Characterising adults unvaccinated for COVID-19 in Scotland

By August 10, 2022, 3,497,208 of the 4,439,078 (79%) adults living in Scotland had received three doses of a COVID-19 vaccine.[1] However, a proportion of the adult population remains unvaccinated (defined as no record of any vaccine) and susceptible to severe COVID-19 outcomes. Characterising this population can help understand gaps in vaccine coverage, determinants of vaccine hesitancy and support targeted public health messaging. Unlike the vaccinated population, on whom information is gathered at point of vaccination, current estimates of the unvaccinated population are calculated using GP records. This is however complicated as GP records can include people who have moved out of Scotland with estimates suggesting that GP records contain a population that is 8% higher than National Records of Scotland population estimates.[2] We used data from linked national health records to estimate the number and describe the characteristics of adults living in Scotland with no record of any COVID-19 vaccination.

This analysis was performed using the Early Pandemic Evaluation and Enhanced Surveillance of COVID-19 (EAVE II) platform.[3] This is a national COVID-19 surveillance platform using anonymised individual patient-level records from all general practices in Scotland (N=940), deterministically linked to multiple datasets recording morbidity, mortality, virology, vaccination, and prescribing (Appendix 1). Linkage was performed using a unique identifier for each resident in Scotland registered with a GP.

The EAVE II cohort includes all individuals registered with a Scottish GP as of March 1, 2020, including those who have subsequently left Scotland without informing their GP. To eliminate people no longer living in Scotland, we defined unvaccinated individuals as those without COVID-19 vaccination records who had any interaction with the National Health Service (NHS) Scotland since Jan 1, 2019. We used the EAVE II cohort at a cut-off date of Dec 8, 2020 (start of the UK's vaccination programme). Appendix 2 outlines the process followed to identify the unvaccinated population. We excluded individuals who died of any cause before the cut-off date and those recorded as having left Scotland. As those aged <18 years were only recently invited for vaccination, analysis was restricted to adults aged ≥18 years.

This yielded 4,712,810 individuals recorded as eligible for COVID-19 vaccination. Linkage of vaccine eligibility data with COVID-19 vaccination records identified -872,268 (18.5%) eligible individuals without vaccination records. Amongst those, 88,820 had documented reasons for non-vaccination, including: "Immunization contraindicated", "Immunization consent not indicated", "Reason for non vaccination", "Generally unwell" and "Vaccine refused by patient".[4] Immunization contraindicated was recorded as reason for nearly one-fifth of all unvaccinated individuals. Laboratory records identified 278,194 individuals with no vaccination record who were tested at least once for Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) by reverse transcriptase-polymerase chain reaction (RT-PCR) since the start of the pandemic. Non-hospital-based prescription records identified 440,327 individuals with no vaccination record who had been prescribed medication of any description since January 1, 2019. A further 302,689 individuals had interacted with the unscheduled care pathway (NHS24, Out of Hours GP

consultations, and/or Scottish Ambulance Service), whilst 13,751 had at least one hospital admission according to the Scottish Morbidity Records (SMR) and Rapid Preliminary Inpatient Data (RAPID) datamart. In total there were 271,815 individuals with no record in any of the above data sources and who did not have a vaccination record.

In total, 600,453 eligible individuals aged ≥18 years were identified as having no record of any COVID-19 vaccination in Scotland and at least one contact with NHS Scotland since Jan 1, 2019. We then excluded those who had died since the start of the vaccination programme, and those for whom "Immunization contra-indicated" was recorded as the reason for non-vaccination. On August 10, 2022, our methodology identified 536,316 individuals with no record of any COVID-19 vaccination.

There were a similar proportion of males and females in this unvaccinated cohort, with similar age distribution across both sexes (Table 1). The mean age was 50.1 years. Most unvaccinated people lived in urban settings and the largest proportion of unvaccinated individuals (29.0%) resided in areas ranked "most deprived 20% of the Scottish population" by the Scottish Index of Multiple Deprivation (SIMD).

Based on GP records, the majority (60.0%) of individuals were not known to have any co-morbidities, whereas 16.3% were recorded as having three or more co-morbidities. The most reported co-morbidities were chronic respiratory disease (15.9%), hypertension (11.0%) and depression (12.8%).

Nearly one-quarter (24.6%) of the unvaccinated were prescribed medications for conditions relating to the central nervous system (CNS), with more than one-third of this group (37.4%) prescribed anti-depressants.

Multivariable logistic regression modelling was used to determine the factors most likely to predict COVID-19 vaccination. Male sex, deprivation, living in large urban areas, being prescribed medication for CNS disorders and having more than three comorbidities were most associated with unvaccinated status, though individuals with specific co morbidities such as hypertension, diabetes and chronic respiratory disease were more likely to be vaccinated.

Previous UK data have reported on inequalities of COVID-19 vaccination coverage, with considerably lower uptake among certain groups.[5,] It is notable that increasing age and presence of comorbidities are among the most recognised risk factors for COVID-19 mortality,[6-8] but despite this those with substantial number of comorbidities remained at increased risk of being unvaccinated.

