Assessment of the appropriateness of antibiotic prescribing in an acute UK hospital using a national audit tool: a single centre retrospective survey

Rhys Owens ,[1] Kathy Bamford,[2] Sophie Pinion,[3] Emma Garry,[4] Emily Cranmer,[5] Catharine Pearce,[6] Htet htet Wint,[7] Simon Gill,[6] Ryan Philips,[8] Adnan Khan,[5] Selina Roy Bentley,[9] Neil Roberts,[10] Bernadette Keating,[8] Natasha Askaroff,[11] Megan Morphew,[12] Charles Orr,[1] Tarek Mouket,[8] Katherine Pope,[8] Neil Powell[13]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/ejhpharm-2022-003569).

For numbered affiliations see end of article.

Correspondence to
Dr Rhys Owens; rhys.owens@nhs.net

Received 4 October 2022
Accepted 28 March 2023
Published Online First 28 April 2023

EAHP Statement 6: Education and Research.

ABSTRACT

Introduction Antibiotic use drives antibiotic resistance. The UK antimicrobial resistance (AMR) strategy aims to reduce antibiotic use. We aimed to quantify excess antibiotic use in a district general hospital in south-west England.

Methods Medical patients discharged in August 2020 who had received antibiotics were included. An audit tool of antibiotic prescribing appropriateness was used to collect relevant clinical information regarding each patient case. The appropriateness of antibiotic use was then determined by two infection specialists and excess days of therapy (DOTs) calculated.

Results 647 patients were discharged in August 2020. Of the 1658 antibiotic DOTs for the 184 patients reviewed, 403 (24%) were excess DOTs. The excess antibiotic DOTs were prescribed in 92 patients (50%); 112/403 (27.8%) excess DOTs originated at the initiation of antibiotic therapy (time point A); 184/403 (45.7%) of excess DOTs occurred at the antibiotic review pre-72 hours (time point B); and 107/403 (26.6%) of excess DOTs were due to protracted antibiotic courses (time point C).

Conclusion 24% of antibiotic DOTs were deemed unnecessary. The greatest opportunity to reduce antibiotic use safely was the pre-72 hours antibiotic review, which may provide a target for reducing excess antimicrobial therapy in line with the national AMR strategy.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Hospitals are required to reduce antibiotic use to meet the national ambition to reduce antimicrobial resistance (AMR). An audit tool has been developed to assess antibiotic appropriateness at the patient level.

WHAT THIS STUDY ADDS

⇒ There is opportunity to reduce antibiotic use by 25%. The greatest opportunity to reduce antibiotic use is through optimisation of the pre-72 hours antibiotic review. There is also significant opportunity to reduce antibiotic use through avoidance of inappropriate initiation of antibiotics and through course length optimisation.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Decision-making around antibiotic prescribing is complex. There are multiple influences on prescribing and therefore a multiple faceted approach which includes behavioural interventions and diagnostic decision support are required.

INTRODUCTION

Antibiotic resistance is a threat to healthcare globally,[1] and in the UK.[2] Antibiotic use drives antibiotic resistance[1] and therefore one of the key aims of the UK antimicrobial resistance (AMR) strategy is to reduce total antibiotic use.[3] In the UK, National Health Service (NHS) hospitals are contractually obliged to reduce antibiotic use by 1% each year.[4]

Identifying opportunities to reduce antibiotic prescribing in hospitals safely will enable prescribers and antimicrobial stewardship teams to focus their efforts to meet this aim—namely, to reduce antibiotic use safely and mitigate the risk of AMR while not compromising patient safety. However, defining the gold standard for appropriate antibiotic prescribing is challenging due to the subjective nature of evaluating quality in prescribing.[5] In 2017 the UK government scientific advisory committee on antimicrobial prescribing, resistance and healthcare associated infection convened a workshop, which included 22 infection experts, to define appropriate antibiotic prescribing, and developed an audit tool that supports the patient-level assessment of antibiotic appropriateness in secondary care.[5]

We aimed to quantify excess antibiotic use, measured as excess days of antibiotic therapy, and to determine whether certain time-points in the prescribing process present greater opportunity for safe reduction in antibiotic use: at initiation, at the pre-72 hours review, or through course length optimisation.

