J R Coll Physicians Edinb 2013; 43:294–300
http://dx.doi.org/10.4997/JRCPE.2013.403

CLINICAL

Improving antimicrobial prescribing: implementation of an antimicrobial IV-to-oral switch policy

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ABSTRACT Antimicrobial stewardship programmes reduce the risk of hospital-associated infections (HAI) and antimicrobial resistance, and include early intravenous-to-oral switch (IVOS) as a key stewardship measure. We audited the number of patients on intravenous antimicrobials suitable for oral switch, assessed whether prescribing guidelines were followed and reviewed prescribing documentation in three clinical areas in the Western General Hospital, Edinburgh, in late 2012. Following this, the first cycle results and local guidelines were presented at a local level and at the hospital grand rounds, posters with recommendations were distributed, joint infection consult and antimicrobial rounds commenced and an alert antimicrobial policy was introduced before re-auditing in early 2013. We demonstrate suboptimal prescribing of intravenous antimicrobials, with 43.9% (43/98) of patients eligible for IVOS at the time of auditing. Only 56.1% (55/98) followed empiric prescribing recommendations. Documentation of antimicrobial prescribing was poor with stop dates recorded in 14.3%, indication on prescription charts in 18.4% and in the notes in 90.8%. The commonest reason for deferring IVOS was deteriorating clinical condition or severe sepsis. Further work to encourage prudent antimicrobial prescribing and earlier consideration of IVOS is required.

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KEYWORDS Antimicrobial, antibiotic, intravenous, oral, IVOS, stewardship

DECLARATION OF INTERESTS No conflicts of interest declared.

INTRODUCTION

Antimicrobial stewardship is essential to optimise antimicrobial use in hospital. Emergence of antimicrobial resistance has been linked to antimicrobial exposure and represents an important public health issue.[1] Inappropriate or unnecessary antimicrobial prescribing is estimated to account for 50% of antimicrobial prescriptions in hospitals, with consequent risks of increased resistance, increased morbidity and mortality, prolonged hospital stay and cost when compared to infections with susceptible organisms.[1,2] Antimicrobial stewardship programmes are key in promoting the appropriate use of antimicrobials through the provision of optimum standards and guidelines for routine antimicrobial use (for example, correct agent, route, dose and duration), education, communication and audit.[1] Periodic post-prescription audit and feedback are therefore necessary components of clinical governance and quality improvement.

Early intravenous-to-oral switch (IVOS) of antimicrobials has important clinical and economic benefits. By curtailing the duration of antimicrobial treatment, the risks of developing antimicrobial resistance, the emergence of *Clostridium difficile* infection, and the risk of peripheral venous cannula infection may be reduced.[1–4] Furthermore, by reducing the duration of intravenous (IV) therapy, hospital discharge can be expedited, patient satisfaction improved and costs saved.[3,4] Indeed, other than the direct increased cost of IV drugs, more time is spent on their preparation and administration than oral therapy, with up to 13 to 113% additional indirect costs attributed to IV therapy.[5,6]

In England and Wales, the Advisory Committee on Antimicrobial Resistance and Healthcare Associated Infection has released the 'Start Smart – then Focus' initiative for inpatient antimicrobial stewardship.[7] 'Start Smart' recommends that antimicrobials are prescribed for bacterial infections after appropriate cultures, according to local guidelines, with appropriate documentation. At 48 hours, they recommend review of diagnosis and need for antimicrobials ('Focus') – the 'antimicrobial prescribing decision'. They propose five options at this stage – stop antimicrobials, IVOS, change antimicrobials, continue current therapy or outpatient parenteral antibiotic treatment (OPAT).[7] It has been

proposed that the optimal time for an oral switch is day 2–4 of IV therapy when the availability of culture results and review of clinical course allow reassessment of the management plan.[4] Early IVOS can be performed safely without an increase in complications.[4,5]

