Modelling strategies for reducing pharmaceutical costs in hospital

C RAINA MACINTYRE, DOUNGKAMOL SINDHU SAKE AND GEORGE RUBIN

Department of Public Health & Community Medicine, Westmead Hospital, New South Wales, Australia

Abstract

Objective. To describe drug utilization and cost in a large hospital and to compare the impact of different strategies on cost associated with drug prescribing.

Design. Retrospective data on drug utilization and cost, linked to patient clinical data and prescriber data from November 1998 were analyzed and modelled.

Main outcome measures. Impact of different strategies for cost control.

Setting. A large hospital in Sydney, Australia.

Results. The mean cost of drugs per episode of care was $28 Australian dollars ($). Of all drug costs, 79% was incurred by medical units and 14% by surgical units. Oncology accounted for 42% and inpatients for 91% of drug costs. Although section-100 (S-100) drugs incurred a high cost ($640) per episode of care, there were only 41 episodes where S-100 drugs (expensive, restricted drugs) were used, and the total cost of S-100 drugs was only 3.7% of the total cost to the hospital. Antibiotics were the most commonly prescribed drug category, prescribed in 14% of all hospital episodes, and accounting for 14% of total drug costs. Anti-ulcer drugs were the next most costly group, accounting for 7% of total drug costs. A 20% reduction in use of antibiotics would save four times that ($233 832 pa) of a 20% reduction in use of S-100 drugs ($61 392 pa).

Discussion. Our study suggests that reducing inappropriate use of high volume drugs such as antibiotics could be more effective in optimising health facility drug budgets than attempts concentrating solely on reducing use of high cost drugs alone. Moreover our study suggests that systematic measurement of drug utilisation patterns is a key element of drug cost control strategies.

Keywords: cost, drugs, hospital, utilization

Outside of salaries and wages, pharmaceuticals represents one of the highest costs to acute hospitals. In Australia, a large hospital may have a pharmaceuticals budget of $10–20 million per annum, yet it is common for hospitals to spend significantly in excess of this budget. This was the case in the study hospital, despite significant efforts to contain costs. These efforts included procurement of pharmaceuticals at minimum costs, contracting with external consultants to advise on drug costs and consideration of a scheme where patients bring their own medications into hospital. The mainstay of efforts to contain costs at this hospital was monitoring and restriction of the use of expensive drugs.

The four major determinants of the cost of pharmaceuticals to hospitals are summarized in Figure 1. These are market factors, patient factors, hospital control mechanisms and prescribing practice. Market factors (such as the cost of drugs) and patient factors (such as severity of illness and number of co-morbidities) are not amenable to change, but hospital control mechanisms and the prescribing patterns of clinicians may be changed.

Cost control can be achieved by targeting either high cost drugs (which are usually low in volume); or high volume, low-moderate cost drugs (such as antibiotics and anti-coagulants). The former is the most commonly utilized cost-containment strategy in hospitals [1,2], usually taking the form of monitoring and restricting the use of S-100 drugs and other expensive drugs. S-100 drugs are highly specialized, expensive drugs, which can only be prescribed by specialized hospital units and dispensed through pharmacies associated with hospitals that participate in the ‘Highly Specialized Drugs Program’. Examples include expensive drugs for the treatment of AIDS or bone marrow transplants. The government

Address reprint requests to C. R. MacIntyre, Immunisation Research, Children’s Hospital at Westmead, Westmead, NSW, Australia 2145. Email: RainaM@chw.edu.au

© 2001 International Society for Quality in Health Care and Oxford University Press
reimburses hospitals for S-100 drugs only if they are prescribed for listed (approved) indications. If the drugs are used in hospitals for other indications, the hospital bears the full cost of the drug. These drugs are usually the focus of attention in hospitals because they are individually expensive.

In contrast, not much attention is paid to commonly used, high volume drugs such as antibiotics and anticoagulants, which are used across all specialties. As more physicians prescribe these high volume drugs, variation in prescribing practice and deviation from guidelines is more likely [3–5]. A survey of 10 overseas hospitals found that antibiotics, intravenous fluids and tranquillizers were the most commonly prescribed, and that there were significant, unpredictable variations in prescribing practices [6]. A study of drug costs in a surgical intensive care unit found that 70% of drug costs were attributed to antibiotics and blood products [7]. At an Australian hospital, review of antibiotic prescribing found significant potential for cost saving by targeting inappropriate prescribing habits [3].