Setting

The study setting is a 750-bed acute secondary care hospital in the south-west of England with an electronic prescribing and medication administration system (EPMA; JAC Computer Services (WellSky), Basildon, UK) deployed in all inpatient areas. The hospital has a longstanding antimicrobial stewardship programme that has embedded the National

To cite: Owens R, Bamford K, Pinion S, *et al*. *Eur J Hosp Pharm* 2024;**31**:505–510.

Institute for Health and Care Excellence (NICE) antimicrobial prescribing guidelines[6] and the Antimicrobial Review Kit intervention in medical specialities.[7] When measured in defined daily doses (DDD) of antibiotics adjusted for hospital admission rate, the study hospital (compared with other non-teaching hospitals in England) is a low antibiotic using hospital and is ranked in the lowest quintile.[8]

METHODS

NHS ethics approval was not required as the study did not meet the Health Research Authority definition for research or the requirements for NHS research ethics committee approval. The patient data were used in accordance with local NHS hospital policy.

In September 2020, pharmacy data analysts used the EPMA system to identify patients who were discharged from medical specialities in August 2020 and who had received at least one dose of an antibiotic. Patients were then grouped into medical specialities according to the discharging specialty on the EPMA system, as follows: acute medicine, eldercare, renal, endocrine, gastroenterology, respiratory, and cardiology. Patients within specialties were grouped by week of discharge and the notes for every third patient discharged that week were requested with the aim to collect data for a pragmatic sample of 25% of medical discharges, thought achievable with the available resource.

The UK Health Security Agency (UKHSA) (formerly Public Health England (PHE)) audit form, adapted from the UKHSA (formerly PHE) tool available via Hood *et al* (online supplemental information), was amended to allow identification of the medical specialty responsible for prescribing at each of the three antibiotic decision time-points; whether antibiotic treatment indicated from the outset, whether antibiotic treatment indicated beyond the pre-72 hours antibiotic review, and whether antibiotic treatment indicated beyond the standard treatment duration for the infection. This enabled any identified excess antibiotic use to be attributed to a specific medical specialty. A further amendment, from 'Was antibiotic treatment indicated beyond the post-prescription (48–72 hours) review?' to 'Was antibiotic treatment indicated beyond the pre-72 hours antibiotic review?', was made because many antibiotics are stopped before 48 hours, and the amended wording captured the scenario more accurately.

Junior doctors were invited to participate in the data collection. Junior doctors were asked to read the 'DEFINING AND MEASURING "APPROPRIATE" ANTIBIOTIC PRESCRIBING – A BRIEFING FOR AUDITORS' document (online supplemental information) to ensure data were collected in a standardised way. After completion of a case, the audit form was emailed to NP (consultant antimicrobial pharmacist) to check the form for completeness and correctness. Auditors were able to collect data once they were 'signed off' as competent to do so by NP. Completed audit forms were emailed to NP and any discrepancies, inconsistencies and errors were discussed with the auditor, as well as any unclear assessment on appropriateness.

Two infection specialists, NP and KB (medical microbiologist), discussed each case in turn and reached a consensus on excess antibiotic use. Excess antibiotic use was defined as (1) prescribing an antibiotic for a patient in the absence of (documented) evidence of bacterial infection or (2) continuing an antibiotic prescription beyond the course length recommended in local or national guidelines, in the absence of a (documented) rationale (as defined in the 'Briefing for Auditors' guide (online supplemental information)). Excess antibiotic use was assessed at the three time points taking into consideration the views of the junior doctor completing the audit. Once consensus was reached, NP input the data into Excel.[9] Total antibiotic use and excess antibiotic use were measured in days of therapy (DOTs), enabling excess antibiotic use to be calculated as a percentage of total usage. Excess DOTs were attributed to the specialty responsible for the prescribing decision at each time point to quantify excess antibiotic use in each medical specialty. Analysis of variance (ANOVA) technique was used to determine any statistical significance between mean excess DOTs between the different medical specialities.