A key component of antimicrobial stewardship, as stipulated by the Health and Social Care Act 2008, is an ongoing programme of audit, revision and update.[8] We present the results of an audit of IVOS practices within infectious diseases (ID), medicine and surgery departments at the Western General Hospital, Edinburgh, before and after implementation of antimicrobial stewardship measures promoting the 'antimicrobial management decision'. The primary objective was to quantify the number of patients on IV antimicrobials who may be considered for an oral switch. Secondary objectives assessed the indication and validity of IV antimicrobials, documentation of antimicrobial prescribing, and consideration of whether the local OPAT service may be utilised in the event that prolonged IV antimicrobial therapy was warranted.

METHODS

This was a prospective audit carried out in the Western General Hospital, Edinburgh, between August 2012 and March 2013. We utilised a pre- and post- study design to this clinical audit. Intravenous antimicrobial prescribing was assessed with reference to the standard set by the Lothian University Hospitals Division (LUHD) antimicrobial prescribing guidelines[9] in three clinical areas (ID 32 beds, general medicine 42 beds, and general surgery 87 beds). These results represent cycle 1 of the audit. We then implemented a quality improvement intervention before reassessing as before (cycle 2) and completing the audit loop. The Acute Receiving and Assessment Unit and urology wards were excluded, as were the specialty wards. The surgical wards assessed here were predominantly colorectal, but incorporated some urology. In each audit cycle the three clinical areas were reviewed on three separate occasions each at least one week apart.

Cases were identified by prescription chart review. Only patients that had been on IV antimicrobials for more than 48 hours were included. Should a case remain on IV antimicrobials when the clinical area was reassessed they would not be recounted. For identified cases, we collected data on patient age, sex, diagnosis and prescribed IV antimicrobial. The antimicrobial prescribing guidelines were consulted to establish if an appropriate empirical prescribing decision had been made.[9] Where this had been varied on microbiology advice this information was recorded and was counted as 'per guideline'. Such advice may be sought by the prescribing doctor or provided unsolicited in the event of positive blood cultures. Where antimicrobial allergies existed we checked that an appropriate alternative was prescribed as per guideline or microbiology advice. Prescription charts were reviewed for the duration of IV antimicrobials thus far, for documentation of an antimicrobial stop date and whether the indication was clearly recorded. Case notes were reviewed to establish if the indication for antimicrobials was recorded.

For each case where IV antimicrobials had been prescribed for more than 48 hours, case note review established whether a switch to the oral administration route was appropriate according to the criteria in Table 1. Furthermore, each case was assessed for specific exclusion conditions where the IV route was indicated, as outlined in Table 2. Where continued IV therapy was required, cases were assessed for their suitability to receive treatment through the local OPAT service. Table 3 details the criteria for OPAT referral.

TABLE 1 Criteria for antimicrobial intravenous-to-oral switch

Temperature <38°C for 48 hours and no unexplained tachycardia
Patient clinically improved and there are no longer clinical indications for IV therapy
Oral fluids/food are tolerated and there is no reason to believe that the oral absorption of antimicrobials may be poor
White cell count and C-reactive protein improving (if being monitored)
Suitable oral alternative

TABLE 2 Indications for >48 hours of intravenous antimicrobials

Microbiology advice
Severe sepsis/failure to respond to existing IV antimicrobial therapy/deteriorating clinical condition
Infections requiring longer courses of intravenous therapy as stated in the antimicrobial prescribing guidelines
Bacteraemia
Deep abscess/tissue infection
Meningitis
Brain abscess
Osteomyelitis/septic arthritis
Encephalitis
Endocarditis
Febrile neutropenia (white cell count <1)
Pyelonephritis
Prosthetic device infection
Cystic fibrosis-related infection

TABLE 3 Indications for outpatient parenteral antibiotic treatment (OPAT)

Patient willing/able to attend OPAT daily/thrice weekly
IV therapy required
Transport available (patient or hospital)
Availability of suitable antimicrobial regime • Efficacious • Good safety profile • No/little need for therapeutic drug monitoring • Long half-life • Short administration time • Stable when reconstituted