Despite clear, evidence-based clinical practice guidelines in most areas of medicine, it has been shown that clinical practice (including drug prescribing) can vary significantly between practitioners, to a degree that cannot be explained by independent patient factors [8–10]. Physician non-compliance with guidelines can partially explain this variation [11–14].

The cost, safety and effectiveness of drugs used in clinical practice depends on the systematic practice of evidence-based medicine. Failure to use evidence-based prescribing can result in ad-hoc practices, sub-optimal patient outcomes, adverse drug reactions and poor use of resources [15–20]. Adverse drug events themselves have been shown to result in significant, avoidable costs [21].

The aim of this study was therefore to determine the pattern of drug utilization and cost in a large teaching hospital and to compare the impact of different strategies on cost associated with drug prescribing at a large hospital in Sydney.

**Figure 1** Factors influencing the cost of pharmaceuticals to hospitals.

**Methods**

We conducted a cross sectional study with cost modelling at a large hospital in Sydney, Australia. This hospital has 690 acute beds and serves a population of 1.5 million people. Retrospective data on drug utilization and cost, linked to patient clinical data and prescriber data were extracted from a series of linked, relational hospital health databases for the month of November 1998. These databases contain data on every patient episode of care, including patient demographics, administrative details, ward, bed days, diagnoses, procedures, pharmaceuticals and clinical costing data. An episode of care is defined as a single stay in hospital, beginning with admission and ending with discharge, death or transfer. The costs analysed were for all pharmaceuticals administered during the hospital stay, in all sites (wards, operating theatre, and emergency). The administrative and costing data were highly reliable, as they were obtained directly from patient activity while in hospital. Only direct costs to the hospital of pharmaceuticals were included in the analysis. Indirect costs such as the costs of administering drugs or the cost of restricting drugs were not included. The quality of clinical information, however, depends on the coding of medical record data into International Classification of Disease version 9 (ICD-9-CM) codes [22]. Studies have shown that coding of clinical information is reasonably accurate in Australia [23]. Analysis of a full years data showed that November is a representative month in terms of number of separations and pharmacy expenditure.

Predictors of cost examined were patient demographics, S-100 status, clinical unit, type of drugs, inpatient or outpatient status, intensive care unit (ICU) admission, emergency admission, length of stay and death. Clinical diagnoses were analyzed by Major Diagnostic Category (MDC) [22].

**Data analysis**

Descriptive statistics, which included mean, median and proportion, were used to describe continuous and categorical variables. Multiple logistic regression, using SAS [24], was used to identify predictors for drug costs per episode. In the logistic regression model, the outcome variable was cost. A dichotomous variable based on the 75th percentile as a cut-off point, was created. High cost was therefore defined as cost > 75th percentile. Dichotomous predictor variables were created for S-100 status, medical units, antibiotics, anticoagulants, anti-ulcer drugs and outpatient status. Only antibiotics used for bacterial infections were included in the variable ‘antibiotics’. Patient age, sex and use of antivirals were examined as predictor variables, but did not add anything to the model.

Cost modeling was performed using Microsoft Excel [25] and examined the impact of varying reductions in use of different groups of drugs. The groups of drugs included in the model were chosen because of the high volume of use. The data collected for one month were projected to estimate costs for a complete year.

**Results**

There were 25,313 inpatient and outpatient episodes of care recorded in the health database for November 1998. The
Table 1 Mean drugs costs and proportional drug costs for selected drugs and clinical categories at a large Sydney hospital, November 1998