RESULTS

Six hundred and forty-seven patients were discharged from medical specialties in August 2020. The number of patients discharged from each specialty, as recorded on EPMA, were as follows: cardiology 26 patients (4.02%), endocrinology 70 (10.82%), eldercare 146 (22.57%), gastroenterology 84 (12.98%), acute medicine 171 (26.43%), renal 54 (8.35%), and respiratory 96 (14.84%).

Of these, 184 (28%) patients were reviewed: cardiology six (3.26%) patients, endocrine 19 (10.32%), eldercare 37 (20.11%) gastroenterology 27 (14.67%), acute medicine 14 (7.61%), renal 14 (7.61%), and respiratory 67 (36.41%). Eighty-five of 184 (46.2%) were female and the median age was 74 years (IQR 60–82.5). The 184 patients received 1658 DOTs with a mean of 9.0 DOTs per patient (range 1–99 days). The mean antibiotic course length per patient was 6.9 days (range 1–99 days).

Excess DOTs

Of the 1658 antibiotic DOTs for the 184 patients reviewed, 403 (24%) were deemed excess DOTs. The excess antibiotic DOTs were prescribed in 92 patients (50%); 42 (45.7%) female, median age 74 years (IQR 58–82). Of these, 112/403 (27.8%) occurred at the initiation of antibiotic therapy (time point A); 184/403 (45.7%) at the antibiotic review pre-72 hours (time point B); and 107/403 (26.6%) as protracted antibiotic courses (time point C).

The final infective diagnoses with the greatest number of excess DOTs were for 46 patients with community-acquired pneumonia and 18 patients with lower urinary tract infection (46 and 40 excess DOTs, respectively). Fifity-six of 184 (30.4%) patients had a final diagnosis of a 'non-infective aetiology', accounting for 172/403 (42.7%) excess DOTs. Excess DOTs by final diagnosis are displayed in the supplementary data.

Initiation of antibiotics (time point A)

The 112 excess DOTs which occurred at the initiation of antibiotic therapy were prescribed in 44/184 (24%) patients; 20 (45.5%) female, median age 74 years (IQR 59–83), median 2 DOTs (IQR 1–3) per patient. In over half of these patients (23 of 44 cases) antibiotics were determined as not indicated from the outset, resulting in 66 excess DOTs. In the remaining 21 patients, antibiotics were determined to be indicated at the outset, but excess DOTs were recorded due to other reasons (eg, unnecessary duplication of antibiotic therapy), and resulted in 46 excess DOTs.

Total and mean excess DOTs attributed to the specialty initiating the antibiotic prescription are displayed in table 1. Ten specialities were responsible for initiating antibiotic therapy. Acute medicine and emergency medicine were responsible for initiating the majority of patients on antibiotic therapy (70 and 54 patients, respectively, 67.4% of patient sample).

Table 1 Excess antibiotic duration of therapy by each specialty initiating antibiotic treatment

		Antibiotics indicated at outset		Excess DOTs		
Specialty	**Number of patients**	**N=**	**%**	**Total**	**Mean (95% CI)**	**P=**
Acute medicine	70	64	91%	50	0.71 (0.35 to 1.08)	
Cardiology	4	1	25%	7	1.75 (–1.53 to 5.03)	
Emergency medicine	54	48	89%	18	0.33 (0.13 to 0.53)	
Eldercare	15	13	87%	10	0.67 (–0.11 to 1.44)	
Endocrine	6	5	83%	4	0.67 (–0.60 to 1.94)	
Gastroenterology	9	8	89%	3	0.33 (–0.44 to 1.10)	
Renal	6	5	83%	2	0.33 (–0.52 to 1.19)	
Respiratory	16	14	88%	8	0.50 (–0.01 to 1.01)	0.40844
Acute GP	1	1	100%	1	1.00	
Surgery	2	1	50%	9	4.50 (–52.68 to 61.68)	
Unknown	1	1	100%	0	0.00	0.010981
Total	**184**	**161**	**87.5%**	**112**	**0.61 (0.41 to 0.81)**	

GP - General Practice
DOTs, days of therapy; GP, ????.

At time point A, the mean excess DOTs per patient was 0.61 (95% CI 0.41 to 0.81). Of the medical specialities reviewed, the lowest mean excess DOTs were attributed to emergency medicine (0.33 DOTs; 95% CI 0.13 to 0.53) and the greatest to cardiology (1.75 DOTs; 95% CI –1.53 to 5.03), but there were no statistically significant differences between specialities (p=0.41).

