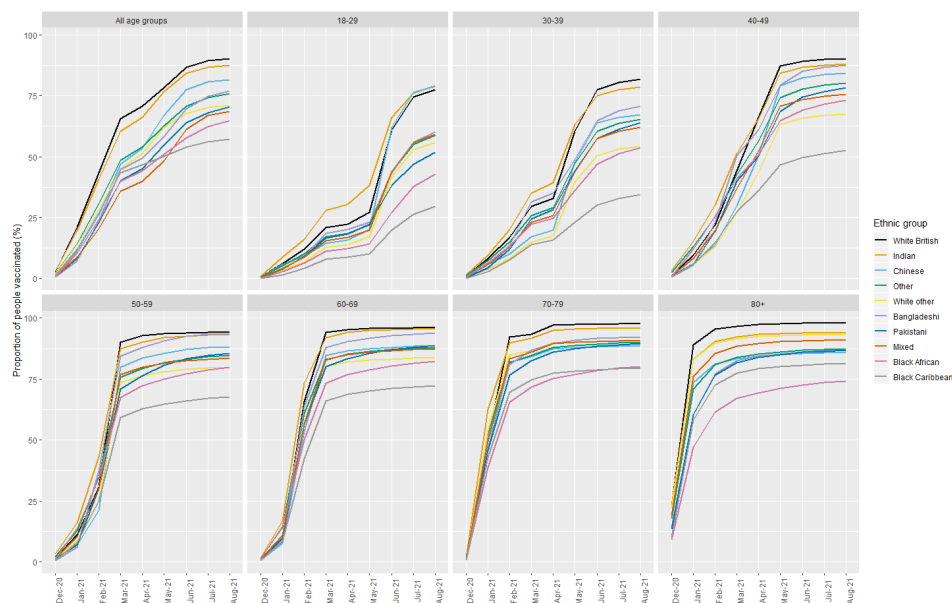


Figure 2 Proportion of people who received at least one dose of COVID-19 vaccination over time, by ethnic group and age group.

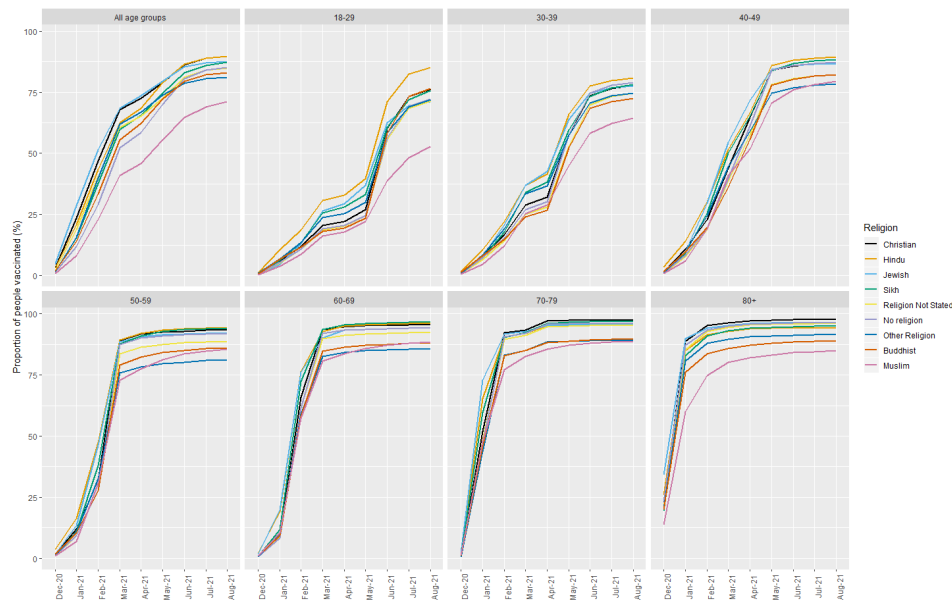


Figure 3 Proportion of people who received at least one dose of COVID-19 vaccination over time, by religion and age group.

diseases including COVID-19, although studies on the latter have previously focused on older adults.^{2-4 6 7 12} A study of seasonal influenza vaccination in England found that uptake was highest among Asian adults aged 18–64.⁴ While different ethnic categories were used in the current study, we did find high uptake among Indian and younger Chinese adults. Religion was recognised as a potential factor in vaccination behaviour prior to COVID-19¹³ and two recent analyses of COVID-19 vaccination among older adults in England found that, after adjusting for geographical and sociodemographic factors, uptake was lowest among individuals identifying as Muslim, Buddhist or other Religion.^{6 14} Greater area deprivation has been associated with lower rates of vaccination in general, and against COVID-19 specifically, although again evidence for the latter has been limited to older adults.²⁻⁷ Our results are also in line

with ecological evidence from the USA, showing a negative association between poverty and vaccination uptake in older adults.¹⁵ Few studies have explored COVID-19 vaccination uptake by sex or disability status. One study of adults aged 80 years and over reported no difference in uptake by sex, and slightly higher uptake among those with physical comorbidities.⁷ Likewise, a recent study reported slightly higher rates of vaccine uptake among adults aged 70 years and over with a disability compared with those without.⁶