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Total cost ($)</th>
<th>% of total drug costs</th>
<th>Episodes (n)</th>
<th>% of all episodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>28</td>
<td>3.4</td>
<td>706641</td>
<td>100</td>
<td>25313</td>
<td>100</td>
</tr>
<tr>
<td>Type of drugs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section-100</td>
<td>640</td>
<td>387</td>
<td>26221</td>
<td>3.7</td>
<td>41</td>
<td>0.2</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>27.6</td>
<td>11.3</td>
<td>97340</td>
<td>13.8</td>
<td>3525</td>
<td>13.9</td>
</tr>
<tr>
<td>Antivirals</td>
<td>81.8</td>
<td>21</td>
<td>73444</td>
<td>10.4</td>
<td>898</td>
<td>3.5</td>
</tr>
<tr>
<td>Anticoagulants</td>
<td>68.2</td>
<td>47.6</td>
<td>22909</td>
<td>3.2</td>
<td>336</td>
<td>1.3</td>
</tr>
<tr>
<td>Anti-ulcer</td>
<td>17.4</td>
<td>5</td>
<td>31313</td>
<td>4.4</td>
<td>1802</td>
<td>7.1</td>
</tr>
<tr>
<td>Admitting clinical specialty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicine</td>
<td>35.4</td>
<td>3.5</td>
<td>542791</td>
<td>79</td>
<td>15349</td>
<td>63</td>
</tr>
<tr>
<td>Surgery</td>
<td>13.9</td>
<td>2.6</td>
<td>94346</td>
<td>14</td>
<td>6778</td>
<td>28</td>
</tr>
<tr>
<td>Obstetrics and gynecology</td>
<td>13.6</td>
<td>2.8</td>
<td>10271</td>
<td>1.5</td>
<td>754</td>
<td>3.1</td>
</tr>
<tr>
<td>Emergency</td>
<td>20.4</td>
<td>2</td>
<td>4783</td>
<td>0.7</td>
<td>235</td>
<td>1</td>
</tr>
<tr>
<td>Patient type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inpatient</td>
<td>29.8</td>
<td>4.2</td>
<td>641104</td>
<td>91</td>
<td>21532</td>
<td>85</td>
</tr>
<tr>
<td>Outpatient</td>
<td>17.4</td>
<td>1.2</td>
<td>65537</td>
<td>9</td>
<td>3768</td>
<td>15</td>
</tr>
<tr>
<td>Top five major diagnostic categories¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplastic disorders</td>
<td>159</td>
<td>23</td>
<td>152037</td>
<td>42</td>
<td>959</td>
<td>7.2</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>10.7</td>
<td>1.8</td>
<td>35538</td>
<td>10</td>
<td>3301</td>
<td>25</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>20</td>
<td>3</td>
<td>28573</td>
<td>8</td>
<td>1434</td>
<td>11</td>
</tr>
<tr>
<td>Digestive system</td>
<td>20</td>
<td>3.7</td>
<td>23499</td>
<td>6.5</td>
<td>1183</td>
<td>9</td>
</tr>
<tr>
<td>Musculoskeletal system and connective tissue</td>
<td>19</td>
<td>2.4</td>
<td>21702</td>
<td>6</td>
<td>1139</td>
<td>8.6</td>
</tr>
<tr>
<td>ICU admission</td>
<td>30</td>
<td>3.8</td>
<td>46433</td>
<td>6.6</td>
<td>1547</td>
<td>6.1</td>
</tr>
</tbody>
</table>

¹ There are 21 Major Diagnostic Categories – the top five in terms of total cost are presented

The mean cost of drugs per episode of care was $28. Table 1 describes mean drugs costs and proportional drug costs by a number of different variables. Although S-100 drugs incurred a very high cost ($640) per episode of care, there were very few episodes where S-100 drugs were used (41 in total), so that the total cost of S-100 drugs was only 3.7% of the total cost of pharmaceuticals to the hospital for the month. The largest proportional cost for a single drug category was for antibiotics, which accounted for nearly 14% of total drug costs, followed by anti-ulcer drugs, which accounted for 7% of total drug costs. The majority of drug costs (79%) were incurred by medical units, followed by surgical units (14%). Inpatient use of drugs accounted for 91% of costs, compared to only 9% in outpatient use. Oncology accounted for 42% of the total drug costs.

Table 2 shows a logistic regression model for predictors of cost per episode of care. The strongest predictor of cost per episode of care was S-100 drugs, followed by anti-coagulants and antibiotics.