Time point B

Antibiotics were stopped appropriately for 40 of 184 (21.73%) patients at a pre-72 hours review; 23 (54.8%) female, median age 74 years (IQR 60–84). In 102 of 184 (55.43%) patients, antibiotics were deemed to be indicated and therefore appropriately continued beyond the pre-72 hours review.

Of the remaining 42 of 184 (23%) patients (19 (45.2%) female, median age 74.5 years (IQR 60–84)), treatments resulted in 184 excess DOTs, 45.7% of all excess DOTS (median 4 DOTs (IQR 3–6). Twenty-nine of 184 (15.76%) patients' antibiotics were continued beyond the pre-72 hours review when they could have been stopped entirely, resulting in 140 excess DOTs. In the remaining 13 patients (7.07%), the continuation of antibiotics was deemed appropriate but there were missed opportunities to reduce the number of different antibiotic agents being used, resulting in 44 excess DOTs.

Total and mean excess DOTs by reviewing specialty are displayed in table 2. Of the medical specialities, renal patients had the highest mean excess DOTs (2.09, 95% CI −0.30 to 4.48). Acute medical patients had the lowest mean excess DOTs (0.71, 95% CI 0.35 to 1.08). Again, there were no statistically significant differences between medical specialities (p=0.42).

Time point C

The 107 excess DOTs occurring due to course length protraction were prescribed in 40 (22%) patients; 27 (67.5%) female, median age 74 years (IQR 60–84), median 2 DOTs (IQR 1–3). In 38 of these patients, antibiotics were not indicated past the standard course length for their infections which resulted in 100 excess DOTs.

Antibiotics were indicated beyond the standard course length for 15 of 184 patients. However, seven excess DOTs occurred in two of these patients due to unnecessary prolongation of antibiotic therapy.

The 107 excess DOTs due to course length protraction occurred in 40 (22%) patients. In 38/40 patients with excess DOTs, antibiotics were not indicated past the standard duration for infection, resulting in 100 excess DOTs. Antibiotics were indicated beyond the standard course length for 15/184 patients. Of these, two patients incurred a total of seven excess DOTs due to unnecessary prolongation of antibiotic therapy.

Excess DOTs occurring due to protracted course length by each specialty are displayed in table 3. Mean excess DOTs per

Table 2 Excess antibiotic duration of therapy by each specialty responsible for antibiotic review before 72 hours

		Number of patients with excess DOTs		Excess DOTs		
Specialty	**Number of patients**	**N**	**%**	**Total DOTs**	**Mean (95% CI)**	**P=**
Acute medicine	43	4	9%	20	0.47 (–0.07 to 1.00)	
Cardiology	6	1	17%	6	1.00 (–1.57 to 3.57)	
Eldercare	39	9	23%	45	1.15 (0.40 to 1.90)	
Endocrine	18	5	28%	15	0.83 (0.08 to 1.58)	
Gastroenterology	25	6	24%	31	1.24 (0.17 to 2.31)	
Renal	11	4	36%	23	2.09 (–0.30 to 4.48)	
Respiratory	40	12	30%	41	1.03 (0.45 to 1.60)	0.417283
Haematology	1	0	0%	0	0	
Surgery	1	1	100%	3	3	0.521292
Total	**184**	**42**	**23%**	**184**	**1 (0.69 to 1.31)**	

DOTs, days of therapy; GP, General Practice.

