Antibiotic management and early discharge from hospital: an economic analysis

Alastair Gray1*, Matthew Dryden2 and Apostolos Charos3

1Health Economics Research Centre, Department of Public Health, University of Oxford, Rosemary Rue Building, Old Road Campus, Headington, Oxford OX3 7LF, UK; 2Royal Hampshire County Hospital, Winchester SO22 5DG, UK; 3Pfizer Ltd, Walton-on-the-Hill, Tadworth, Surrey KT20 7NS, UK

*Corresponding author. Tel: +44-(0)1865-289279; Fax: +44-(0)1865-289271; E-mail: alastair.gray@dph.ox.ac.uk

Received 16 January 2012; returned 1 March 2012; revised 5 April 2012; accepted 23 April 2012

Objectives: To evaluate potential costs and savings from implementing an evaluation tool that uses bedside review of antibiotic use and infection management to assess whether patients with infections in acute medical and surgical wards could have their antibiotic regimen changed and be safely managed out of hospital.

Methods: The tool was implemented in 30 acute wards in five UK hospital trusts. Data were collected on demographic variables, diagnosis, social situation, hospital stay and all current antibiotic prescribing for 291 patients. A physician and pharmacist assessed antibiotic therapy and feasibility of discharge. Resource use was measured for each patient, unit costs attached, and mean and total costs of implementing recommendations were calculated.

Results: Implementation of these recommendations could reduce total inpatient days by 494 at a saving of £186731, and save £20215 from adjustment of antibiotic therapy. Additional costs were associated with implementation of the assessment (£2468), community support (£6227) and outpatient parenteral antimicrobial therapy (£5616). As a result, the net potential savings would be £192635 in total or £662 (95% CI: £393, £930) for every patient assessed. Excluding eight patients with the highest potentially avoidable inpatient stays (>15 days), mean savings would fall to £363 per patient assessed but remain highly significant (95% CI: £261, £465).

Conclusions: Careful assessment of antibiotic use in acute wards has the potential to reduce the use and cost of antibiotics, and length of stay. Added costs of assessment and out-of-hospital support services would offset a small proportion of these potential savings. Randomized studies are now needed to test these results.

Keywords: cost analysis, antibiotic review, hospital infections, outpatient parenteral antimicrobial therapy, OPAT

Introduction

The management of infections in hospital represents a significant burden to the UK National Health Service (NHS). Once acute infection has been controlled, patients may be discharged into the community with no continuing antibiotic therapy, oral antibiotic therapy or intravenous (iv) infusion therapy outside the hospital. Government policy firmly supports the objective of moving care closer to home and providing an increasingly large proportion of the care pathway outside the hospital setting. However, there are still thought to be significant numbers of patients who could potentially be discharged but who remain in hospital.

To evaluate the potential impact of an antibiotic management and early discharge programme on NHS resources and patient pathways in this population, a series of service evaluations was undertaken in a sample of hospital trusts/health boards across the UK. These service evaluations were exploratory studies designed to provide useful descriptive information for a sample of individual medical and surgical inpatients across a range of different practice settings. The information collected included antibiotics used, scope for changing or stopping current antibiotic therapy, suitability of patients on iv antibiotics for continuation of iv therapy either as an outpatient or outside the hospital environment if an outpatient parenteral antimicrobial therapy (OPAT) service was available, and whether discharge from hospital is recommended. Full clinical details of this study are reported in a companion paper. From these and other data collected, it was possible to undertake an economic analysis to estimate the cost consequences of potential changes in...
antibiotic therapy, discharge dates and community support, and so provide estimates of the potential cost savings from an antibiotic management and early discharge intervention in the study population.