No other active medical conditions requiring admission
• Condition not rapidly deteriorating
• Less than two of:
  • Temperature <36°C or >38°C
  • Heart rate >90 beats per minute
  • Respiratory rate >20 breaths per minute
  • Blood pressure <100 mm Hg systolic

No history of active/current alcohol or drug misuse
No cognitive impairment/mental health issues that would preclude OPAT

Following completion of the first audit cycle, the data collected were presented to the local departmental educational meetings and at the Western General Hospital grand rounds. Promotion of local guidelines, 'Start Smart – then Focus' recommendations and contact details for antimicrobial advice through ID or microbiology departments was included in the presentation. Posters (Figure 1) detailing the recommendations and contact details were put up in doctors' rooms at the Western General Hospital and Royal Infirmary sites. In conjunction with these interventions, combined ID and microbiology consult rounds commenced at the Western General site. These provide a regular advice service with a key emphasis on antimicrobial stewardship. As a final measure, an alert antimicrobial policy was introduced between review cycles. This imposes restrictions on the prescription of certain antimicrobials (ceftazidime, daptomycin, fidaxomicin, levofloxacin, linezolid, meropenem, moxifloxacin and tigecycline) to specific 'permitted' indications. For 'non-permitted' indications, microbiology or ID approval is required. After implementation of these interventions, the audit cycle was repeated.

Cycle 1 of the audit was completed between August and September 2012. Re-auditing (cycle 2) occurred between February and March 2013. This was a blinded study in that prescribing doctors were not informed. Recommendations were not made to the clinical teams and the consultants responsible for each patient were not identified. The study was registered with the local NHS Quality Improvement Scotland (QIS) teams and adherence to Caldicott principles was ensured throughout.

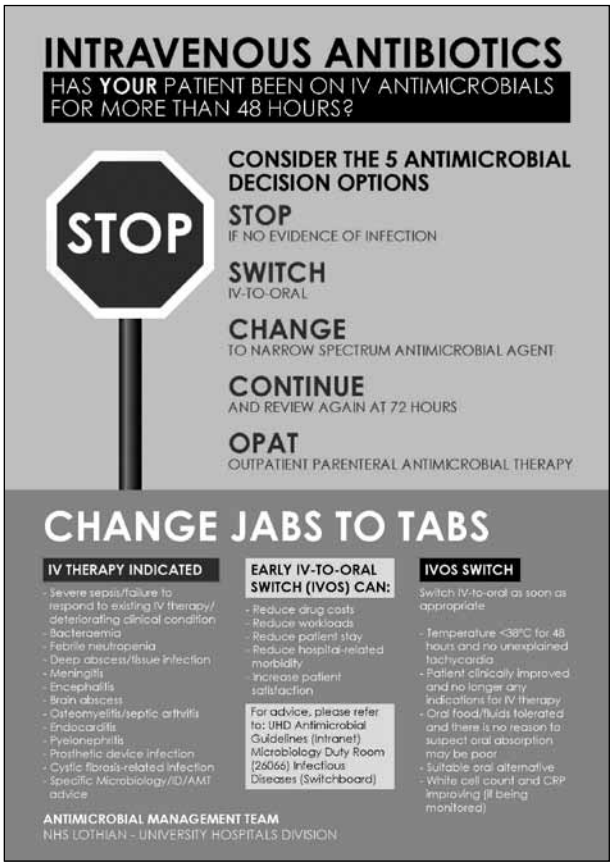

FIGURE 1 Posters detailing local guidelines, 'Start Smart – then Focus' recommendations and contact details for antimicrobial advice.

Limited statistical analysis was performed. The two-sample t-test was used in comparing percentages between the two audit cycles. The two-tailed Student's t-test compared the age distribution of the two groups. The chi-squared test compared those suitable for IVOS for each clinical area. Statistical significance was set at the conventional level of 5%.