Table 2 Predictors of cost per episode

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-100</td>
<td>1264</td>
<td>22–73143</td>
</tr>
<tr>
<td>Medical</td>
<td>1.8</td>
<td>1.69–1.96</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>3.1</td>
<td>2.9–3.4</td>
</tr>
<tr>
<td>Anticoagulants</td>
<td>125</td>
<td>76–212</td>
</tr>
<tr>
<td>Anti-ulcer</td>
<td>2.25</td>
<td>2–2.5</td>
</tr>
<tr>
<td>Outpatient</td>
<td>0.27</td>
<td>0.24–0.31</td>
</tr>
</tbody>
</table>

The largest impact is made by a reduction most commonly prescribed drugs and S-100 drugs were prescribed. It shows that the use of S-100 drugs is extremely low. Figure 3 shows the contribution of the most commonly prescribed drugs and S-100 drugs to the proportion of total drug costs. Despite the cost of S-100 drugs being expensive per episode, the total cost to the hospital is relatively low.
range of clinical settings and for many different conditions. In the latter scenario, the use of the drug spans many disciplines and wards, which often have different practices and policies and is therefore subject to much greater variation in clinical practice. It makes empiric sense that a policy restricting the use of indinavir will be less effective than one which restricts the use of cefotaxime. The high costs in cardiology are contributed to by use of thrombolytic therapy (TT) for myocardial infarction. We did not focus on TT for the same reason. There is a strict TT protocol in the hospital, with rigid eligibility criteria for TT. The only TT agent used in the hospital is streptokinase, and therefore we did not feel there was any gain in pursuing TT as a means of reducing drug costs. The same rationale applies to excluding oncology drugs.

Any strategy to contain costs must, therefore, focus on areas where change can realistically be achieved – that is, on arms B and C in Figure 1. Unfortunately, current strategies do focus on limiting the use of expensive S-100 drugs, which are reflected more in arm D of Figure 1.

Our study shows that S-100 drugs, whilst individually expensive, are not used frequently, so that the impact of reducing their use on overall costs is minimal. A much greater impact on cost is achieved by reducing the use of high volume drugs, particularly antibiotics, which are the single most commonly prescribed category of drugs in hospital [3]. In addition, because S-100 drugs are used in such defined, specialized settings, there is less likelihood of inappropriate variation in prescribing practice. This means that our estimate of 20% reduction in use for S-100 drugs is unlikely to be achieved in practice, so that the real cost savings are even less. A 5–10% reduction in use may realistically be achieved.

It is much more likely that there are significant inappropriate variations in prescribing practice for antibiotics, which are prescribed broadly across a hospital, in all specialties and by all levels of clinicians. Due to higher variation, a 20% reduction in usage of antibiotics may be more achievable in practice, so that the true cost savings may be up to 16 times that achieved by reducing S-100 drugs by 5%.

An area of antibiotic and anticoagulant use which may be subject to clinical practice variation is the use of oral versus intravenous (in the case of antibiotics) or subcutaneous versus intravenous (in the case of anticoagulants) therapy. We were unable to study this, but this is an important area for consideration in reducing drug costs. In one Australian hospital, antibiotics were the most commonly prescribed drugs, and were prescribed to 42% of inpatients. Of these, 65% were prescribed parenterally and 35% orally, with a total number of doses estimated at 200 200 per year at a total cost of nearly 2 million dollars for this hospital alone [3]. Antibiotic use exceeded that of the other most commonly prescribed drugs in hospitals, anticoagulants and anti-ulcer drugs [4,5].

Whilst it is tempting to focus on high cost, low volume drugs, gains are more readily achieved by focussing on high volume drugs, such as antibiotics, anticoagulants and anti-ulcer drugs. The use of such drugs span all disciplines, and they are used by a much wider range of clinicians, so that there is more room for variation in prescribing practice. Due
Table 3 Impact of 20% reduction in use of various drugs over 1 year

<table>
<thead>
<tr>
<th>Drug Type</th>
<th>% Episodes</th>
<th>% Cost</th>
<th>Cost/episode</th>
<th>Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticoagulants</td>
<td>1.3</td>
<td>3.2</td>
<td>68.2</td>
<td>54,924</td>
</tr>
<tr>
<td>S-100 drugs</td>
<td>0.2</td>
<td>3.7</td>
<td>639.5</td>
<td>61,392</td>
</tr>
<tr>
<td>Anti-ulcer drugs</td>
<td>7.1</td>
<td>4.4</td>
<td>17.4</td>
<td>75,240</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>13.9</td>
<td>13.8</td>
<td>27.6</td>
<td>233,832</td>
</tr>
</tbody>
</table>

To these factors and the high volume of usage, strategies which target inappropriate use of these drugs are more likely to make an impact on cost. We also found that antivirals were expensive and contributed significantly to the total pharmaceutical costs, but these are not generally used across all disciplines.