Methods

The service evaluation was conducted across six hospital settings in the UK: the Royal Hampshire County Hospital, Winchester; the Northern General Hospital, Sheffield; Glasgow Royal Infirmary; Imperial College NHS Trust; Guys & St Thomas’s NHS Foundation Trust; and Leeds NHS Trust. Data on patient demographics and current antibiotic prescribing were collected on the day of the evaluation from the patient notes and drug charts by the service evaluation facilitator, and assessment of suitability for discharge on the day of the evaluation was made by a suitably qualified healthcare professional, acting independently from the clinical care team. Data relating to the date of actual discharge and the formal reason for admission were also collected by the service evaluation facilitator. Information was collected for each patient on age, specialty, home circumstances, presence or absence of antibiotic allergy and other salient characteristics, current antibiotic treatment(s), assessed ability to have antibiotic treatment changed or stopped, whether hospital discharge was recommended with or without community support, and whether discharge was not recommended but would have been had OPAT services been available.

Unit costs were obtained from a range of sources and are reported in Table 1. The costs per day in different specialties were taken from NHS Trust Financial Returns5 updated to 2008/09 prices using the NHS Hospital and Community Health Services Pay and Prices Index.6 All antibiotic use recorded was costed using net ingredient costs as reported in the 2010 British National Formulary (BNF),7 with any assumptions concerning doses, mode of administration and brand agreed with clinical opinion. The cost of OPAT services was taken from a UK study reported in 2009,8 which estimated a cost of £151.80 per patient per day. Community care costs were based on an estimate of the median daily cost of delivering a package of health and social care services to a domiciliary setting.9 The costs associated with iv administration in hospital were taken from a Dutch study, which included staff and material costs for pump, bolus injection, piggyback infusion and insertion/removal of iv catheter; £5.71 per administration in 2003 prices, up-rated to 2008/09 £s, assuming three administrations per day.

Unit costs were obtained from a range of sources and are reported in Table 1. The costs per day in different specialties were taken from NHS Trust Financial Returns5 updated to 2008/09 prices using the NHS Hospital and Community Health Services Pay and Prices Index.6 All antibiotic use recorded was costed using net ingredient costs as reported in the 2010 British National Formulary (BNF),7 with any assumptions concerning doses, mode of administration and brand agreed with clinical opinion. The cost of OPAT services was taken from a UK study reported in 2009,8 which estimated a cost of £151.80 per patient per day. Community care costs were based on an estimate of the median daily cost of delivering a package of health and social care services to a domiciliary setting.9 The costs associated with iv administration in hospital were taken from a Dutch study, which included staff and material costs for pump, bolus injection, piggyback infusion and insertion/removal of iv catheter; £5.71 per administration in 2003 prices, up-rated to 2008/09 £s, assuming three administrations per day.

Unit costs were then attached to the observed resource use volumes of each patient, and to the predicted resource use volumes if antibiotic therapy had been switched, the patient had been discharged and community support services had been provided, to obtain a cost per patient. For the study population, mean estimates of resource volumes, costs and changes in costs were then reported, accompanied by appropriate measures of variance, for total costs and for main cost categories: antibiotics, bed-days and community support, with all 95% CIs calculated directly from the variance in the calculated costs per patient. From these estimates, the potential cost savings arising from an antibiotic management and early discharge programme were calculated, giving an indication of the maximum costs that could be incurred in

