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Antibiotic pharmacoeconomics: an attempt to find the real cost of hospital antibiotic prescribing

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SUMMARY

Antibiotics account for a large part of all hospital pharmacy budgets, but the actual cost of their prescription is unknown. These costs include intravenous administration, labour, serum antibiotic assay, monitoring of haematological and biochemical indices, disposal of sharps and adverse effects. An in-house method of costing antibiotic therapy is presented, to quantify these hidden expenses. Since not only an awareness, but an accurate quantification, of hidden costs is required, a study of various hospital procedures relating directly to antibiotic therapy was undertaken in an acute medical ward; this involved the identification of particular staff members performing various procedures, consumables used and time taken. The cost of five-day courses of gentamicin, penicillin G, ampicillin, flucloxacillin, cefuroxime, ceftotaxime and erythromycin has been calculated; drug and hidden costs for each are presented graphically for comparison. The breakdown cost for gentamicin is presented to illustrate the method. The costing of adverse effects has not been attempted. We suggest that costings of this sort are used in cost-benefit analysis of antibiotic use. These calculations have been incorporated into a computer spreadsheet and this costing service will be offered to clinical areas of our hospital.

INTRODUCTION

Financial restraints on the National Health Service have increased in recent years. One area in which there is scope for rationalisation and cost savings is drug prescribing. Antibiotics account for a large part of all hospital pharmacy budgets, but the actual cost of their prescription is unknown. It is a widely held belief among health care staff in general that the cost of antibiotic therapy is equal to the cost of the drug itself. Seldom considered are the 'hidden costs' such as maintenance of intravenous access, labour, serum antibiotic assay, monitoring

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of haematological and biochemical indices and waste disposal.[1,2,3] Almost never considered are those extra costs due to adverse effects of antibiotics in terms of finance,[4] human suffering[5] and environmental deterioration.[6]

In order to obtain a more accurate assessment of the cost of antibiotic therapy we have developed a costing structure within which subtotals will vary depending on the antibiotic and the hospital area in question. To assess the cost of antibiotics used in an acute medical ward, a study of procedures relating directly to antibiotic therapy was undertaken.

METHODS

After group discussion it was concluded that for any antibiotic the total cost could be divided into eight cost categories (Table I). The quantification of these cost categories requires, first, the basic costs of consumables, labour, transport and incineration of waste, and secondly, knowledge of consumables used and time spent by the various grades of staff on each of the procedures involved. The basic costs within these eight categories were obtained as follows: antibiotic costs were obtained from the Monthly Index of Medical Specialities (MIMS), contract costs of other consumables were obtained from the hospital purchasing department and the pharmacy, costs of standard haematological and biochemical tests (tests performed to assess the adverse effects of the antibiotic used, for example serum urea and electrolyte measurement for nephrotoxic antibiotics such as gentamicin and vancomycin) were obtained from their respective departments, costs of

TABLE I

Eight cost categories making up the cost of any antibiotic course

Cost category	*Summarised costs*
1. Antibiotic	The drug itself
2. Maintenance of IV access	Insertion of an IV cannula and maintenance of its patency
3. Drug delivery	Administration of the drug to the patient
4. Drug monitoring	Measurement of serum antibiotic to ensure therapeutic and to avoid toxic levels
5. Dose readjustment	Modification of the dose of antibiotic following serum antibiotic measurement
6. General monitoring	Haematological and biochemical indices relating to the use of the drug. For example, urea and electrolytes are measured during a course of a nephrotoxic antibiotic
7. Sharps disposal	Sharps are packed in plastic sharps boxes; these boxes are then packed in clinical waste bags, delivered to the place of incineration and incinerated
8. Adverse effects	A substantial cost: the costing of these has not been attempted in this study

labour were obtained from the various personnel departments, and information on employers' National Insurance and Superannuation contributions was obtained from the Department of Health and Social Services. For the labour categories staff nurse and porter, the most commonly occurring levels of each of these staff grades was taken as representative — grade D staff nurse and grade 3 porter. This simplification was not necessary in the case of the junior house officer labour category as all the participating members of staff in this category were employed at the basic point on the scale.