What this study adds

We provided novel evidence for COVID-19 vaccination rates by sociodemographic characteristics among adults in England. Unlike previous studies, we disaggregated uptake by age group,

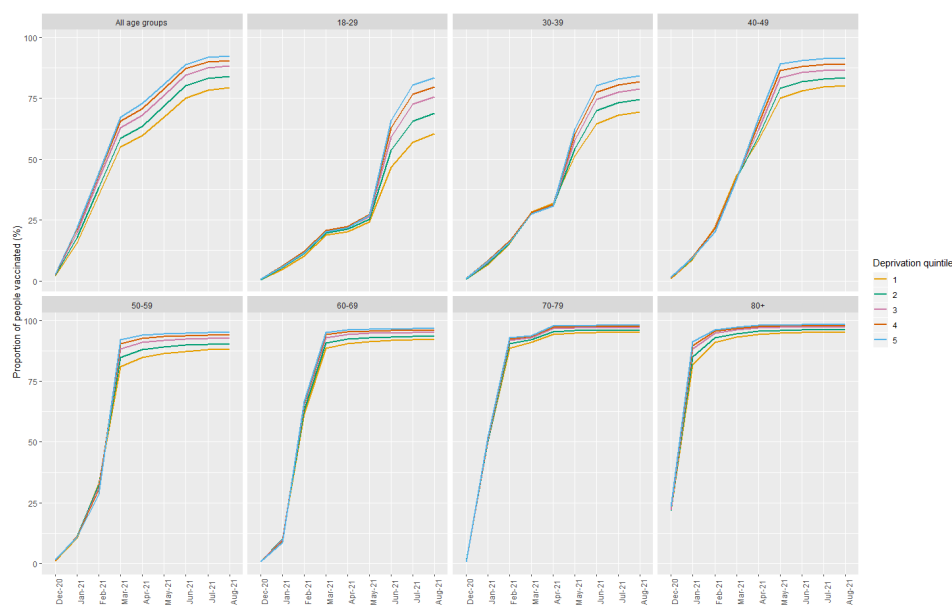


Figure 4 Proportion of people who received at least one dose of COVID-19 vaccination over time, by Index of Multiple Deprivation (IMD) quintile and age group. Note: IMD quintile one indicates those living in the most deprived areas and quintile five indicates those living in the least deprived areas.

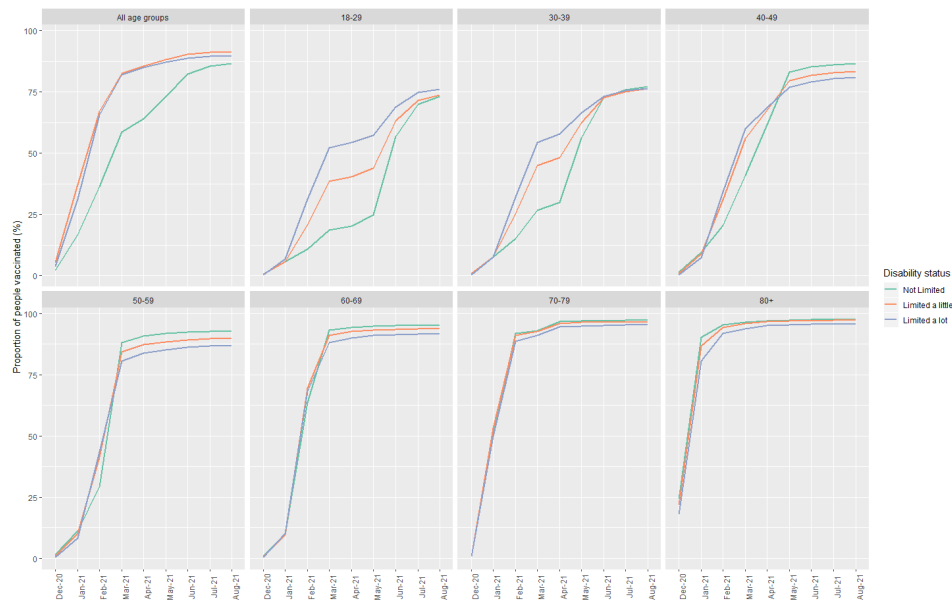


Figure 5 Proportion of people who received at least one dose of COVID-19 vaccination over time, by disability status and age group.

which showed that disparities in vaccination uptake by sociodemographic characteristics differed according to age group. This highlights the importance of separating age groups when examining vaccination uptake.

While previous studies have shown lower vaccination rates among Black ethnic groups in general, we demonstrated that the lowest uptake was for black Africans in the 80 years and over age group, and Black Caribbeans in all other age groups. We also found, for the first time, high rates of vaccination among young adults belonging to Indian and Chinese ethnic groups. Our results add to mounting evidence that vaccination uptake is particularly low among Muslim individuals. Like previous research, we found no evidence for sex differences in vaccination rates among older adults. However, by disaggregating our data by age group we demonstrated for the first time that there were sex differences between the ages of 18 and 59, with greater uptake among females compared with males in this age group. This sex difference was greatest in the initial months of roll-out of the vaccination programme, which may be due to the greater proportion of women in health and social care roles who were initially prioritised for vaccination. However, this sex difference has not been eliminated over time. Our findings are consistent with previous studies showing that vaccination uptake is lower among people with disabilities and in those living in more deprived areas, however we additionally found that the differences in uptake by area deprivation appeared to be greater among younger adults.