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit cost (£s)</th>
<th>Note</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per inpatient day in:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cardiac surgery</td>
<td>£1057.16</td>
<td>£870.66×1.214</td>
<td>trust financial returns 2003/04 up-rated to</td>
</tr>
<tr>
<td>endocrine/cardiology</td>
<td>£625.21</td>
<td>£514.91×1.214</td>
<td>2008/09 using HCHS index</td>
</tr>
<tr>
<td>medical geriatric</td>
<td>£213.24</td>
<td>£175.62×1.214</td>
<td></td>
</tr>
<tr>
<td>medicine</td>
<td>£273.04</td>
<td>£224.87×1.214</td>
<td></td>
</tr>
<tr>
<td>orthopaedics</td>
<td>£521.33</td>
<td>£429.36×1.214</td>
<td></td>
</tr>
<tr>
<td>respiratory</td>
<td>£314.27</td>
<td>£258.83×1.214</td>
<td></td>
</tr>
<tr>
<td>surgery</td>
<td>£486.34</td>
<td>£400.54×1.214</td>
<td></td>
</tr>
<tr>
<td>vascular surgery</td>
<td>£1057.16</td>
<td>£870.66×1.214</td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td>NIC</td>
<td>NIC×quantity/dose prescribed, converted into a</td>
<td>BNF 60,7 2010</td>
</tr>
<tr>
<td>OPAT services</td>
<td>£151.8</td>
<td>cost per day</td>
<td>Chapman et al.,8 2009</td>
</tr>
<tr>
<td>Community care package</td>
<td>£27</td>
<td>based on PSSRU estimate of median cost of</td>
<td>PSSRU,9 2009</td>
</tr>
<tr>
<td>iv administration in hospital</td>
<td>£24.57 per day</td>
<td>includes staff and material costs for pump,</td>
<td>van Zanten et al.,10 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bolus injection, piggyback infusion and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>insertion/removal of iv catheter; £5.71 per</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>administration in 2003 prices, up-rated to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008/09 £s, assuming three administrations per day</td>
<td></td>
</tr>
</tbody>
</table>

HCHS, Hospital and Community Health Services; NIC, net ingredient cost; PSSRU, Personal Social Services Research Unit.
This service evaluation aimed to illustrate the potential clinical and economic impact of implementing a formal antibiotic review and early discharge programme across a number of different hospitals, specialties and patient characteristics. The assessment indicated that 28% of patients assessed were considered suitable for some form of policy change.

Table 2 summarizes the costs or cost savings arising if these recommendations had been implemented. A total of 494 inpatient days would have been saved at a potential cost saving of £186 731. Additional savings that would have been made included £4 446 saved by switching from an oral antibiotic to no antibiotic, £10 536 by switching from an iv antibiotic to no antibiotic and £9 233 by switching from iv to oral antibiotic. Additional costs would have been incurred relating to the assessment (£2 468), community support costs (£6 227) and OPAT (£5 616). As a result, net potential savings would be £19 2635 in total or £662 (95% CI: £393, £930) per patient assessed.

**Sensitivity analyses**

Lengths of stay are frequently skewed, with a small number of patients incurring long lengths of stay and therefore contributing disproportionately to overall bed-days and, in this instance, possible bed-day savings. Excluding eight patients with the highest potentially avoidable inpatient stays (>15 days), mean savings would fall to £363 per patient assessed but remain highly significant (95% CI: £261, £465) (Table 4).

The estimated cost of providing an OPAT service—£151.80 per person per day—is taken from a large, detailed and recent UK study; however, it is possible that support costs for iv antibiotic users in the community could be higher or lower than the figure used, if such services were configured differently or depending on patient characteristics. Increasing or reducing this figure by 25% has little effect on the overall results: if 25% lower, the net saving per person would fall to £363 per patient assessed but remain highly significant (95% CI: £261, £465) (Table 4).

As a result, net potential savings would be £19 2635 in total or £662 (95% CI: £393, £930) per patient assessed.

**Results**

A total of 429 patients were identified across all six hospital sites as being on antibiotics; however, in one site (Sheffield) full information was not available on the length of stay and actual discharge date of patients, and so the economic analysis was performed for the 291 patients on antibiotics in the five hospitals for which full information was available. Table 2 reports descriptive information on this population. Patients were on 30 wards, mainly in general medicine (n=134, 46%) or general surgery (n=91, 31%) specialties. One-hundred-and-seventy-six patients (61%) were on oral antibiotics and 4 (14%) should remain on iv antibiotics. In addition, of the 209 patients who were not suitable for discharge, 27 on oral therapy (13%) and 16 on iv or oral therapy (8%) were considered suitable for cessation of therapy, and a further 25 patients were assessed as suitable to be switched from iv or oral therapy to oral therapy only. In total, 150 (51%) of the 291 patients assessed were considered suitable for some form of policy change.