The times taken and consumables involved in the performance of various hospital procedures relating directly to antibiotic therapy were studied over a three month period in the acute medical ward. Intravenous cannula insertion, drug delivery and drawing of blood for laboratory tests were performed by the junior house officer. Packing of full sharps boxes into clinical waste bags and erecting new, empty ones was performed by the staff nurse. Portering staff are involved in the delivery of laboratory samples from the ward to the laboratory and in collection and transport of clinical waste bags. For delivery of laboratory samples from the ward to the laboratory, laboratory staff recorded the time taken to walk the same route. For collection of clinical waste bags, simulation was not possible and so the cost of this time has not been included. In the study the staff member performing a particular procedure recorded their own name, grade, the procedure, and the time taken and any consumables involved from setting out to perform the procedure to total completion of it, including disposal of waste and handwashing, if appropriate.

Also recorded was the number of gentamicin courses occurring in the ward, the length of each and how many times serum gentamicin and serum urea and electrolyte measurements were performed during each course for monitoring purposes. For each serum gentamicin assay performed it was noted whether or not the dose was readjusted, and how much time this process took. The number of courses of the other antibiotics were not noted as serum assay of these is not normally required. To assess the proportion of a sharps disposal box occupied by waste from the various antibiotic course regimens, the precise amount of waste for each regimen was calculated. In each case the waste was placed in the box and the proportion filled was noted; this varied from 33% for gentamicin to 50% for ampicillin.

It has been assumed that all blood specimens sent to the laboratory in a specimen bag for any routine test require the same time for the junior house officer and the porter. The cost of ward consumables for serum gentamicin and serum urea and electrolyte measurements were noted specifically. It has also been assumed that all antibiotics require the same time for administration by the junior house officer. The consumables for particular antibiotic courses were noted specifically where possible, and the times taken for the various procedures were arrived at by calculating average values (Table II). The consumables used in the various procedures were determined by noting the minimum number necessary to perform a particular procedure: it was found that serum gentamicin and serum urea and electrolyte measurements were each performed once for each course of gentamicin, and calculations were made on this basis. No dose readjustments were needed after any serum gentamicin assay, so this cost category was considered to be zero for this study. The cost of sharps disposal was based on the most common

TABLE II

Hospital procedures relating to antibiotic therapy: times taken, consumables used and staff members involved

Procedure (Cost category number)	*Staff member*	*Measurements (number)*	*Time (range) min*	*Time (mean) min*	*Consumables*
Insertion of IV cannula (2)	Junior house officer	69	4–9	6·7	IV cannula × 1 anticoagulant × 1 10 ml syringe × 1 cotton wool × 1 alcohol swab × 1 bandage × 1
Drug delivery (3)	Junior house officer	184	—	4·7	For 80 mg gentamicin: needle × 1 2 ml syringe × 1 For 1 g erythromycin: 20 ml sterile water × 1 20 ml syringe × 1 needle × 1 For 1·5 g cefuroxime, 2 g cefotaxime, 1 g flucloxacillin, 1 g ampicillin and 1·2 g penicillin G: 10 ml sterile water × 1 10 ml syringe × 1 needle × 1
Drawing of blood (4+6)	Junior house officer	90	—	5·3	For serum gentamicin assay; peak and trough: 10 ml syringe × 2 needle × 2 alcohol swab × 2 cotton wool × 2 blood bottle × 2 specimen bag × 1
Sharps box (7)	Staff nurse	41	2–6	4·0	—
Delivery of blood specimens to laboratory (4+6)	Porter (simulated by laboratory staff)	41	5–9	6·9	—

sharps box in use, how much waste filled this particular box to the recommended level, how many courses of a particular antibiotic regimen this represented, nursing time, and the cost of transport and incineration.

The resulting data were used to calculate the cost of the following five-day courses of IV antibiotics: gentamicin 80 mg three times daily, penicillin G 1·2 g four times daily, ampicillin 1 g four times daily, flucloxacillin 1 g four times daily, cefuroxime 1·5 g three times daily, cefotaxime 2 g three times daily, and erythromycin 1 g four times daily. The five-day regimen chosen was used to facilitate comparison of cost between different antibiotics. The itemisation and costing of the gentamicin regimen is shown in detail. All costs were calculated as contract costs except the antibiotic cost which is taken from MIMS; the hospital contract cost of antibiotics and other specific items is not given and these costs therefore appear as subtotals. Value added tax has not been included on any item as it is paid by the hospital.