RESULTS

Patient and cycle details

In the first audit cycle a total of 55 patients on IV antimicrobials for more than 48 hours were identified. In cycle 2 (post-intervention) 43 patients were identified. Table 4 details the patient demographics in each cycle. There was no significant difference in the age and sex distribution of patients between the two cycles.

Each clinical area was assessed on three separate occasions per cycle, with ID having 20 patients of 96 (20.8%) on IV antimicrobials for more than 48 hours in the first cycle, medicine, six patients of 126 (4.8%), and surgery, 29 patients of 261 inpatients (11.1%). On average, 11.4% of patients remained on IV antimicrobials for more than 48 hours in these clinical areas.

TABLE 4 Patient demographics

Feature	Audit cycle 1	Audit cycle 2	Significance
Number*	55/483 (11.4%)	43/483 (8.9%)	p=0.20†
Male	22 (40%)	18 (41.9%)	p=0.43†
Female	33 (60%)	25 (58.1%)	p=0.13†
Mean age (range)	64.4 (30–92)	67.37 (28–94)	p=0.35‡
Infectious diseases*	20/96 (20.8%)	15/96 (15.6%)	p=0.35†
Medicine*	6/126 (4.8%)	5/126 (4.0%)	p=0.76†
Surgery*	29/261 (11.1%)	23/261 (8.8%)	p=0.38†

*Patients on IV antimicrobials for >48 hours/total number of inpatients during cycle (%)
†2-sample t-test, ‡2-tailed Student's t-test

On re-auditing, ID had 15 patients of 96 (15.6%) on IV antimicrobials for more than 48 hours, medicine, five patients of 126 (4.0%) and surgery, 23 patients of 261 (8.8%). On the second cycle, an average of 8.9% of patients remained on IV antimicrobials for more than 48 hours.

Suitability for IVOS

Patients were assessed for suitability for IVOS by the criteria in Table 1. Furthermore, should patients be diagnosed with any of the conditions in Table 2, they were deemed unsuitable for IVOS due to an ongoing clinical indication for IV therapy. In the first cycle in ID, seven of 20 patients (35%) could be considered for IVOS – that is, 35% were inappropriately on IV antimicrobials. Twelve of 20 patients (60%) required IV therapy for conditions detailed in Table 2, of whom five were due to severe sepsis/failure to respond to existing IV antimicrobial therapy/deteriorating clinical condition. By the second cycle in ID, two of 15 patients could be considered for IVOS. Thirteen patients required further IV therapy for the indications in Table 2. There was no statistically significant difference in the number of patients requiring IVOS in ID between audit cycles (p=0.15).

On initial audit in medicine, three of six patients (50%) were suitable for IVOS. Two patients were not suitable due to conditions detailed in Table 2 (bacteraemia and deteriorating clinical condition). On the second audit cycle, one of five patients was suitable for IVOS (20%). Those unsuitable included three patients with a deteriorating clinical condition. There was no statistically significant difference in the number of patients requiring IVOS in medicine between audit cycles (p=0.30).

In the surgery wards, 15 of 29 patients (51.7%) on IV antimicrobials could be considered for IVOS in cycle 1. Ten of 29 patients (34.5%) required IV therapy for conditions detailed in Table 2. Of these, microbiology had advised ongoing IV therapy in six patients. On the second audit cycle, 15 of 23 patients (65.2%) could be considered for IVOS. In those requiring ongoing IV therapy the commonest indication was deteriorating clinical condition or severe sepsis (four patients). There was no statistically significant difference in the number of patients requiring IVOS in surgery wards between audit cycles (p=0.33).

Overall, 43 of 98 (43.9%) of patients on IV antimicrobials for more than 48 hours could be considered for an oral switch (25 of 55 [45.5%] in cycle 1; 18 of 43 [41.9%] in cycle 2). The commonest explanation for prolonged IV antimicrobial therapy was severe sepsis/failure to respond to existing IV antimicrobial therapy/deteriorating clinical condition in 20 patients (20.4%). Osteomyelitis/septic arthritis and bacteraemia were the second commonest reasons (seven patients each).

