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Community antibiotic prescribing in patients with COVID-19 across three pandemic waves: a population-based study in Scotland, UK

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ABSTRACT

Objectives This study aims to examine community antibiotic prescribing across a complete geographical area for people with a positive COVID-19 test across three pandemic waves, and to examine health and demographic factors associated with antibiotic prescribing.

Design A population-based study using administrative data.

Setting A complete geographical region within Scotland, UK.

Participants Residents of two National Health Service Scotland health boards with SARS-CoV-2 virus test results from 1 February 2020 to 31 March 2022 (n=184 954). Individuals with a positive test result (n=16 025) had data linked to prescription and hospital admission data ±28 days of the test, general practice data for high-risk comorbidities and demographic data.

Outcome measures The associations between patient factors and the odds of antibiotic prescription in COVID-19 episodes across three pandemic waves from multivariate binary logistic regression.

Results Data included 768 206 tests for 184 954 individuals, identifying 16 240 COVID-19 episodes involving 16 025 individuals. There were 3263 antibiotic prescriptions ±28 days for 2395 episodes. 35.6% of episodes had a prescription only before the test date, 52.3% of episodes after and 12.1% before and after. Antibiotic prescribing reduced over time: 20.4% of episodes in wave 1, 17.7% in wave 2 and 12.0% in wave 3. In multivariate logistic regression, being female (OR 1.31, 95% CI 1.19 to 1.45), older (OR 3.02, 95% CI 2.50 to 3.68 75+ vs <25 years), having a high-risk comorbidity (OR 1.45, 95% CI 1.31 to 1.61), a hospital admission ±28 days of an episode (OR 1.58, 95% CI 1.42 to 1.77) and health board region (OR 1.14, 95% CI 1.03 to 1.25, board B vs A) increased the odds of receiving an antibiotic.

Conclusion Community antibiotic prescriptions in COVID-19 episodes were uncommon in this population and likelihood was associated with patient factors. The reduction over pandemic waves may represent increased knowledge regarding COVID-19 treatment and/or evolving symptomatology.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study included a large number of individuals with COVID-19 (16 025).
⇒ The universal patient identifier across all National Health Service services in Scotland enabled multiple datasets to be linked longitudinally.
⇒ The study timeframe allows analysis of trends over multiple pandemic waves.
⇒ Some cases of COVID-19 will not have been included in this testing dataset, with COVID-19 rates lower than health board-reported population estimates.

INTRODUCTION

Antibiotic surveillance and stewardship remain priorities during viral pandemics,[1] with the majority of antibiotics prescribed in the community.

Many studies on antibiotic use during the COVID-19 pandemic have focused on hospitalised patients. Systematic reviews report high rates of antibiotic prescriptions early in the pandemic at around 70%, despite bacterial coinfection being confirmed in less than 10% of patients.[1–4]

Studies of community antibiotic prescribing have largely described overall changes at the population level, particularly during the first pandemic wave.[5–8] National Health Service (NHS) England reported antibiotic prescriptions decreased 15.5% from 1 April to 31 August 2020, compared with the same period in 2019, but adjusted for the reduction in appointments, this represented an increase of 6.7%.[8] At the local start of the pandemic in March 2020, Scotland saw a 44% increase in community prescriptions for antibiotics commonly used to treat respiratory infections compared with 2019, but this dropped to 34% below the 2019 rate by May 2020.[9]

In Scotland, policies around antibiotics early in the pandemic were focused primarily on hospitalised patients and overall infection prevention. National guidance around antimicrobial prescribing in those with suspected or confirmed COVID-19 advised that antibiotics should not be prescribed if there was no clear evidence of pneumonia.[10] For respiratory conditions such as bronchitis or pneumonia, doxycycline, amoxicillin and azithromycin were recommended.[10] The guidance also emphasised the need to adhere to already established antimicrobial stewardship practices in primary and secondary care. National lockdowns to reduce the spread of COVID-19 changed how healthcare was accessed in the community, with consultations moving to mainly remote. The first lockdown was put in place on 26 March 2020, with a three-phased reopening of services across Scotland running from 29 May to 10 July 2020. Regional restrictions began again in wave 2 on 9 October 2020, with a new five-level tier system for restrictions starting on 2 November. The second national lockdown started during the second wave on 5 January 2021, with a phased easing of lockdown in Scotland from 26 April to 9 August 2021.[11]