Table 3 Excess antibiotic duration of therapy by each specialty responsible for antibiotic treatment at the end of the recommended treatment course duration

Specialty	Number of patients	Number of patients with excess DOTs	Excess DOTs		
			Total	Mean (95% CI)	P=
Acute medicine	32	7	20	0.63 (−0.09 to 1.16)	
Cardiology	7	0	0	0.00 (0.00 to 0.00)	
Eldercare	39	7	16	0.41 (0.04 to 0.78)	
Endocrine	19	6	12	0.63 (0.09 to 1.17)	
Gastroenterology	28	5	16	0.57 (−0.12 to 1.26)	
Renal	11	5	17	1.55 (0.00 to 3.09)	
Respiratory	46	10	26	0.57 (0.13 to 1.00)	0.376727
Haematology	1	0	0	0.00	
Surgery	1	0	0	0.00	0.560567
Total	**184**	**40**	**107**	**0.58 (0.37 to 0.95)**	

DOTs, days of therapy.

patient was 0.58 (95% CI 0.37 to 0.95). Renal patients had the highest mean excess DOTs per patient (2.09, 95% CI −0.30 to 4.48), and cardiology patients had the lowest (0 excess DOTs). There was no significant difference found between medical specialities (p=0.38).

Excess intravenous antibiotic DOTs

One hundred and thirty-nine of 184 (75.54%) patients received 664 intravenous (IV) DOTs, of which 140/644 (21.08%) were deemed unnecessary. The median age of patients on IV therapy was 72 years (IQR 59–81 years) and 78/139 (56.1%) were male.

Fifty-one of 140 (36.4%) excess IV DOTs were encountered on antibiotic initiation (16 patients), 79/140 (56.8%) at the pre-72 hours antibiotic review (23 patients), and 10/140 (6.6%) due to protracted course lengths (three patients). Of the 140 unnecessary IV DOTS, 67 (47.9%) occurred when the antibiotic was indicated but the route was inappropriate. The remaining 73 excess IV DOTs occurred because antibiotics were not indicated.

DISCUSSION

Main findings

Using the UKHSA antibiotic assessment tool, we identified excess antibiotic prescribing across all medical specialities.[5] Of the 1658 antibiotic days prescribed, 403 (24.3%) DOTs were deemed unnecessary. Of note, excess DOTs were seen in only 92 of the 184 (50%) patients, with zero excess DOTs in the other 92 patients. The largest number of excess DOTs were due to missed opportunities to stop antibiotics at the pre-72 hours antibiotic review (time point B), with 184 of 403 (45.7%) excess DOTs occurring at this stage in the prescribing process. By diagnosis, the greatest number of excess DOTs occurred in patients with a non-infective final diagnosis, with the majority of excess DOTs in this group occurring at time point B. This indicates a failure to stop unnecessary antibiotics in the context of a non-infective cause of symptoms.

Antibiotics were appropriately stopped at the pre-72 hours review in 21.73% of patients; however, there was a missed opportunity to stop antibiotics at the pre-72 hours review for a further 15.76% of patients. This suggests that a pre-72 hours antibiotic stop rate of 37.49% is achievable in our patient population, similar to the 36% stop rate reported in another English hospital.[10]

Excess DOTs at antibiotic initiation and excess DOTs due to protracted course lengths (time points A and C) were similar, with 112 of 403 (27.8%) and 107 of 403 (26.6%) DOTs, respectively. Previous work in the study hospital in 2019 identified the opportunity to optimise antibiotic course lengths for community-acquired pneumonia (CAP), hospital-acquired pneumonia (HAP), pyelonephritis, infective exacerbation of chronic obstructed pulmonary disease (IECOPD), and cellulitis with local course length optimisation work undertaken since.[6] Although opportunity remains to reduce course lengths further, this study demonstrates median reductions in course lengths since our 2019 study of 1 day for CAP (7 vs 6 days), HAP (7 vs 6 days) and IECOPD (7 vs 6 days), and 1.5 days for cellulitis (9 vs 7.5 days).[6]

Others have found excess antibiotic use due to protracted course lengths and to the absence of signs and symptoms consistent with infection. Vaughn *et al* identified 68% of pneumonia patients in a Michigan hospital group received excess antibiotic course lengths with a median duration of 8 days for CAP and median excess of 2 days compared with our median for CAP of 6 days and mean excess 1.4 DOTs.[11] A recent US study of inpatient antibiotic prescribing found antibiotic treatment was unsupported in 55.9% of patients, primarily due to protracted antibiotic course lengths or lacking evidence of infection signs or symptoms.[12]

