Costing clinical biochemistry services as part of an operational management budgeting system

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SUMMARY The process of costing clinical biochemistry tests as a component of the commissioning of a unit management budgeting system based on an International Computers Limited (ICL) mini-computer system was examined. Methods of apportioning consumable and labour costs under direct and indirect cost headings and as test and request charges were investigated, and in this currently operational system it was found that 38% of consumable costs and 57% of labour costs were not a direct component of the routine analysis function.

Means of assigning test costs to a given request source and the incorporation of such charges into clinical budget statements were looked at. A reduction in laboratory workload did not produce a comparable reduction in laboratory costs. For a theoretical reduction in workload of 20% only a 3.8% laboratory saving in recoverable costs could be expected.

After the publication of the Griffiths Report management budgeting systems were started in several centres. With the object of monitoring and controlling use of resources, procedures are continually being devised to cost the use of services by the clinician end user and provide him or her with regular budget information.

After the initial pilot studies of management budgeting in 1983¹ Newcastle Health Authority asked Arthur Young, McClelland, Moors and Co (AYMM) to set up a management budgeting system at Freeman Hospital, Newcastle upon Tyne, using ICL International Computers Limited DRS (Distributed Resource System) computer hardware.

The clinical biochemistry department at Freeman Hospital (720 beds, including a 180 bed regional cardiothoracic unit) is staffed by a consultant chemical pathologist, senior registrar, top grade biochemist, three other biochemists, and 21 medical laboratory scientific officers. Workload in 1985 was 171 259 requests, which generated 775 559 tests.

The AYMM team arrived on site in August 1984. Their brief was to create suitable costing procedures and management budgeting mechanisms and achieve an operational package by April 1 1985. To show the system's ability to promote cost effective patient care a small group of eight clinicians participated during the pilot stages as end users. After the system became operational the number of clinicians receiving budget statements and given guidance in their interpretation gradually increased, and continues to do so.

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Costing procedures

AYMM consultants contacted the pathology departments in September 1984 and requested the provision of a full range of analysis costs by the end of October 1984. For the clinical biochemistry department, this entailed the production of over 170 individual costings within about eight weeks. For certain groups of analysis probably performed on more than one instrument, as with the serum electrolyte profile processed on SMA 6/60 or Beckman Astra analysers, each instrument profile had to be costed separately. As well as composite costings for electrolyte, bone and liver, and cardiac profiles, costings had to be assessed for each analysis within the profile that might be requested individually. Although there are perhaps 12-14 analyses that are regularly requested "on-call" and are accepted as part of the clinical biochemistry emergency service, there are a further group of analyses that could, in certain circumstances, be clinically justifiable as an emergency request—for example, serum iron or plasma digoxin. Any analysis of this nature also required costing on an emergency basis.

To minimise the extra work burden placed on any one person each section head (senior medical laboratory scientific officer or senior biochemist) was given the task of assessing consumable and reagent usage rates and labour time entailed in each analytical procedure within his or her section. Helped by the senior chief medical laboratory scientific officer, each section head then assigned consumable and reagent costs per

test based on known costs from purchasing records. The senior chief medical laboratory scientific officer and top grade biochemist then checked each completed costing.

DIRECT CONSUMABLE COSTS

For automated equipment we saw the simple equation of theoretical tests per hour with number of samples processed per hour as overly simplistic for several reasons:

- 1 The speed of analysis of any automated instrument in tests per hour does not equate with the true sample throughput rate; calibration standards and quality control sera occupy a major proportion of "sample" positions in any analysis run.
- 2 Repeat analysis may be required if a particular batch of tests are "out of control", or instrument or power failure occurs.
- 3 The consumption of reagents can be severely affected by unproductive instrument start up, shut down, and stand by periods.

We assessed the true consumable costs over four months for each analysis or group of analyses by considering the actual number of sample analyses completed for any given volume of reagent. For each reagent and consumable the total cost to the department over the given period was divided by the number of samples analysed and reported in that period—to arrive at a cost per sample for the analysis procedure. Built in to these reagents costs per sample, therefore, are the cost of calibration, the cost of running quality control material, repeat analyses, and purging of instrument lines.