Community antibiotic prescribing for individuals with COVID-19 is less well studied than for hospitalised patients or overall population trends.[4 9 12 13] Of three previous relevant studies, in the USA,[12] Italy[14] and England,[13] one used diagnostic codes rather than testing data and was limited to one medical insurance provider.[12] Another examined patients-prescribed antibiotics during the COVID-19 pandemic and quantified how many of those had COVID-19.[13] All examined short intervals before and after the diagnosis (so may have underestimated prescribing) and covered only the first two pandemic waves.

This study aimed to examine community antibiotic prescribing rates across a complete geographical area for people with a positive COVID-19 test across three pandemic waves, and to examine health and demographic factors associated with antibiotic prescribing.

METHODS

Study population

Anonymised data were made available from two neighbouring NHS Scotland regional Health Boards (authorities responsible for the delivery of health services),[15] NHS Tayside and NHS Fife, in the east of Scotland, UK. This includes approximately 20% of the Scottish population (n=863 974) and is broadly representative of the whole population in sociodemographic terms. Data were accessed via a University of Dundee Health Informatics Centre (HIC) secure remote desktop. Datasets were linked at the individual level using the Community Health Index (CHI) number, a unique identifier used to identify patients across all NHS Scotland healthcare episodes.

Data

COVID-19 test results from 28 February 2020 (date of the first COVID-19 positive test in Scotland)[16] to 31 March 2022 included PCR test and Lateral Flow Test results from NHS and private (with NHS contracts) laboratories and at-home tests centrally analysed. Multiple tests per patient on the same day were deduplicated, and repeated positive results within 90 days were considered the same episode of COVID-19, in accordance with NHS Scotland testing guidance.[17]

All COVID-19 episodes were linked to community antibiotic prescriptions, demography, high-risk comorbidity/shielding, hospital admission and death data. The community prescribing dataset captures dispensed prescribed items ('prescriptions') using pharmacy claims for reimbursement. Prescriptions for all oral antibiotics listed in the British National Formulary, Chapter 5, subsections 5.1—Antibacterial Drugs, were included. Prescriptions from 28 days prior (−28 to −1 days) to 28 days post (0 to +28 days) positive test were included to capture pharmacy claims data batched monthly. Prescriptions from 14 days prior to 14 days postpositive test were included for sensitivity analyses to reduce the potential inclusion of some antibiotics prescribed for other indications (but increasing the potential exclusion of some antibiotics prescribed for the COVID-19 episode).

The HIC demography data set provided included calculated age, sex, health board of residence and Scottish Index of Multiple Deprivation quintile (SIMD5). SIMD5 is a measure of relative deprivation based on residential postcode, taking employment, pay, healthcare, crime, housing and education into account.[18] Quintile 1 includes the most deprived areas and 5 the least.

The high-risk comorbidity dataset included patients flagged in primary care records for possible shielding advice based on diagnoses and/or prescriptions. The conditions included asthma, chronic obstructive pulmonary disorder, diabetes, hypertension, ischaemic heart disease, other respiratory conditions and immunological conditions (online supplemental table S1). All patients flagged for any of these conditions were considered to have high-risk comorbidity for this study.

Hospital admissions were extracted from the Scottish Morbidity Record 01 dataset as an additional comorbidity indicator. To include the effect of hospital admission on subsequent antibiotic prescriptions, hospital stays with discharge (rather than admission) dates from 28 days prior to 28 days postpositive test dates were included.

COVID-19 episodes were categorised into pandemic waves as previously defined for Scotland,[19] with the end dates of each wave extended to prevent gaps in the study period. Wave 1 started on 28 February 2020, wave 2 on 1 August 2020 and wave 3 on 1 May 2021. Individuals could have more than one episode, in one or more waves.