Antibiotic prescribing is complex.[13] Diagnostic uncertainty is recognised as a driving factor for antibiotic overuse,[14] with clinicians preferring to err on the side of caution and give antibiotics just to be safe, using antibiotic prescribing as a method to manage uncertainty.[15] An online choice experiment study with acute/general hospital prescribers in England looked at attributes likely to play a key role in decisions to continue or discontinue antibiotics at the pre-72 hours antibiotic review.[16] The study highlighted the competing risks of continuing versus discontinuing antibiotics, such as AMR versus treatment failure, respectively, and found a higher risk of discontinuing antibiotics affected prescribers' decisions twice as much as an equally higher risk of continuing treatment. Action bias, a preference for action over inaction even if the action is likely to result in poorer outcomes, has been discussed in the context of antibiotic prescribing and implicated in over-treatment.[17]

In this study, infection specialists assessed the antibiotic prescribing of non-infection specialists and identified that 24% of antibiotic use was excess. Fawcett *et al*[18] compared antibiotic use between infectious diseases physicians and other medical teams and found antibiotic DOTs to be 30% lower in the patients managed by infectious diseases physicians. Clinically stable patients with an uncertain diagnosis were also more likely to

have their antibiotics stopped, with no differences in treatment failure or mortality. The reduction in antibiotic use may have been achieved in part by watchful waiting, as these patients were more likely to be admitted overnight; the reduced antibiotic usage may need to be balanced with the potential implications for hospital occupancy and costs from increased length of stay. In addition, high-profile public campaigns and national health commissioning have focused on sepsis and initiating aggressive early treatment with bundles such as the 'Sepsis Six'.[19 20] This has provoked significant debate about the impact of such campaigns on sepsis treatment, not only on reversing undertreatment but also increasing overtreatment.[21 22] Knowledge and skills about sepsis identification and treatment, and beliefs held about the consequences of initiating treatment, were identified as key domains affecting 'Sepsis Six' performance in NHS hospitals.[23] Both antimicrobial stewardship and sepsis management exist on the same spectrum of clinician behaviour, and recognition of this remains key to effective intervention in both sepsis management and antimicrobial stewardship.

Strengths and limitations

We have measured excess antibiotic use in DOTs, the preferred metric for antibiotic consumption, because unlike DDDs, DOTs are not influenced by differences in dosing due to body weight or renal/hepatic dysfunction.[24] Assessment of appropriateness is at the discretion of the auditors and is subjective. Decisions on appropriateness were made on the information available to the prescriber at the time using the information recorded in the medical notes and the available electronic sources: pathology, radiology and observations. Auditors did have sight of subsequent observations and clinical test results, but these were not used to guide auditor decisions at each point of the prescribing process as they were not known to the prescriber at the time. The determinations of appropriateness were made by two infection specialists until consensus was reached with input from the auditor, thereby making this a three-way decision adding validity to the judgements made here. A strength of this study is the use of a national audit tool developed by infection specialists.[5]

This is a single centre study that reviewed only a proportion of patients in 1 month only. Due to seasonality the findings may not be representative of annual prescribing practices nor generalisable to other UK hospitals. Differing rates of excess antibiotic use were noted between the specialties, but the differences were not statistically different, likely due to the small sample sizes when the data were presented by specialty. Patients discharged from respiratory medicine were overrepresented, and discharges from acute medicine were underrepresented, which may have an impact on the overall excess antibiotic use estimate. However, as we were not able to demonstrate a difference between specialties this is unlikely to have a significant impact on our findings.

Collecting data at the individual patient level is resource intense. We estimate between 45 and 75 min of junior doctor/antibiotic pharmacist time to collect the data into the audit tool per patient (average 1 hour) and estimate 1 hour for the two infection specialists to review 10 patients and to reach consensus. Therefore, we estimate 184 hours of junior doctor/antibiotic pharmacist time and 38 hours of infection specialist time (consultant medical microbiologist and consultant antimicrobial pharmacist) were required for this study.

There is potential for variation in performance by the number of junior doctors who gathered the initial data. It is unlikely that this would reduce the reliability of the study because each underwent training and review of their data collection. In addition, each dataset was reviewed by the same two senior infection specialists with cross checking electronic records with re-review of the patient's notes to clarify any gaps or discrepancies before judging the antimicrobial management.