Choice and duration of IV antimicrobial

Overall, 29 of 55 (52.7%) patients were on appropriate empiric or microbiology-guided IV antimicrobials on the first audit cycle. Following the interventions on the second cycle, 26 of 43 (60.5%) patients were on appropriate antimicrobials, a non-significant improvement (p=0.44). In ID, guidelines were followed in 65% of the first cycle cases, 26.7% of the second cycle cases, a statistically significant decrease (p=0.03). In medicine, the adherence to guidelines had improved from 83.3% to 100% (p=0.36). In surgery, adherence to guidelines or microbiology advice improved from 37.9% to 73.9% (p=0.01).

A wide variety of IV antimicrobial combinations were used in each area. The commonest prescriptions were for piperacillin-tazobactam (29 patients), co-amoxiclav (13 patients) and meropenem (eight patients). Piperacillin-tazobactam in combination with another antimicrobial (ceftriaxone, metronidazole, or flucloxacillin) accounted for a further 11 prescriptions.

The median duration patients had been on IV antimicrobials was six days in both audit cycles. The mean duration was 6.8 days (range 3–47 days) in cycle 1, 7.0 days (range 3–48 days) in cycle 2. The mode was three days.

Documentation

The stop date for antimicrobials was recorded on the prescription chart 14.3% of the time (ID 17.1%, medicine 36.4%, surgery 7.7%), with no significant difference seen between cycles (9.0–20.9%). The indication was clearly recorded in the notes in 90.8% of cases (ID 100%, medicine 100%, surgery 82.7%), but on the prescription chart only 18.4% of the time (ID 17.1%, medicine 27.3%, surgery 15.4%). While a slight improvement was seen in

detailing the indication for antimicrobials on the prescription chart between cycles (16.4–25.6%) this was not statistically significant (p=0.26).

Suitability for OPAT

Those that were required to remain on IV therapy were assessed for their suitability to attend OPAT. A total of 48 of 98 (49.0%) patients were required to remain on IV therapy, typically for diagnoses outlined in Table 2. Of these, six (6.1%) could be considered candidates for OPAT (20.8% in cycle 1, 4.2% in cycle 2). Of those still requiring IV therapy, 20 of 48 (41.7%) were unsuitable for OPAT due to severe sepsis or deteriorating clinical condition.

DISCUSSION

This audit identified 98 patients of a total of 966 in ID, medicine and surgery who had continued on IV antimicrobials for more than 48 hours over two audit cycles. Of these, as many as 43.9% could be considered for IVOS on the basis of local prescribing guidelines, and were inappropriately receiving IV therapy. This figure echoes a recent Swiss study that identified that 38% of patients on general medical wards would be suitable for IVOS on the third day of IV therapy.[4] Similarly, one study assessing the impact of infection team review identified that of 139 patients requiring ongoing antimicrobial therapy, 34% could be switched from IV-to-oral therapy without adverse effect.[10] Although fewer patients in the second cycle should have been switched to oral therapy by the time of review (41.9% vs. 45.5%), this change was not statistically significant. In reviewing the duration of IV antimicrobials in our study the mode was three days, suggesting that in many, IVOS had simply been overlooked and may be possible at an earlier juncture. Early IVOS is a key feature of antimicrobial stewardship programmes, with benefits to the patient and organisation without compromising patient safety.[1,4]