Table 3 summarizes the costs or cost savings arising if these recommendations had been implemented. A total of 494 inpatient days would have been saved at a potential cost saving of £186 731. Additional savings that would have been made included £4 446 saved by switching from an oral antibiotic to no antibiotic, £10 536 by switching from an iv antibiotic to no antibiotic and £9 233 by switching from iv to oral antibiotic. Additional costs would have been incurred relating to the assessment (£2 468), community support costs (£6 227) and OPAT (£5 616). As a result, net potential savings would be £19 2635 in total or £662 (95% CI: £393, £930) per patient assessed.

**Sensitivity analyses**

Lengths of stay are frequently skewed, with a small number of patients incurring long lengths of stay and therefore contributing disproportionately to overall bed-days and, in this instance, possible bed-day savings. Excluding eight patients with the highest potentially avoidable inpatient stays (>15 days), mean savings would fall to £363 per patient assessed but remain highly significant (95% CI: £261, £465) (Table 4).

The estimated cost of providing an OPAT service—£151.80 per person per day—is taken from a large, detailed and recent UK study; however, it is possible that support costs for iv antibiotic users in the community could be higher or lower than the figure used, if such services were configured differently or depending on patient characteristics. Increasing or reducing this figure by 25% has little effect on the overall results: if 25% lower, the net saving per person would fall to £363 per patient assessed but remain highly significant (95% CI: £261, £465) (Table 4).

As a result, net potential savings would be £19 2635 in total or £662 (95% CI: £393, £930) per patient assessed.

**Sensitivity analyses**

Lengths of stay are frequently skewed, with a small number of patients incurring long lengths of stay and therefore contributing disproportionately to overall bed-days and, in this instance, possible bed-day savings. Excluding eight patients with the highest potentially avoidable inpatient stays (>15 days), mean savings would fall to £363 per patient assessed but remain highly significant (95% CI: £261, £465) (Table 4).

The estimated cost of providing an OPAT service—£151.80 per person per day—is taken from a large, detailed and recent UK study; however, it is possible that support costs for iv antibiotic users in the community could be higher or lower than the figure used, if such services were configured differently or depending on patient characteristics. Increasing or reducing this figure by 25% has little effect on the overall results: if 25% lower, the net saving per person would fall to £363 per patient assessed but remain highly significant (95% CI: £261, £465) (Table 4).

As a result, net potential savings would be £19 2635 in total or £662 (95% CI: £393, £930) per patient assessed.

**Discussion**

This service evaluation aimed to illustrate the potential clinical and economic impact of implementing a formal antibiotic review and early discharge programme across a number of different hospitals, specialties and patient characteristics. The assessment indicated that 28% of patients assessed were considered to be potentially suitable for early discharge, with a further 23% of patients considered not suitable for early discharge but still showing potential for therapy switching savings and potentially doubling the potential clinical and economic impact of implementing a formal antibiotic review and early discharge programme across a number of different hospitals, specialties and patient characteristics. The assessment indicated that 28% of patients assessed were considered to be potentially suitable for early discharge, with a further 23% of patients considered not suitable for early discharge but still showing potential for therapy switching savings and potentially doubling the potential clinical and economic impact of implementing a formal antibiotic review and early discharge programme across a number of different hospitals, specialties and patient characteristics.
discharge but suitable for some form of change to their current antibiotic treatment altered. A companion paper gives fuller details and discussion of the assessment procedures used, and places these in the wider context of antibiotic stewardship.

Our economic analysis found that careful assessment of antibiotic use in acute wards has the potential to reduce the use and cost of antibiotics, and length of stay. The added costs of assessment and out-of-hospital support services would offset a small proportion of these potential savings. Most of the savings are related to potential reductions in lengths of stay as a result of earlier discharge.