Next steps

The study hospital implemented the Antimicrobial Review Kit (ARK) study intervention into medical specialties in July 2018.[25] ARK aimed to optimise the pre-72 hours antibiotic review and increase the pre-72 hours antibiotic stop rate. Before ARK implementation the average pre-72 hours antibiotic review stop rate was 10%, which increased to 15% on average post-implementation.[26] We were unable to use the ARK decision support tool reliably because the EPMA system was not able to accommodate it.[26] The EPMA upgrade due in the spring of 2023 will accommodate the decision support tool, enabling full deployment of ARK at our hospital, and potentially increase our pre-72 hours antibiotic stop rate further. A local quality improvement programme of work optimising antibiotic course lengths in medical specialties continues.[6] The clinical decision support frameworks in the recently published 'Statement on the initial antimicrobial treatment of sepsis on managing sepsis' have now been implemented in our emergency department and are expected to result in fewer patients initiated on antibiotics for sepsis diagnoses.[27]

CONCLUSION

This study used an expert developed consensus national audit tool to determine appropriateness of antibiotic use in a single hospital in England. Twenty-four per cent of antibiotic DOTs were deemed unnecessary. The greatest opportunity to reduce antibiotic use safely was at the pre-72 hours antibiotic review, with significant opportunity to reduce antibiotic use at initiation of therapy and through optimising course lengths. IV antibiotic therapy was initiated in the majority of patients prescribed antibiotics, with a fifth of IV antibiotic days deemed unnecessary.

Author affiliations
[1]Emergency Department, Royal Cornwall Hospitals NHS Trust, Truro, UK
[2]Medical Microbiology, Royal Cornwall Hospitals NHS Trust, Truro, UK
[3]Anaesthetics, Royal Cornwall Hospitals NHS Trust, Truro, UK
[4]Department of Obstetrics and Gynaecology, Royal Cornwall Hospitals NHS Trust, Truro, UK
[5]Eldercare, Royal Cornwall Hospitals NHS Trust, Truro, UK
[6]Respiratory department, Royal Cornwall Hospitals NHS Trust, Truro, UK
[7]Neurology department, Royal Cornwall Hospitals NHS Trust, Truro, UK
[8]Acute Medicine, Royal Cornwall Hospitals NHS Trust, Truro, UK
[9]Enhanced Perioperative Care Unit, Royal Cornwall Hospitals NHS Trust, Truro, UK
[10]University Hositals Plymouth NHS Trust, Plymouth, UK
[11]Oncology Department, Royal Cornwall Hospitals NHS Trust, Truro, UK
[12]Oncology, Royal Cornwall Hospitals NHS Trust, Truro, UK
[13]Pharmacy Department, Royal Cornwall Hospital NHS Trust, Cornwall, UK

Contributors RO and NP led the manuscript write up. All authors collected data and contributed to the write up. NP and KB discussed all cases and attributed excess antibiotic use after consensus was reached. RO is responsible for all content as guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement The data that supports the findings of this study are available from the corresponding author upon reasonable request.