For small batches of manual analysis costs were assigned on the basis of the size of the average batch. Thus if the average batch of serum "rhubarb" analysis contains 12 samples, four calibrants, and three quality control samples then the total consumables costs for running these 19 tests is assigned to the 12 samples to determine the consumable cost per sample. All consumable costs must be incorporated into each costing, including, for example, pump tubing, dialysis membranes, and printer paper on automated procedures and pipette tips, plastic disposables, and filter paper for manual assays.

DIRECT LABOUR COSTS

Given the time scale of the exercise, we were not able to carry out the more detailed assessments of analytical time performed in previous costing studies.^{2,3} As factors such as laboratory housekeeping, staff training, machine maintenance, coffee breaks, answering telephone enquiries all cut into the theoretical time available for sample analysis, it was

decided that six hours per working day per member of staff was a realistic time available for analysis. Labour time for analysis procedures could be assessed most easily with automated analysis, particularly where one or more members of staff were fully committed to a particular analysis group throughout the working day. Thus for the bone and liver profile 35 000 test profiles were performed in 1984 over 260 working days, giving an average sample throughput of 140 profiles per working day. This analysis profile was performed by one basic grade medical laboratory scientific officer for whom the available analysis time per day was 6×60 minutes (360 minutes). Thus for one bone and liver profile labour time was 360/140 minutes—that is, 2.6 minutes at basic grade medical laboratory scientific officer labour rates.

For smaller batches of analyses the section head was asked to assess a realistic time for analysis of the average size batch, including reagent, calibrant, and quality control preparation, drawing up of worksheets and result reporting. This time per average batch was divided by the number of samples (not tests) in the average batch to determine the average time per sample.

We were concerned that supervision of routine analysis should be seen as a direct labour charge on tests. It was agreed with AYMM consultants that a certain percentage of senior staff time should be allocated to direct costs and spread equally across each test under senior staff control. Similarly, vetting and validating reported results was regarded as a direct charge on tests, and an appropriate cost element for participating senior staff labour was assigned.

Table 1 shows the labour rates per minute of working time for each grade of medical laboratory scientific officer. These were calculated by the treasurer's department in the manner outlined. Changes in labour costs resulting from national pay awards and revised working conditions will, of course, necessitate adjustment on a regular basis.

To apply the then current on call rate of £8.33 to each emergency request received would be grossly excessive when more than one emergency request is received on the same emergency call out. We therefore decided to calculate an average labour cost per request as the most reasonable approach to charging for on call services, by dividing the total cost of emergency clinical biochemistry services for 1984 (including stand by payments) by the total number of emergency requests for 1984, giving a labour cost per emergency request of £4.06. Obviously, this charge will vary according to the average number of requests per call (currently 2.28).

Tables 2 and 3 give examples of complete costing profiles. Table 2 shows the detailed costing for the electrolyte profile on the SMA 6/60, which, with its

Table 1 Calculation of labour rate per unit time

Time per year available	Basic grade medical laboratory scientific officer	Time (days)
Days = 260		Annual holidays = 20 Public holidays = 10 <hr/> 30
Working days = 260 - 30		= 230
Working minutes (7.4 hour working day) = 230 × 7.4 × 60 = 102120		
Mid point salary scale for grade (including employer's contributions)	= £7597	
Labour rate per minute = $\frac{7597}{102120}$	= £0.074	
Further modifying factors: Allowance for illness Average day release for grade		5 7.5 <hr/> 12.5
Adjustable available working time = 230 - 12.5		= 217.5 days = 96750 minutes
Adjusted labour rate per minute = $\frac{7597}{96750}$	= £0.079	

Labour rates per unit time

Grade	Rate/minute (£)	Grade	Rate/minute (£)
Junior medical laboratory scientific officer	0.063	Senior medical laboratory scientific officer	0.097
Junior/basic medical laboratory scientific officer	0.071	Senior or chief medical laboratory scientific officer	0.106
Basic medical laboratory scientific officer	0.079	Chief medical laboratory scientific officer	0.114
Basic/senior medical laboratory scientific officer	0.088		

Based on 1985 salary figures before pay settlement.