These savings should be viewed as opportunity costs rather than cash savings, i.e. each inpatient day saved can then be used for other purposes (such as reducing waiting times) or, in

Figure 1. Flow diagram of patients through service evaluation.

Table 3. Change in costs per patient from adoption of recommendations (n=291)

<table>
<thead>
<tr>
<th>Item</th>
<th>Total cost change</th>
<th>Cost/saving per patient, mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saved length of stay costs</td>
<td>−£186731</td>
<td>−£642 (−£365, −£918)</td>
</tr>
<tr>
<td>Switch from oral to no antibiotic</td>
<td>−£446</td>
<td>−£1.53 (£0.3, −£3.4)</td>
</tr>
<tr>
<td>Switch from iv to no antibiotic</td>
<td>−£10536</td>
<td>−£36 (−£9.3, −£63)</td>
</tr>
<tr>
<td>Switch from iv to oral antibiotic</td>
<td>−£9233</td>
<td>−£32 (−£17, −£46)</td>
</tr>
<tr>
<td>Additional community support</td>
<td>£6227</td>
<td>£21 (±£8, +£35)</td>
</tr>
<tr>
<td>OPAT costs</td>
<td>£5616</td>
<td>£19 (−£4, +£42)</td>
</tr>
<tr>
<td>Assessment costs</td>
<td>£2468</td>
<td>£8 (−)</td>
</tr>
<tr>
<td>Total</td>
<td>−£192635</td>
<td>−£662 (−£393, −£930)</td>
</tr>
</tbody>
</table>

the longer term, could be realized in actual savings in the form of fewer beds.

It is clear from our analysis that most of the savings identified would accrue to hospitals while additional costs are mainly incurred by community services; this argues a need for good integration of service and budgets.

It is possible that early discharge schemes may shift costs from the formal healthcare sector onto informal carers, such as family and friends. Very few studies have addressed this issue in the context of early discharge or domiciliary care schemes\(^1\) and no information on this was collected in the present study, but data could usefully be collected in future research studies.

Future full evaluations of such interventions should also consider health outcomes such as morbidity, quality of life and mortality as well as costs, within the framework of an incremental cost-effectiveness or cost–utility study.

Increasing recognition of the potential gains from improving inpatient antibiotic prescribing has led to the development of explicit recommendations, such as the use of an antimicrobial self-assessment toolkit\(^12\) and of antibiotic prescribing bundles.\(^13\) However, the fact that studies, audits and official reports\(^3\) continue to identify considerable scope for improvement suggests that either the evidence or the incentives to take action are not sufficiently compelling to induce change. A more explicit and quantified focus on the potential cost savings from formal antibiotic review, in the context of more cash-constrained healthcare systems for the foreseeable future, may stimulate interest in such initiatives.

This study was a service evaluation and did not adhere to a formal research design, such as a randomized trial, case–control study or before–after comparison. In consequence, the results may be subject to a number of biases and limitations. Randomized studies are now needed to test these results.

However, the evaluation does provide useful descriptive information for a sample of individual patients across a range of different practice settings, and the economic analysis has generated data that may be helpful when designing an intervention study, including the likely magnitude and variance of potential costs and savings.

We are grateful to pH Associates, Marlow, UK and to staff in participating hospitals for assistance with data collection.

**Funding**

The economic analysis of this study was sponsored by Pfizer Ltd. A. G. was a paid consultant to Pfizer in connection with research relating to this study including the development of this manuscript.

**Transparency declarations**

A. G. has received consultancy fees from Pfizer. M. D. has received research grants from Pfizer and Bayer and honoraria from Pfizer, Bayer, Novartis and Johnson and Johnson. A. C. is an employee of Pfizer Ltd.

The funding source reviewed the data in the manuscript for accuracy. The authors had full access to the data in the study, interpreted the data, prepared the manuscript and had final responsibility for the decision to submit for publication.

pH Associates provided assistance with study design, data acquisition and statistical and other analyses.

**References**