Deaths for those with a positive COVID-19 test were identified for descriptive purposes. Deaths within 28 days of a positive test were categorised by whether COVID-19 was included on the death certificate (International Classification of Disease 10th revision code U.071—COVID-19 virus identified)[20] and by pandemic wave.

Statistical analysis

Univariate and multivariate binary logistic regression analyses were used to examine associations between health and demographic factors and the likelihood of receiving a community antibiotic prescription for that COVID-19

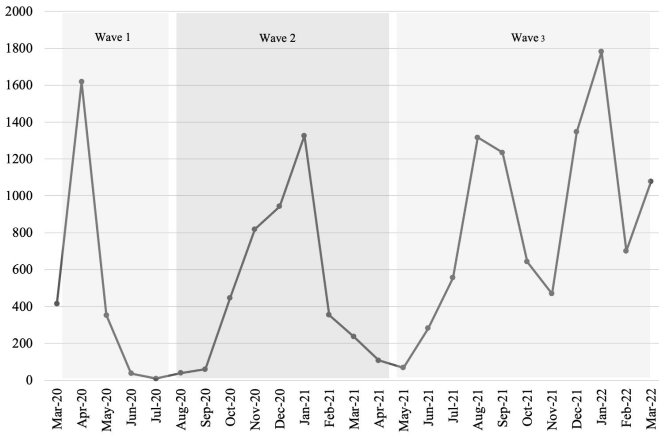

Figure 1 Number of captured COVID-19 episodes, March 2020–March 2022.

episode (±28 days of positive test). Variables included age (<25, 25–44, 45–64, 65–74, 75+ years), gender (F/M), health board of residence (A vs B), high-risk comorbidity (Y/N), hospital admissions ±28 days of positive test (Y/N), SIMD5 (1–5) and pandemic wave (1–3). All variables in univariate analyses were included in multivariate analysis, regardless of statistical significance, due to social and/or clinical relevance. Interactions between variables and pandemic waves (wave 2 vs 1 and wave 3 vs 1) were examined to investigate differential effects as the pandemic evolved.

All analyses used RStudio V.4.1.2.

Patient and public involvement

None.

RESULTS

The dataset included 768 206 tests for 184 954 individuals (21.4% of the population). There were 16 240 COVID-19 episodes involving 16 025 individuals. The trend of COVID-19 episodes in this study population showed steep increases in each wave of the pandemic (figure 1). 98.7% of included individuals had one episode, 1.3% had two and 0.01% had three. The mean age at episode was 51.9 years (SD 24.8), 59.4% were female and 57.2% were in health board B (table 1). The age distribution of episodes varied across waves, with 30.2% in wave 1 involving people aged 75+ years, compared with 18.2% in wave 3 and 3.0% in wave 1 aged <25 years compared with 23.0% in wave 3.

The most common comorbidities were hypertension, other respiratory disorders and asthma. 17.4% of those with at least one episode had one high-risk comorbidity, and 2.3% of patients had four or more comorbidities (figure 2).

There were 3263 antibiotic prescriptions within 28 days of 2395 (18.1%) episodes. 853 (35.6%) of episodes had an antibiotic prescription before the test only, 1252 (52.3%) after only and 290 (12.1%) both before and after. The number of antibiotic prescriptions per episode ranged from 1 to 8, but the majority (54.5%) had one.

Antibiotic prescribing in COVID-19 reduced over time, at 20.4% of episodes in wave 1, 17.7% in wave 2 and 12.0% in wave 3 (table 2). This is in contrast to the pattern of community prescribing across the whole health board population, where antibiotic prescriptions increased in wave 3 (online supplemental figure S1).

The pattern of reduction in antibiotic prescribing across the three waves was consistent for all demographic categories (online supplemental table S2). However, examining rates by age group by gender identified that females of childbearing age (15–45 years) had no reduction across waves, with consistently higher rates than in males the same age (online supplemental figure S2).

Amoxicillin (26.9%) and doxycycline (15.9%) were most prescribed in COVID-19 episodes, accounting for 46.9% of antibiotic prescriptions in wave 1, 40.5% in wave 2 and 42.7% in wave 3 (online supplemental table S3).