Table 2 Standard cost calculation—electrolyte profile (SMA)

Consumables		Labour			
Item	Cost per sample (£)	Grade	Rate/minute	Minutes	Cost (£)
Lithium sulphate	0.0093	Senior medical laboratory scientific officer	0.097	2.0	0.194
Propane gas	0.0013	Basic medical laboratory scientific officer	0.079	2.0	0.158
Chloride diluent	0.0047	Consultant/registrar/scientist*			0.050
Chloride colour reagent	0.0067	Total labour			0.40
Carbon dioxide diluent	0.0030	Total unit rate = £0.57			
Carbon dioxide colour reagent	0.0112				
Urea acid reagent	0.0026				
Urea colour reagent	0.0042				
Creatinine sodium hydroxide reagent	0.0017				
Creatinine sodium chloride reagent	0.0016				
Creatinine colour reagent	0.0024				
Calibration serum	0.0496				
Quality control serum	0.0295				
Phasing serum	0.0032				
Pump tubing	0.0149				
Dialysis membranes	0.0034				
Computer paper	0.0005				
Teletype labels	0.0205				
Total consumables	0.1703				

*Element of cost incorporated for vetting and validation of reports.

high throughput and low reagent costs, is relatively cheap compared with the cost of paraprotein investigation by immunoelectrophoresis (Table 3), a complex manual investigation using costly reagents and therefore considerably more expensive.

Table 3 *Standard cost calculation—immunotyping by immunoelectrophoresis*

<i>Consumables</i>			
<i>Item</i>	<i>Cost per sample (£)</i>		
Electrophoresis buffer	0.043		
Sample tips	0.050		
Protein stain	0.010		
Stain remover	0.016		
Agarose electrophoresis plate	1.350		
STA-moist paper	0.213		
Antisera	1.060		
Total consumables	2.740		
<i>Labour</i>			
<i>Grade</i>	<i>Rate/minute</i>	<i>Minutes</i>	<i>Cost (£)</i>
Basic/senior medical laboratory scientific officer	0.088	60.0	5.28
Consultant/registrar/scientist			0.05
Total labour			5.33
Total unit rate = £8.07			

Direct costs relating to requests rather than tests also had to be incorporated into the system. Essentially, this concerned the costs of receiving and separating samples before analysis. Consumables used in the sample reception area and their costs were determined over four months, and the consumable cost per sample received was determined by dividing the total cost of each consumable over the four months by the number of samples processed in that period. Similarly, the total labour time over that period was divided by the number of samples processed to determine labour time (and hence costs) per sample. This

gave a total request cost for sample handling of £0.22, which was incorporated into a blanket overhead cost per request.

INDIRECT COSTS

It was recognised that the income generated from the total direct cost of tests would not entirely recoup the departmental budget. There are two possible approaches to full recovery:

1 A uniform overhead charge per request that incorporates the indirect costs of running the department.

A proportion of each senior member of staff's salary was seen as an indirect cost and incorporated into this general request cost and reflected the costs incurred in departmental management, provision of advice and consultation services to clinicians, research and method development functions, and education and training functions. In addition, the sample handling charge of £0.22 per request had been assigned to recovery under this heading. Table 4 details the cost elements incorporated in this overhead charge. It is the intention that medical staff salaries and hotel and general service charges will soon be charged to departmental budgets and will eventually appear under this overhead charge per request.

2 Once a full year's costing data are available, the extent to which the total consumables budget for the department is recovered as direct costs of tests can be assessed.