The limitations of our approach include a lack of ethnicity data, which is important given known ethnic variations in vaccine uptake.[9] Whilst minimising false inflation of the unvaccinated denominator, some unvaccinated individuals will have had no recent interaction with the healthcare system and, consequently, remain undetected by our approach. Unvaccinated people may also be less likely to have health seeking behaviour, reducing the chance of being detected through this method.[10] Further, some individuals may have been vaccinated outside of Scotland, which was not captured in our analysis. Determining those vaccinated abroad will improve future estimates of unvaccinated populations

In summary, this national analysis has found that even after accounting for possible over-inflation of population size a sizeable proportion of the adult Scottish population remains unvaccinated. We have also identified predictors of being unvaccinated, which can help with formulating revised national vaccination strategy.

(1000 words)

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Table 1 – Characteristics of Unvaccinated and Adjusted Odds Ratio for COVID-19 Vaccination

Characteristic	No (%)		Adjusted Odds Ratio (95% CI)
	Unvaccinated	Vaccinated	
	536316	3840542	
Sex			
Male	272362 (50.8)	1834025 (52.2)	1
Female	263954 (49.2)	2006517 (47.8)	1.20 (1.19 – 1.20) ***
Age			
18-29	172967 (32.2)	594900 (15.5)	1
30-39	127544 (23.8)	573402 (14.9)	1.31 (1.30 -1.32) ***
40-49	76663 (14.3)	591062 (15.4)	2.16 (2.14 – 2.18) ***
50-59	52390 (9.8)	739572 (19.2)	3.86 (3.81 -3.90) ***
60-69	36354 (6.8)	625955 (16.3)	4.46 (4.40 – 4.52) ***
70-79	29106 (5.4)	462098 (12.0)	3.99 (3.93 – 4.05) ***
80+	41292 (7.7)	253553 (6.6)	1.64 (1.61 – 1.66) ***
SIMD			
1 – Most deprived	155547 (29.0)	715940 (18.6)	1
2	117163 (21.8)	751771 (19.6)	1.29 (1.28 – 1.31) ***
3	96772 (18.0)	768149 (20.0)	1.52 (1.50 – 1.53) ***
4	81996 (15.3)	797045 (20.7)	1.86 (1.84 – 1.88) ***
5 – Least deprived	75694 (14.1)	783932 (20.4)	2.20 (2.17 – 2.22) ***
Setting			
Large urban areas	229377 (43.5)	1258528 (33.0)	1
Other urban areas	174854 (33.2)	1431672 (37.5)	1.35 (1.34 – 1.36) ***
Accessible small town	40189 (7.6)	370703 (9.7)	1.33 (1.31 – 1.4) ***
Accessible rural	39853 (7.5)	362035 (9.5)	1.27 (1.26 – 1.29) ***
Remote small town	21817 (4.1)	193717 (5.1)	1.32 (1.30-1.34)
Remote rural	21082 (3.4)	200182 (5.2)	1.26 (1.24 –1.28)
Comorbidities			
0	321822 (60.0)	1966549 (51.5)	1
1	80452 (15.0)	748260 (19.6)	0.99 (0.98 – 1.00)
2	71907 (13.4)	622614 (16.3)	0.91 (0.90 – 0.92)
3-4	46680 (13.4)	398878 (10.4)	0.67 (0.66-0.69)
5+	15455 (2.9)	80432 (2.1)	0.33 (0.32 – 0.34) ***
Risk factors			
Chronic respiratory diseases	85129 (15.9)	636940 (16.7)	1.33 (1.31 – 1.35)
Depression	68965 (12.8)	487925 (12.8)	0.97 (0.96 – 0.98)
Hypertension	59051 (11.0)	707928 (18.5)	1.33 (1.31 – 1.35) ***
Chronic heart diseases	33762 (6.3)	281783 (7.4)	0.10 (0.98 – 0.14)
Diabetes	25946 (4.8)	270545 (7.1)	1.24 (1.22 – 1.26) ***
Medication			
Central nervous system	112641 (24.6)	649716 (19.1)	0.80 (0.79 – 0.81) ***
Cardiovascular system	45107 (9.8)	553681 (16.3)	1.13 (1.12 – 1.14) ***
Respiratory	31860 (6.9)	240811 (7.1)	1.01 (0.10 – 1.02)

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SIMD – Scottish Index of Multiple deprivation; Large Urban Areas - Settlements of 125,000 people and over; Other Urban Areas - Settlements of 10,000 to 124,999 people; Accessible Small Towns - Settlements of 3,000 to 9,999 people, and within a 30 minute drive time of a Settlement of 10,000 or more; Remote Small Towns - Settlements of 3,000 to 9,999 people, and with a drive time of over 30 minutes to a Settlement of 10,000 or more; Accessible Rural Areas - Areas with a population of less than 3,000 people, and within a 30 minute drive time of a Settlement of 10,000 or more; Remote Rural Areas - Areas with a population of less than 3,000 people, and with a drive time of over 30 minutes to a Settlement of 10,000 or more.

Chronic respiratory diseases - Includes Asthma, COPD and Extrinsic allergic alveolitis. *** -P < <0.001