A total of 1100 (6.9%) patients died within 28 days of a positive COVID-19 test, with the proportion decreasing from 13.7% in wave 1 to 2.8% in wave 3. 884 (80.3%) deaths within 28 days had COVID-19 listed as a cause of death and this proportion also decreased over pandemic waves (online supplemental table S4).

In univariate logistic regression, all variables were significantly associated with the odds of having a prescription, although the pattern was inconsistent for SIMD (table 3). In multivariate analysis, being female (OR 1.31, 95% CI 1.19 to 1.45), older (OR 3.02 (2.50 to 3.68) for 75+ vs <25 years), having a high-risk comorbidity (OR 1.45 (1.31 to 1.61)), having a hospital admission within 28 days of an episode (OR 1.58 (1.42 to 1.77)) and living in health board B rather than A (OR 1.14 (1.03 to 1.25)) significantly increased the likelihood of receiving an antibiotic. Having an episode in wave 2 (OR 0.86, 95% CI 0.75 to 0.99) or wave 3 (OR 0.71, 95% CI 0.62 to 0.81) significantly decreased the odds of receiving an antibiotic prescription compared with wave 1 (table 3).

Sensitivity analyses, including episodes with a prescription within 14 days of a positive test, aligned with the results of the main 28-day model (online supplemental table S5). There was a total of 1930 antibiotic prescriptions within 14 days of 1597 episodes. The multivariate ORs were all found to be in the same direction as the main model, with slight variations in the size of the effect.

There were significant interactions between pandemic wave and the effects of age, sex, hospital admission ±28 days and SIMD on the odds of antibiotic prescription, so logistic regression analyses were conducted for each wave separately (online supplemental table S6). The overall patterns of associations between demographic factors and odds of antibiotic prescriptions were similar to the combined model, but with increasing age having even stronger associations in waves 1 and 2, female sex only increasing in wave 3, hospital admission having the most effect in wave 3 and health board only being significant in wave 1 (online supplemental tables S7 and S8). The same patterns exist for the 14-day antibiotic prescription window (online supplemental tables S9 and S10).

Table 1 Demographic characteristics of the study population and COVID-19 episodes across three pandemic waves

Variable categories	Total study population	Pts with ≥1 test	Pts. with ≥1 episode	COVID-19 episodes		
				Wave 1*	Wave 2*	Wave 3*
Total	863 974 (100%)	184 953 (21.4%)	16 025 (1.9%)	2430 (0.3%)	4324 (0.5%)	9434 (1.1%)
Age group						
<25	200 441 (23.2%)	30 220 (16.3%)	2632 (16.4%)	81 (3.0%)	385 (8.9%)	2172 (23.0%)
25–44	220 996 (25.6%)	41 959 (22.7%)	3888 (24.3%)	537 (22.1%)	940 (21.7%)	2464 (26.1%)
45–64	237 115 (27.4%)	52 017 (28.1%)	4337 (27.1%)	850 (35%)	1222 (28.3%)	2313 (24.5%)
65–74	101 797 (11.8%)	23 783 (12.9%)	1417 (8.8%)	229 (9.4%)	427 (9.9%)	773 (8.2%)
75+	103 625 (12.0%)	36 974 (20.0%)	3751 (23.4%)	733 (30.2%)	1350 (31.2%)	1712 (18.2%)
Sex						
Male	426 794 (49.4%)	75 605 (40.9%)	6533 (40.8%)	897 (36.9%)	1549 (35.8%)	4135 (43.8%)
Female	437 180 (50.6%)	109 348 (59.1%)	9492 (59.2%)	1533 (63.1%)	2775 (64.2%)	5299 (56.2%)
Any high-risk comorbidity						
No	630 838 (73.0%)	113 573 (61.4%)	9975 (62.2%)	1454 (59.8%)	2401 (55.5%)	6221 (65.9%)
Yes	233 136 (27.0%)	71 381 (38.6%)	6050 (37.8%)	976 (40.2%)	1923 (44.5%)	3213 (34.1%)
Hospital admission ±28 days						
No	N/A	N/A	12 842 (80.1%)	1770 (72.8%)	3141 (72.6%)	8088 (85.7%)
Yes	N/A	N/A	3183 (19.9%)	660 (27.2%)	1183 (27.4%)	1346 (14.3%)
Health board of residence						
A	404 094 (46.8%)	67 887 (36.7%)	6882 (42.9%)	779 (32.1%)	1667 (38.6%)	4473 (47.4%)
B	459 880 (53.2%)	117 066 (63.3%)	9143 (57.1%)	1651 (67.9%)	2657 (61.4%)	4961 (52.6%)
Scottish Index of Multiple Deprivation quintile						
1 (most deprived)	135 851 (15.7%)	30 411 (16.4%)	3194 (19.9%)	426 (17.5%)	888 (20.5%)	1922 (20.4%)
2	145 538 (16.8%)	31 357 (17.0%)	2839 (17.7%)	374 (15.4%)	878 (20.3%)	1604 (17.0%)
3	153 304 (17.7%)	32 195 (17.4%)	2808 (17.5%)	447 (18.4%)	746 (17.3%)	1650 (17.5%)
4	203 258 (23.5%)	46 426 (25.1%)	3556 (22.2%)	649 (26.7%)	934 (21.6%)	2007 (21.3%)
5 (least deprived)	152 013 (17.6%)	29 995 (16.2%)	2312 (14.4%)	317 (13.0%)	599 (13.9%)	1417 (15.0%)
Missing data	74 010 (8.6%)	14 569 (7.8%)	1316 (8.2%)	217 (8.9%)	279 (6.5%)	834 (8.8%)