While IVOS was the main focus of this audit, choice of IV antimicrobial was also reviewed. Clear guidance as to empiric therapy in LUHD exists, yet only 56.1% of cases followed these guidelines or microbiology recommendations.[9] Documentation of the rationale for deviation from protocol was rarely recorded. When assessed by clinical area, ID followed empiric guidelines less frequently on the second cycle (26.7% vs. 65%). It could be argued that antimicrobial stewardship represents a key role of the ID physician, and that although not following empiric guidelines, a cognisant antimicrobial choice taking into account likely organisms and sensitivities would have been made in these circumstances. Indeed, with the results of microbiology samples becoming available, the prescription would frequently be changed from empiric antimicrobials to narrower spectrum antimicrobials without specifically seeking microbiology input. Infectious Diseases admits proportionately more patients requiring IV therapy (Table 2), and there is an argument for excluding ID from future audits in light of the complex, specialty patients on these wards. Encouragingly, adherence to guidelines or microbiology advice significantly improved in surgery from 37.9% to 73.9%. We presume this is secondary to the three interventions in this study: promotion of the 'Start Smart – then Focus' guidelines, introduction of an alert antimicrobial policy and the impact of the twice-weekly combined ID and microbiology consult rounds. Data collected prospectively from the consult rounds occuring twice-weekly at the Royal Infirmary of Edinburgh have shown that review by an infection specialist results in a recommendation to rationalise the antimicrobials (narrow the spectrum, switch IV to oral or stop) in 50% of cases.[11]

In the first audit cycle, the combination of piperacillin-tazobactam and metronidazole was one of the commonest prescriptions in the surgical directorate. Piperacillin-tazobactam has a broad spectrum of activity – including anaerobic cover – and is recommended as monotherapy for peritonitis, diverticulitis, cholecystitis and cholangitis.[9] Following the interventions, the combination of piperacillin-tazobactam and metronidazole was not seen. In the UK, prescribing data have shown a three-fold increase in piperacillin-tazobactam prescribing, and 50% increase in co-amoxiclav prescribing, echoing our findings here.[12]

For a number of patients, IV therapy beyond 48 hours had been advised following consultation with the microbiologists. Telephone calls to the microbiology duty room are likely to produce a cautious response and recommend the use of IV therapy due to the difficulty in clinically assessing a patient over the telephone. Studies have demonstrated a poor assessment of the severity of infection in the absence of infection specialist input, resulting in over-treatment of less severe infection and under-treatment of more severe infection.[13,14] Furthermore, one of the commonest reasons for deferred IVOS was severe sepsis or deteriorating clinical condition. A study of the use of IVOS checklists by Mertz et al. identified that the absence of clinical improvement and the abatement of fever were the commonest explanation for deferred IVOS.[4] Joint ID and microbiology ward rounds would be well placed to advise on IVOS and antimicrobial usage with those patients discussed with microbiology on continued IV antimicrobials being clinically reviewed on these rounds.

Documentation was a key issue in data collection. Discussions with the microbiology department were not always recorded and the indication for antimicrobials was not always specified. In 90.8% of the

patients reviewed, the case notes recorded the indication, but this was only documented on the prescription chart in 18.4% of cases. Little improvement was seen between cycles and may in part be explained by the changeover of junior doctors. Furthermore, a stop/review date was only included 14.3% of the time. The Department of Health guidelines recommend this information be recorded as part of the 'Start Smart' initiative, and the new LUHD prescription charts will contain boxes for this information.[7] A common explanation for the unnecessary continuation of antimicrobials in hospital is that information as to the indication and proposed duration of antimicrobial were not available to the clinical team, particularly in the context of transferred care.[1]

It was noted that some patients in this audit had been commenced on empirical antibiotics on admission that continued despite the diagnosis being revised. For example, in surgery a number of patients were commenced on piperacillin-tazobactam ± metronidazole for presumed diverticulitis or intra-abdominal collections that continued despite lack of radiological evidence for these conditions. Furthermore, some remained on IV therapy pending a decision on operative management. A routine reassessment at the 48 hour juncture may reduce this occurrence. The development of IVOS checklists placed in the medical charts has been shown to shorten the duration of IV antimicrobial prescribing,[4] and may provide a helpful prompt to encourage consideration of antimicrobial prescribing. Clear step down options in the antimicrobial guidelines should facilitate IVOS. Three patients were identified that had continued on surgical prophylaxis antimicrobials for more than 48 hours. Where surgical prophylaxis antimicrobials are used, these should be single dose only.[7,9]