RESULTS

The study of procedures relating directly to antibiotic therapy in an acute medical ward showed the mean time for insertion of an intravenous cannula to be 6·7 minutes, for drug delivery, 4·7 minutes, for drawing of blood, 5·3 minutes, for sharps box management, 4 minutes, and for delivery of a blood sample to laboratory, 6·9 minutes (Table II).

There were 4 only courses of gentamicin prescribed in the ward during the three month study period; ranging in length from five to nine days, and in each case one set of peak and trough serum gentamicin assays and one serum urea and electrolyte measurement was performed. The dose of gentamicin was not adjusted in any case. Table III shows the itemised cost categories and resultant subtotals for a five-day course of intravenous gentamicin. Fig 1 shows these subtotals graphically; drug costs and hidden costs account for 35% and 65% respectively of the total cost.

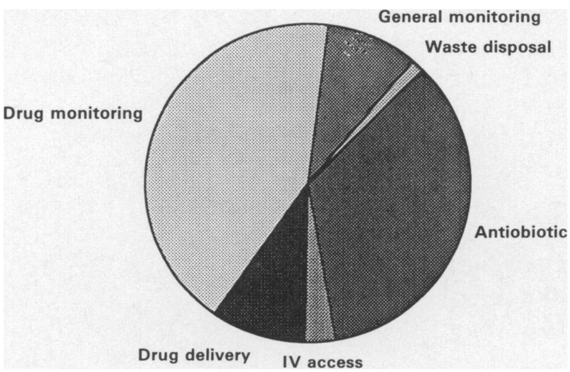

Fig 1. Graphical representation of the cost of gentamicin therapy shown in Table III.

The drug costs and hidden costs for 7 different antibiotic regimens, including gentamicin, calculated according to these methods are shown in Fig 2.

DISCUSSION

For gentamicin, the drug costs and hidden costs account for 35% and 65% respectively of the total cost. The true ratio of hidden cost to antibiotic cost is actually greater in this hospital as pharmacy contracting arrangements significantly reduce the drug cost below that shown in the Monthly Index of Medical Specialities. If the cost of adverse effects were quantified the drug cost contribution would decrease still further.

TABLE III

The itemised cost categories and corresponding costs for a five·day course of intravenous gentamicin 80 mg three times daily

Cost category	*Items involved*	*Cost*
1. Antibiotic	80 mg gentamicin × 15	£23.70
2. Maintenance of IV access	IV cannula anticoagulant 10 ml syringe cotton wool bandage alcohol swab 6·7 minutes 9–5 pm JHO	£2.03
3. Drug delivery	needle × 15 2 ml syringe × 15 47 minutes 9–5 pm JHO 23·5 minutes OnCall JHO	£6.41
4. Drug monitoring (peak and trough serum levels, measured × 1)	10 ml syringe × 2 needle × 2 alcohol swab × 2 cotton wool × 2 blood bottle × 2 specimen bag gentamicin assay × 2 10·6 minutes 9–5 pm JHO 6·9 minutes 9–5 pm porter	£28.77
5. Dose readjustment	—	£0.00
6. General monitoring (urea and electrolytes measurement)	10 ml syringe needle alcohol swab cotton wool blood bottle specimen bag U and E 5·3 minutes 9–5 pm JHO 6·9 minutes 9–5 pm porter	£6.29
7. Waste disposal	⅓ cost of 10 l plastic sharps box 4/3 minutes 9–5 pm staff nurse Contract cost of waste, transport and incineration	£0.78
8. Adverse effects	Nephrotoxicity Ototoxicity Bacterial resistance Superinfection IV cannula site infection	not costed
	Total	**£67.98**