*Individuals may appear in multiple waves and may have multiple episodes in a single wave if they occur >90 days apart.

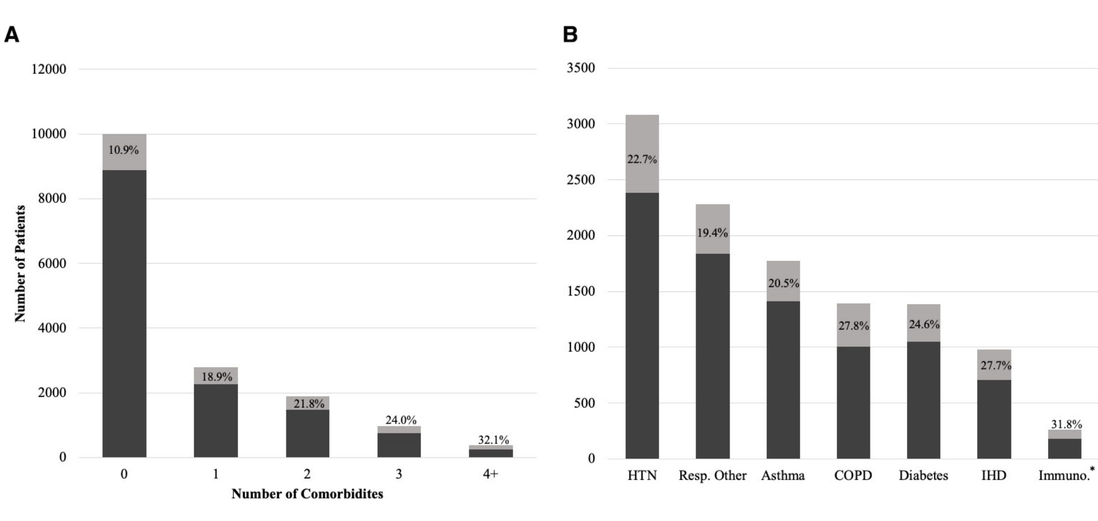

Figure 2 Distribution of (A) number of high-risk comorbidities, (B) individual high-risk comorbidities, for individuals with a COVID-19 episode and proportion (%) with an antibiotic prescription in each category. *Immunosuppression.

Table 2 Testing and antibiotic prescribing frequencies for study COVID-19 episodes by UK pandemic wave

	Total tests	Mean tests per month	Total episodes	Episodes with antibiotic prescription(s) ±28 days	Proportion of episodes with an antibiotic prescription ±28 day (%)
Wave 1	47606	3967	2432	496	20.4
Wave 2	432278	48031	4330	765	17.7
Wave 3	288232	24019	9478	1134	12.0
Total	768206	30728	16240	2395	14.7

Wave 1: 28 February 2020–31 July 2020; wave 2: 1 August 2020–30 April 2021; wave 3: 1 May 2021–31 March 2022 (end of study period).