Strengths and limitations

A major strength of this study is the use of nationwide linked population-level data from clinical records and the 2011 Census. Unlike studies based solely on electronic health records, we were able to examine a wide range of sociodemographic characteristics; and unlike surveys, we were able to precisely estimate vaccination rates for small groups, due to the large size of the overall sample. Unlike previous research that has focused on initial months of the vaccination programme in England and is therefore limited to certain groups such as older adults and the clinically vulnerable, our data spans the entire vaccination programme between December 2020 and August 2021 and is

therefore more representative of the whole adult population. This also enabled us to examine vaccination rates by age group in addition to other sociodemographic characteristics. Another strength of this study is the publication of up-to-date vaccination rates broken down by sociodemographic characteristics on the COVID-19 Health Inequalities Monitoring for England tool.¹¹ The tool provides the opportunity for users to monitor inequalities in vaccination rates over time, as it will be updated with new data every month. This paper presents the data used in this new tool, which is a key part of the surveillance system designed to help the COVID-19 policy response.

A limitation of this study is that most of the demographic and socio-economic characteristics were derived from the 2011 Census and are therefore 10 years old. We focused primarily on characteristics that are unlikely to change over time, such as ethnicity and religion, but for characteristics that are more likely to change over time, such as disability status, the time difference may introduce some bias. However, we would expect this to dilute any differences observed rather than over-inflate them, because we will be missing new disabilities. Area deprivation was derived from GPES and measured in 2019 and is therefore not subject to the same bias. Because the PHDA was based on the 2011 Census, it excluded people who were living in England in 2011 but did not take part in the Census, as well as respondents who could not be linked to the 2011–2013 NHS patient register and recent migrants. As a result, we excluded 19.9% of vaccinated people who could not be linked to the PHDA and our population may not be fully representative of the population living in England.

All the analyses presented in this paper were descriptive and stratified by, but did not adjust for, likely confounders. Descriptive statistics were the most appropriate method for examining differences in vaccination rates to identify areas of greatest public health priority, and enabled us to stratify by the main confounder, which is age. A previous study in older adults showed that adjusting for covariates only marginally reduced differences in COVID-19 vaccination uptake by ethnic group, religious affiliation, and area deprivation.⁶ While our analysis enabled us to demonstrate sociodemographic inequalities in vaccination uptake, it did not enable exploration of the

underlying reasons for these inequalities, and this should be a key focus for future research. Understanding the reasons for low uptake among certain groups could help to inform the development of public health or community engagement programmes aimed at increasing uptake in these groups. This is especially important given that some of the groups for whom vaccination uptake is lowest have also been disproportionately affected by the COVID-19 pandemic, including an increased risk of severe illness and mortality.^{16 17}

CONCLUSION

There are differences in COVID-19 vaccination rates over time by sex, ethnic group, religious affiliation, area deprivation, disability status, English language proficiency, socioeconomic position and educational attainment, but some of these differences vary by age group, highlighting the importance of disaggregating age groups when examining vaccination uptake. Many of the groups with lowest vaccination uptake are the ones that have been disproportionately affected by the pandemic, including severe illness and mortality, and research is urgently needed to understand why these disparities exist and how they can be addressed, for example, through public health or community engagement programmes.

Twitter Katie Finning @katiefinning

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Contributors Study conceptualisation was led by VN, TD and KF. VN, TD, KF, AB and LD contributed to the development of the research question, study design, with development of statistical aspects led by TD and VN. TD and VN were involved in data specification, curation and collection. TD, KF and VN conducted and checked the statistical analyses. AB and LD developed the tool to visualise the results. All authors contributed to the interpretation of the results. KF and VN wrote the first draft of the paper. TD, TY, CR, KK, AB contributed to the critical revision of the manuscript for important intellectual content. All authors approved the final version of the manuscript. VN had full access to all data in the study and takes responsibility of the integrity of the data and the accuracy of the data analysis and is therefore the guarantor of the study. The lead authors (TD and KF) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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Competing interests KK is Chair of the Ethnicity Subgroup of the UK Scientific Advisory Group for Emergencies (SAGE) and Member of SAGE.

Patient consent for publication Not applicable.

Ethics approval Ethical approval was obtained from the National Statistician's Data Ethics Advisory Committee (NSDEC(20)12).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. The data on vaccination rates by sociodemographic characteristics used in this paper are publicly available via the COVID-19 Health Inequalities Monitoring for England (CHIME) tool (<https://analytics.phe.gov.uk/apps/chime/>) and are readily available for reuse.

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ORCID iDs

Katie Finning <http://orcid.org/0000-0001-5774-5837>

Vahe Nafilyan <http://orcid.org/0000-0003-0160-217X>

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