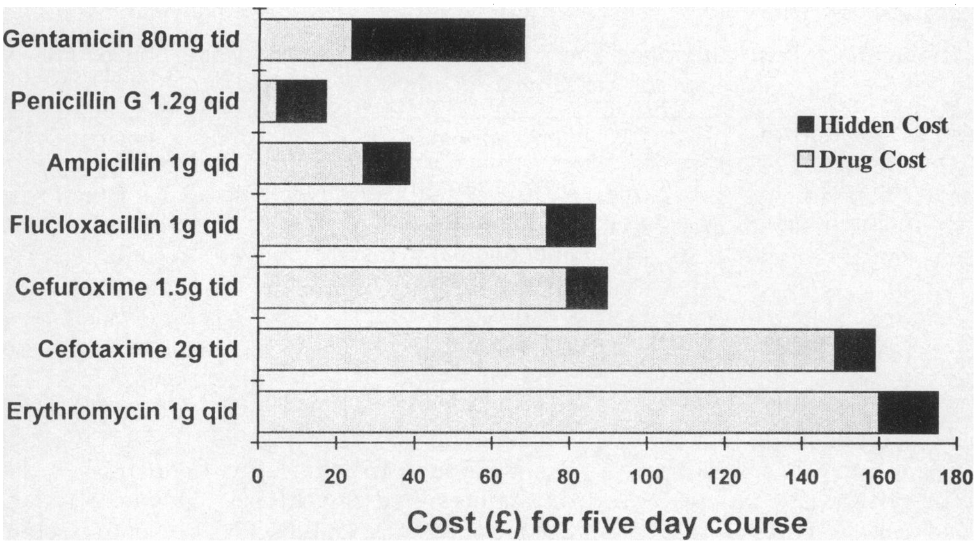

Fig 2. Published drug cost versus hidden cost for seven antibiotics

Labour and consumable costs vary from regimen to regimen, accounting for some of the variations in hidden costs. Antibiotics which require serum level monitoring, for example gentamicin, have larger hidden costs than those which do not, for example cefuroxime, other factors being equal. Antibiotics administered four times per day, for example penicillin G, will have a higher hidden cost than those administered three times per day, for example cefuroxime. Erythromycin is the most expensive of the regimens costed (Fig 2) because each dose costs over eight pounds, because it is administered four times daily, and because it is quite insoluble; a dose of 1g requires twenty millilitres of sterile water to dissolve it. In this hospital, on-call drug delivery by nursing staff has been about three times more expensive than that by junior doctors, and it has therefore been cheaper for the hospital to employ doctors rather than staff nurses to administer drugs at night. The recent changes in legislation relating to the workload of junior doctors will change this.

Although the numbers of measurements for all procedures are reasonably high, a weakness in the study is that the calculations on serum monitoring of gentamicin are based on data from only four courses. Although it is recommended procedure, it is our impression that only a fraction of courses of aminoglycosides are monitored with serum antibiotic and serum urea and electrolyte measurement. It has been assumed that all antibiotics require the same time for drug delivery; this is obviously not the case. For example, a water-soluble antibiotic will take a shorter time to prepare and administer than a relatively insoluble one; this is because a larger volume of water and more time are required to prepare an insoluble antibiotic for therapeutic administration. This is a very difficult area to quantify accurately as it is routine practice for junior doctors to batch the preparation and administration of intravenous antibiotics.

As these calculations are complex and ever-changing with cost variation, this system is at present being installed into the form of computer spreadsheets. The spreadsheet chosen was Microsoft Excel, version 4.0 (Microsoft, UK), running under Windows 3.1 (Microsoft, UK), on a Compaq Deskpro 386s personal computer (Compaq Computer Corporation, USA). The system consists of one 'master' spreadsheet, containing all basic costs, linked to many individual antibiotic spreadsheets. The antibiotic spreadsheets each begin with a questionnaire which exactly specifies the course regimen. This information and the appropriate costs from the master spreadsheet are then used to calculate the cost for each cost category; these are then added to obtain the total. Both the published and the pharmacy contract costs are calculated and each is displayed both numerically and graphically. Computerisation simplifies (a) cost updating, as the costs are updated only in the master spreadsheet, (b) calculation, as the calculation mechanism is permanent in the individual antibiotic spreadsheet, and (c) data extraction, as only the last section of any antibiotic spreadsheet need be printed. The system is very flexible as an antibiotic spreadsheet can accommodate any drug regimen; the answers to the questionnaire are incorporated directly in the calculations. This costing service will be offered to clinical areas of our hospital; if costs are required, a questionnaire on the particular regimen would be completed by the ward and returned to the department of bacteriology for calculation of the cost of the regimen. A printout from the spreadsheet on cost analysis will be returned to the ward.

Efficacy of antibiotics is clearly of prime importance. As antibiotic cost awareness is still in its early stages, the primary issue of efficacy of antibiotics has not been addressed in this study. Cost is only one of a number of factors to be taken into account in antibiotic prescribing.

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