DISCUSSION

Principal findings

In this large, population-based study, we saw a changing demographic profile for COVID-19 episodes over time. We found a relatively low rate of community antibiotic prescriptions for COVID-19 episodes at 14.7%, with a reduction from 20.4% of episodes in wave 1 to 12.0% in wave 3. We also found clear associations between individual demographic and healthcare factors and receipt of an antibiotic.

The decrease in antibiotic prescribing over time will have multiple contributing factors. Early COVID-19 treatment guidelines were modified during the pandemic as data regarding low levels of bacterial coinfection emerged.[21] Testing patterns also changed, and, as testing became available to the public and mandated for many sectors, misdiagnosis as bacterial infections became less likely. Vaccination roll-out, with attenuated symptom severity, may have reduced medical presentations with COVID-19, public anxiety and clinicians' likelihood of prescribing an antibiotic. Emerging viral variants had different symptoms and/or severity,[22] likely also affecting antibiotic prescriptions. The high proportion of amoxicillin and doxycycline prescriptions aligns with Scottish guidance for the treatment of (presumed bacterial) respiratory tract infections and with another study.[13 23 24] The

Table 3 Associations between demographic and healthcare factors and the odds of a community antibiotic prescription for COVID-19 episodes, from binary logistic regression

Variable	Category	Frequency	Univariate OR (95% CI)	P value	Multivariate OR (95% CI)	P value
Age group	<25	2652	Reference	–	–	–
	25–44	3958	1.53 (1.28 to 1.84)	<0.001	1.35 (1.11 to 1.64)	0.003
	45–64	4394	1.88 (1.58 to 2.24)	<0.001	1.51 (1.25 to 1.84)	<0.001
	65–74	1431	2.83 (2.32 to 3.48)	<0.001	1.91 (1.52 to 2.39)	<0.001
	75+	3805	4.89 (4.15 to 5.78)	<0.001	3.02 (2.50 to 3.68)	<0.001
Sex	Male	6599	Reference	–	–	–
	Female	9641	1.25 (1.15 to 1.37)	<0.001	1.31 (1.19 to 1.45)	<0.001
Any high-risk comorbidity	No	10108	Reference	–	–	–
	Yes	6132	2.34 (2.05 to 2.44)	<0.001	1.45 (1.31 to 1.61)	<0.001
Hospital admission ±28 days	No	13047	Reference	_	_	_
	Yes	3193	2.28 (2.07 to 2.51)	<0.001	1.58 (1.42 to 1.77)	<0.001
Health board of residence	A	6943	Reference	–	–	–
	B	9297	1.15 (1.06 to 1.26)	<0.001	1.14 (1.03 to 1.25)	0.01
Scottish Index of Multiple Deprivation quintile	1 (most deprived)	3251	Reference	–	–	–
	2	2864	0.83 (0.72 to 0.96)	0.01	0.81 (0.70 to 0.94)	0.01
	3	2849	1.07 (0.94 to 1.24)	0.29	1.00 (0.86 to 1.15)	0.99
	4	3604	1.07 (0.94 to 1.22)	0.31	0.88 (0.77 to 1.01)	0.07
	5 (least deprived)	2341	0.93 (0.80 to 1.09)	0.38	0.84 (0.72 to 0.98)	0.03
COVID-19 wave	1	2432	Reference	–	–	–
	2	4330	0.84 (0.74 to 0.95)	0.005	0.86 (0.75 to 0.99)	0.03
	3	9478	0.53 (0.47 to 0.60)	<0.001	0.71 (0.62 to 0.81)	<0.001

proportion of prescriptions for these drugs was lowest in wave 2, which may reflect the dominant variants in wave 2 (alpha and delta) having less respiratory symptoms.[22 25] Despite early research on the potential use of azithromycin in COVID-19 patients,[26 27] we did not find high rates of azithromycin prescribing in this population (online supplemental table S4). During the second wave, by March 2021, the National Institute for Health Care Excellence in the UK advised again the use of azithromycin for COVID-19.[28] Antibiotic prescribing in primary care during the pandemic has also been found to vary depending on the type of consultation. Remote consultations for adults in England with acute respiratory infections were found to have a 23% higher chance of receiving an antibiotic than face-to-face consultations.[29] Wave 3 in our study was outside of any lockdown restrictions, with a likely higher proportion of face-to-face encounters, which may have contributed to the reduction in prescriptions.