This was a pre- and post- audit and it has a number of limitations. It does not count the number of successful IV-oral switches that have occurred, but rather missed opportunities for IVOS and rationalising therapy. Those that were switched to oral therapy in a timely manner would not be picked up by this audit. Only a small number of wards were included in this preliminary study and may not be representative of the hospital, or indeed the specialties, as a whole. Inclusion of care of the elderly wards in future audits may be informative. The limited numbers of patients identified means that we should look to the trends to gain an impression of the result of any intervention. The acute admission wards were specifically not included due to the high turnover of patients, and due to the fact that most patients were discharged or moved to downstream beds within 48 hours. It is appreciated that complete turnover of inpatients in each ward between cycles was unlikely. As such some patients were likely to remain inpatients but would not be counted twice.

It could be argued that the 48 hour antimicrobial prescribing decision is a useful antimicrobial stewardship tool but means that few patients will have been afebrile for 48 hours – one of the local criteria for IVOS. As such, these criteria should be used as a guideline and if the patient is making a clear improvement, early IVOS at the 48-hour juncture would be appropriate. Although no recommendations were made to the prescribing doctors, future audits may assess perceived benefit and adherence to suggestions made by the infection consult and antimicrobial ward rounds. One study of infection team review on antimicrobial prescribing identified significant numbers of patients that could IVOS, utilise OPAT services or stop antimicrobials.[10] An average of £662 of net savings could be made for each patient assessed.[15] Further audits may assess the health economics of antimicrobial review in terms of length of stay reduction and cost of therapy in this setting.

For the 48 patients still requiring IV therapy, OPAT was an option for six. This represented 20.8% of cases in cycle 1, and 4.2% in cycle 2. This reduction in the numbers suitable for OPAT may be due to earlier referral to OPAT with ward discharge due to the increased local profile of OPAT and recommendations from the infection consult rounds. From the ID department patients may be referred directly to OPAT on admission. Where appropriate, the use of outpatient therapy may increase inpatient capacity through admission avoidance and reduced inpatient stay, reduce costs compared to inpatient care, reduce risk of healthcare-associated infection and improve patient satisfaction.[16]

A number of recommendations arise from this evaluation. Firstly, there are a significant proportion of patients that may benefit from early IVOS and promotion of the local guidelines and results of this audit may work to improve this. Separate antimicrobial prescription charts with pre-printed recommendations may help, and have shown benefits in earlier IVOS in general medical wards,[3] as may empowerment of pharmacists to highlight the need for IVOS. Indeed, antimicrobial rounds consisting of an ID physician and an antimicrobial pharmacist have now been introduced twice-weekly at the Western General and Royal Infirmary sites to review prescribing of antimicrobials and make recommendations. Formal adoption of the 'start smart – then focus' initiative may be helpful in promoting a 48 hour antibiotic review, as would use of the five prescribing decision options – stop, switch, change, continue, OPAT.[7] The majority of inpatient prescriptions are written by junior medical staff, and thus promotion of this initiative at an undergraduate level or in foundation training may improve antimicrobial stewardship. Should electronic prescribing be brought into LUHD, automatic antimicrobial review prompts at 48 hours may provide a useful reminder. Regular audit should monitor progress in antimicrobial stewardship strategies.

We would conclude that there is a clear need to educate staff in LUHD on the risks and benefits of both oral and IV antimicrobials, and to encourage early IVOS. This would have benefits in terms of direct and indirect cost reduction, reduced risks of peripheral line infections and bacteraemia, increased patient satisfaction and potential bed days saved. This audit demonstrates improvement in antimicrobial prescribing and IVOS rates following three simple interventions, and represents a generalisable and feasible approach to improved antimicrobial stewardship as part of a quality improvement exercise.