ORCID iD
Rhys Owens http://orcid.org/0000-0002-9631-8050

REFERENCES

1 World Health Organization. *Antimicrobial resistance: global report on surveillance*. Geneva: WHO, 2014.
2 UHS Agency. English surveillance programme for antimicrobial utilisation and resistance (ESPAUR). 2021.
3 HM Government. Tackling antimicrobial resistance 2019–2024 the UK's five-year national action plan. 2019.
4 National Health Service. NHS standard contract. 2021. Available: https://www.england.nhs.uk/nhs-standard-contract/
5 Hood G, Hand KS, Cramp E, *et al*. Measuring appropriate antibiotic prescribing in acute hospitals: development of a national audit tool through a Delphi consensus. *Antibiotics (Basel)* 2019;8:49.
6 Powell N, Stephens J, Rule R, *et al*. Potential to reduce antibiotic use in secondary care: single-centre process audit of prescription duration using NICE guidance for common infections. *Clin Med (Lond)* 2021;21:e39–44.
7 Santillo M, Sivyer K, Krusche A, *et al*. Intervention planning for antibiotic review kit (ARK): a digital and behavioural intervention to safely review and reduce antibiotic prescriptions in acute and general medicine. *J Antimicrob Chemother* 2019;74:3362–70.
8 Public Health England. AMR local indicators. n.d. Available: https://fingertips.phe.org.uk/profile/amr-local-indicators
9 Microsoft. Microsoft Excel. 2018.
10 Cross ELA, Sivyer K, Islam J, *et al*. Adaptation and implementation of the ARK (antibiotic review kit) intervention to safely and substantially reduce antibiotic use in hospitals: a feasibility study. *J Hosp Infect* 2019;103:268–75.
11 Vaughn VM, Flanders SA, Snyder A, *et al*. Excess antibiotic treatment duration and adverse events in patients hospitalized with pneumonia: a multihospital cohort study. *Ann Intern Med* 2019;171:153–63.
12 Magill SS, O'Leary E, Ray SM, *et al*. Assessment of the appropriateness of antimicrobial use in US hospitals. *JAMA Netw Open* 2021;4:e212007.
13 Papoutsi C, Mattick K, Pearson M, *et al*. Social and professional influences on antimicrobial prescribing for doctors-in-training: a realist review. *J Antimicrob Chemother* 2017;72:2418–30.
14 Stefan MS, Spitzer KA, Zulfiqar S, *et al*. Uncertainty as a critical determinant of antibiotic prescribing in patients with an asthma exacerbation: a qualitative study. *J Asthma* 2022;59:352–61.
15 Pandolfo AM, Horne R, Jani Y, *et al*. Understanding decisions about antibiotic prescribing in ICU: an application of the necessity concerns framework. *BMJ Qual Saf* 2022;31:199–210.
16 Roope LSJ, Buchanan J, Morrell L, *et al*. Why do hospital prescribers continue antibiotics when it is safe to stop? Results of a choice experiment survey. *BMC Med* 2020;18:196.
17 Tarrant C, Krockow EM. Antibiotic overuse: managing uncertainty and mitigating against overtreatment. *BMJ Qual Saf* 2022;31:163–7.
18 Fawcett NJ, Jones N, Quan TP, *et al*. Antibiotic use and clinical outcomes in the acute setting under management by an infectious diseases acute physician versus other clinical teams: a cohort study. *BMJ Open* 2016;6:e010969.
19 Daniels EN. The sepsis manual, 5th edition. n.d. Available: https://sepsistrust.org/wp-content/uploads/2020/01/5th-Edition-manual-080120.pdf
20 Health and Social Care Information Centre. Sepsis commissioning for quality and innovation (CQUIN) data collection. 2018.
21 Singer M, Inada-Kim M, Shankar-Hari M. Sepsis hysteria: excess hype and unrealistic expectations. *Lancet* 2019;394:1513–4.
22 Reinhart K, Daniels RD, Schwarzkopf D, *et al*. Sepsis hysteria: facts versus fiction. *Intensive Care Med* 2020;46:1477–80.
23 Hooper DG, Roberts DN, Lorencatto DF, *et al*. Why do clinicians treat, or not treat, a patient for sepsis? Using the theoretical domains framework to elicit barriers and enablers to performing the sepsis six in UK hospitals. *J Infect* 2021;83:709–37.
24 Chen J, Ekaney I, Shah PJ. Comparison of antimicrobial utilization metrics: food for thought for an antimicrobial stewardship programme. *Int J Antimicrob Agents* 2022;60:106681.
25 Llewelyn MB, Laskaweic-Szkonter M, Cross ELA, *et al*. Antibiotic review kit for hospitals (ARK-hospital): a stepped-wedge cluster-randomised controlled trial. *Lancet Infect Dis* 2022.
26 Roy-Bentley S, Bethune R, Powell N. Implementation of the antimicrobial review kit (ARK) to optimise antimicrobial prescribing at the Royal Cornwall Hospital: a behavioural change odyssey. *Clin Med (Lond)* 2022;22:455–60.
27 Academy of Medical Royal Colleges. Statement on the initial antimicrobial treatment of sepsis. 2022. Available: https://www.aomrc.org.uk/wp-content/uploads/2022/10/Statement_on_the_initial_antimicrobial_treatment_of_sepsis_V2_1022.pdf