Older age was the strongest demographic predictor of antibiotic prescribing, likely due to higher testing rates and lower thresholds for antibiotic prescriptions.[30] Older patients are less likely to be asymptomatic,[31] and, in this study, had more hospital admissions and more comorbidity. Females were more likely to have a test, consistent with other studies,[32] and had more positive tests and more antibiotic prescriptions. This may reflect differences in accessing medical care, with females reportedly contacting health services more often and earlier in an illness.[33] Antibiotics are also commonly used at a high rate in pregnant women, which could impact the odds of prescribing in women overall.[34] While pregnancy status was not available for this study, examining antibiotic prescribing by age and gender identified that females of childbearing age (15–45 years)[35] had higher rates than males of the same age and no reduction across pandemic waves. This may be associated with concerns around increased severity of COVID-19 in pregnant women.[36 37]

The association between community prescribing and hospital admissions may reflect COVID-19 episodes with recent hospitalisation having longer symptoms and/or more concern and community healthcare contact. However, it may reflect more vulnerable individuals having more healthcare contact in general, rather than specific features of the COVID-19 episode.

Comparison with other studies

There are very few studies examining community antibiotic prescribing in individuals with COVID-19, with more focused on changes in total community or hospital prescribing.[5–7 9] Of 154 studies in a 2021 meta-analysis of antibiotic prescribing in COVID-19, 12 were mixed inpatient and outpatient settings, but none were community only.[4] A 2022 study examined antibiotic prescriptions for American Medicare beneficiaries with prescription drug (part D) coverage, with an outpatient, including Emergency Department visit, from April 2020 to April 2021 with a primary diagnosis code of COVID-19 (U071). Of >1 million encounters, around 30% of patients received an antibiotic prescription within 7 days previsit or post visit.[12] This is higher than in our study (despite our longer time window pre/postdiagnosis), but the Medicare population was limited to those over 65 and to the first two pandemic waves, where we also observed higher rates. We have also been able to include all age groups, including children, rather than focusing on older individuals who had greater odds of receiving an antibiotic prescription. The authors note their lack of data on underlying health conditions and hospital admissions as limitations,[12] and we found these factors influential in prescribing.

An Italian study examined community prescriptions for 331 704 individuals with laboratory-confirmed positive COVID-19 PCR tests from March 2020 to May 2021. Prescriptions were included from 3 days prepositive to 7 days postpositive test. 23% of cases received an antibiotic, with a notable increase from 18% of cases in November 2020 to 31% in March 2021.[14] The overall rate is higher than in our study, and the increase over time is contrary to our findings, but they did not include data from wave 3.

One study in England examining community antibiotic prescribing during COVID-19 reported that 1.7% of people with an antibiotic prescription had a positive COVID-19 test (0.5% of prescriptions were within 14 days of the test)[13] but did not report the total number of COVID-19 episodes, or the proportion with antibiotics.

Studies examining trends in overall community antibiotic prescribing all report decreases across 2020. Quarterly US data reported an overall reduction, including a decrease of 44% in amoxicillin prescriptions, from calendar quarter 2 to quarter 4.[38] A study from Spain reported a decrease (pooled DDD reduction) in prescribed antibiotics of 7.6% in quarter 1 and 36.8% in quarter 2 of 2020 compared with the same time in 2019.[7] Similarly, France and Canada reported overall reductions of 18.2% and 31.2%, respectively, in outpatient antibiotic prescriptions in 2020 compared with 2019.[6 39]

In hospital settings, early COVID-19 systematic reviews found that bacterial coinfections were confirmed for only around 7%–8% of patients, but 70%–72% received an antibiotic.[1–3] An April 2020 survey in Scottish hospitals found that 38.3% of patients with suspected or confirmed COVID-19 were prescribed an antibiotic.[40] These rates are higher than we observed, but the threshold for antibiotic prescribing will be lower in hospitalised patients, who are more unwell and higher risk, and they are from earlier in the pandemic.