REFERENCES

1 Ashiru-Oredope D, Sharland M, Charani E et al. Improving the quality of antibiotic prescribing in the NHS by developing a new Antimicrobial Stewardship Programme: Start Smart – Then Focus. *J Antimicrob Chemother* 2012; 67 Suppl 1:i51–i63. http://dx.doi.org/10.1093/jac/dks202

2 Davey P, Brown E, Fenelon L et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. *Cochrane Database Syst Rev* 2005; 19:CD003543.

3 Laing RB, Mackenzie AR, Shaw H et al. The effect of IV to oral switch guidelines on the use of parenteral antimicrobials in medical wards. *J Antimicrob Chemother* 1998; 42:107–11. http://dx.doi.org/10.1093/jac/42.1.107

4 Mertz D, Koller M, Haller P et al. Outcomes of early switching from intravenous to oral antibiotics on medical wards. *J Antimicrob Chemother* 2009; 64:188–99. http://dx.doi.org/10.1093/jac/dkp131

5 Sevinc F, Prins JM, Koopmans RP et al. Early switch from intravenous to oral antibiotics: guidelines and implementation in a large teaching hospital. *J Antimicrob Chemother* 1999; 43:601–6. http://dx.doi.org/10.1093/jac/43.4.601

6 van Zanten AR, Engelfriet PM, van Dillen K et al. Importance of nondrug costs of intravenous antibiotic therapy. *Crit Care* 2003; 7:R184–90. http://dx.doi.org/10.1186/cc2388

7 Department of Health. *Antimicrobial stewardship: start smart – then focus* [Internet]. London: Department of Health; 2011 [cited 2013 Oct 10]. Available from: http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_131181.pdf

8 The Health and Social Care Act 2008. *Code of practice on the development and control of infections and related guidance* [Internet]. 2008 [cited 2013 Oct 10]. Available from: http://www.legislation.gov.uk/ukpga/2008/14/pdfs/ukpga_20080014_en.pdf

9 Antimicrobial Management Team (NHS Lothian). *University Hospitals Division: Antimicrobial prescribing guidelines in adults* [Internet]. Edinburgh: NHS Lothian; 2012 [cited 2013 Oct 10]. Available from: http://www.nhslothian.scot.nhs.uk/AntimicrobialPrescribingGuidelines/Documents/UHDAntibioticGuidelines.pdf

10 Dryden M, Saeed K, Townsend R et al. Antibiotic stewardship and early discharge from hospital: impact of a structured approach to antimicrobial management. *J Antimicrob Chemother* 2012; 67:2289–96. http://dx.doi.org/10.1093/jac/dks193

11 Mackintosh CL. Unpublished data.

12 Kritsotakis EI, Gikas A. Surveillance of antibiotic use in hospitals: methods, trends and targets. *Clin Microbiol Infect* 2006; 12:701–4.

13 Koerner R, Johnson AP. Changes in the classification and management of skin and soft tissue infections. *J Antimicrob Chemother* 2011; 66:232–4. http://dx.doi.org/10.1093/jac/dkq443

14 Marwick C, Broomhall J, McCowan C et al. Severity assessment of skin and soft tissue infections: cohort study of management and outcomes for hospitalised patients. *J Antimicrob Chemother* 2011; 66:387–97. http://dx.doi.org/10.1093/jac/dkq362

15 Gray A, Dryden M, Charos A. Antibiotic management and early discharge from hospital: an economic analysis. *J Antimicrob Chemother* 2012; 67:2297–302. http://dx.doi.org/10.1093/jac/dks194

16 Chapman AL, Seaton RA, Cooper MA et al. Good practice recommendations for outpatient parenteral antimicrobial therapy (OPAT) in adults in the UK: a consensus statement. *J Antimicrob Chemother* 2012; 67:1053–62. http://dx.doi.org/10.1093/jac/dks003