The majority of successful strategies to reduce drug cost have focussed on changing drug utilization and prescribing habits [26,27]. Hospital control mechanisms, on the other hand, have less potential to impact on cost saving, because they are limited by patient factors (such as type and severity of illness), which are not amendable to change. Restriction of the use of more expensive aminoglycosides in a US hospital resulted in only modest cost savings [2]. A New Zealand study showed that the combination of a preferred drug list (procedural change) and a drug utilization review (clinical practice change) reduced drug costs, but the relative contribution of each change could not be determined [28].

Variation in practice has been addressed by a number of studies which show that evidence-based decision support systems result in more cost-effective delivery of health care [29–35]. A study in the United Kingdom (UK) found that left to their own devices, doctors ignored a cheaper, equally effective drug in a median 50% (range 25–75%) of cases. Where they were encouraged with clinical decision support, this figure decreased to 36% (8–67%) with limited support and 35% (0–67%) with full support [30]. Another study found that use of a computerized decision support system significantly reduced the time to achieving stable, therapeutic levels of anticoagulation in patients, and resulted in better quality of care when used by a nurse-practitioner compared to that by trainee doctors who were not using such a system [33].

The use of computerized decision support systems in clinical practice has been described in a wide range of settings, ranging from outpatient clinics to intensive care units [36–44]. In the UK and Holland, computerized systems to assist general practitioners in prescribing have been developed. The Prodigy system in the UK provides computerized advice on different drug choices to general practitioners during the consultation, and has been tested on a national basis and shown to be effective [45,46]. It is proposed that this be developed into a national system for everyday use by general practitioners [46].

An antibiotic decision support system developed in a United States hospital has been shown to be effective in improving antibiotic usage, reducing costs and stabilizing the emergence of antimicrobial resistance [47,48]. This system also resulted in a significant reduction in prescribing errors, drug-related adverse events and hospital length of stay [15]. These examples show that costs associated with hospital pharmaceuticals can be reduced.

The problem of reducing inappropriate prescribing is a challenge, but one which has been successfully tackled in some instances. Drug utilization review is a necessary step towards changing prescribing practice, and systematically addressing, understanding and reducing drug costs [49,50]. The systematic collection and analysis of drug utilization data has been proven to reduce costs [51]. The Australasian Society of Clinical and Experimental Pharmacologists and Toxicologists, and the Drug Usage Evaluation Network of Australia have outlined a strategy for drug utilization evaluation (DUE), which many hospitals have already implemented [52]. A New Zealand hospital reported significant cost containment after introducing DUE and a 'preferred drug' list to encourage doctors to adhere to prescribing guidelines [28].

Our study suggests that reducing inappropriate use of high volume drugs such as antibiotics can be more effective in optimizing health facility drug budgets than attempts concentrating solely on reducing use of high cost drugs alone. Moreover, our study suggests that systematic measurement of drug utilization patterns is a key element of drug cost control strategies. Without a systematic understanding of the patterns of drug usage and areas of major variation from recommended guidelines for drug use, attempts at controlling drug costs will be undirected.

Our recommendation, therefore, is that all health facilities implement a systematic drug usage evaluation mechanism to identify high use drugs and potential for improvement. In addition clinicians, pharmacists and managers need to work together to determine strategies to reduce inappropriate prescribing. These strategies, which will increasingly involve the use of interactive computerized decision support systems, will require continuing education, regular dissemination of prescribing guidelines and drug utilization evaluation information and feedback. It is also important to recognise that pharmacy budget is only one aspect of cost, and that the impact of total treatment costs, including indirect costs, should be considered.

References

C. R. MacIntyre et al.


36. Caironi PV, Portoni L, Combi C et al. HyperCare: a prototype of an active database for compliance with essential hypertension...
Reducing pharmaceutical running costs in hospital


Accepted for publication 27 September 2000