Strengths and limitations

Key strengths of this study are the size of the population-level dataset and the use of administrative data, which increases generalisability and minimises missing data. SIMD was the only variable with notable missing data (8%), but these were missing completely at random and evenly distributed across categories of other variables, so not affecting findings or interpretation. Another key strength is the universal use of CHI numbers (deidentified for the study) across all NHS services, enabling multiple datasets to be linked longitudinally. The timeframe of this study allows analysis of trends over multiple pandemic waves. A limitation of the study is that the proportion of the population with a COVID-19 episode was lower than reported estimates of infection rates, as the datasets do not capture all cases.[16] However, the outcomes of interest were calculated among confirmed cases rather than evaluating risk of COVID-19, so the findings hold. Another limitation is that the indication for the antibiotic prescriptions was unavailable, potentially including antibiotics prescribed for other conditions. However, primary care coding is of variable quality and utility for research,[41] and patients presenting with a febrile illness coded as something else but subsequently diagnosed as COVID-19 would be missed by coding inclusion criteria. Bacteriology data were not included, and some individuals may have had bacterial secondary or coinfection with appropriate antibiotic treatment. However, most patients with presumed bacterial respiratory tract infections, including pneumonia, never have a bacteriological diagnosis,[42] and some bacterial pathogens can be commensals, so bacteriology data are unlikely to facilitate evaluation of appropriateness at the population level. Data on individual COVID-19 vaccination status were not available, but vaccine uptake was high in the study population (≥85% of the eligible population had 2+ doses).[16] The findings may not be generalisable to areas with different demographic characteristics (ethnicity data were unavailable), but the study regions are demographically representative of the Scottish population. The impact of antibiotic prescribing on clinical outcomes of COVID-19 episodes was not examined as it would be prone to confounding by indication, as patients with more severe illness would get more antibiotics and have more adverse outcomes.

Implications for policy and practice

The decreasing use of antibiotics found in each subsequent COVID-19 wave suggests that prescribers and the public responded to changing guidance and recommendations and became better at recognising and managing COVID-19. Reducing unnecessary antibiotic prescriptions overall is a key aim of antimicrobial stewardship, and the findings align with previous work indicating that vaccines to reduce symptomatic illness, including viral, can reduce antibiotic prescribing.[43] Antimicrobial stewardship is an established priority in Scotland, in alignment with the UK Government's National Action Plan, with ongoing work to optimise the use of antimicrobials.[44] As this was a population-based study with limited data on indication or microbiological testing, it is not possible to truly assess the appropriateness of individual antibiotic prescriptions, but the downward trend in total prescribing over time aligns with antimicrobial stewardship goals.[45] The difference in prescribing between health boards presents an opportunity for sharing good stewardship practice.

Although this study used rich, linked administrative data, GP consultation data are not routinely available in Scotland, and, despite the limitations of such data, this gap should be addressed to support surveillance and research to inform practice, for example, on the appropriateness of antibiotic prescriptions.

Implications for future research

This work highlights the need for more research on community management of individuals with COVID-19, and the drivers of potentially unnecessary antibiotic prescribing. Qualitative work with prescribers in the community could enhance understanding of practice changes over time, and with individuals who had COVID-19 could enhance understanding of changes in healthcare-seeking behaviour or access. It would also be of interest to examine whether changes in community prescribing observed in COVID-19 are replicated for other viral illnesses. These findings could inform antimicrobial stewardship strategies, including in future viral pandemics.

CONCLUSIONS

Community antibiotic prescriptions in people with COVID-19 were relatively uncommon in this study population and were associated with increased age and comorbidity. There was a significant reduction over time, which may represent increased knowledge and experience of COVID-19 and/or decreased symptom severity due to vaccination and changes in the dominant viral variants over time.

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