Any shortfall from total recovery can be corrected by applying a percentage uplift factor based on this shortfall to each test's total consumables costs, so that for the following year the total consumables budget will be recovered in full as direct costs of tests. Similarly, once the first year's costs have been

Table 4 *Derivation of request costs and charges*

<i>Elements of non-staff costs in 1985/86 SAS budget not attributable to test costs (£)</i>		<i>Agreed percentages of senior staff salaries not attributable to test costs</i>	
Ancillary staff	8674	1 Top grade scientist	85
Travel and subsistence	3651	1 Principal grade scientist	65
Medical and surgical equipment	31383	1 Senior grade scientist	65
		1 Basic grade scientist	75
		1 Senior chief medical laboratory scientific officer	100
		2 Chief medical laboratory scientific officers	40
Subtotal	£43 708	Subtotal	£65 414
Total request costs			£109 122
Actual routine requests (1985)			161 800
Overhead charge per request	$\frac{£109122}{161800}$		£0.67
Specimen reception and separation cost per request			£0.22
Total request charge			£0.89

SAS = NHS standard accounting system

Test Rate List Department: Freeman Biochemistry			Test Rate List Department: Freeman Biochemistry		
Test Code	Test Rate	Description	Test Code	Test Rate	Description
011	0-5700	Urea and electrolytes profile (SMA)	087	1-5200	Zinc
012	1-0400	Urea and electrolytes profile (ASTRA)	089	0-2700	Protein total SMA
013	0-6931	Bone and liver profile and AST	090	2-6400	RIA—Digoxin
014	1-7200	Cardiac enzyme profile, CK + CK - MB	091	3-7100	RIA—T3 uptake
015	0-9500	Acid phosphatase	092	0-9900	RIA—T4
016	0-2800	Albumin (SMA)	093	5-3200	RIA—Ferritin
017	1-4600	Alcohol	094	1-9600	RIA—TSH
018	2-0700	Albumin manual	095	2-9800	RIA—FSH, LH
019	2-2600	Alpha fetoprotein	096	2-9500	RIA—TSH, T4
020	0-2900	Alkaline phosphatase	097	3-5000	RIA—T3
021	2-5600	Alkaline phosphatase isoenzymes	098	4-4900	RIA—Microglobulin
023	1-2700	Amylase	100	0-3100	Urine—Albumin
024	1-5800	Acid glycoproteins	102	2-0400	Urine—Amylase (diastase)
025	1-8800	Antitrypsin	103	1-5000	Urine—Bilirubin
026	0-2500	Aspartate aminotransferase, (AST)	104	0-8100	Urine—Calcium
027	0-3000	Bilirubin	106	2-0400	Urine—Copper
028	4-2300	Bilirubin (direct)	107	2-6000	Urine—Cortisol
029	3-0200	Caeruloplasmin	108	0-6800	Urine—Creatinine
030	0-2700	Calcium (SMA)	110	1-1000	Urine—5HIAA
031	0-6600	Calcium (atomic absorption)	111	2-0100	Urine—HMMMA
032	3-5200	Ionised calcium	112	0-3900	Urine—Homogentisic acid
033	0-2900	CO ₂ content (SMA)	113	0-3800	Urine—Hypobromite
034	0-4600	CO ₂ content (ASTRA)	114	0-7500	Urine—Indican
035	0-4300	Carboxyhaemoglobin	115	0-8100	Urine—Magnesium
036	2-4400	Carotenoids	116	3-8300	Urine—Metadrenaline
037	0-2600	Chloride (SMA)	117	0-4100	Urine—Melanin
038	0-4400	Chloride (ASTRA)	118	0-4100	Urine—Myoglobin
039	4-8400	Cholesterol, triglyceride	119	8-9500	Urine—Oxalate
040	3-3200	Cholinesterase	120	0-4500	Urine—Osmolality
041	1-5200	Copper	121	0-2900	Urine—pH
043	1-6400	Cortisol	122	0-3500	Urine—Phosphate
044	0-4100	Creatine kinase, (CK)	123	0-6500	Urine—Protein quantitative
045	0-2700	Creatinine (SMA)	124	0-5900	Urine—Potassium
046	0-5100	Creatinine (ASTRA)	125	1-7400	Urine—Porphyrin
047	0-8600	Cryoglobulins	126	0-9300	Urine—Reducing substances
048	0-8600	Complement C3, C4	127	0-3300	Urine—Specific gravity
051	5-4400	Differential protein clearance	128	0-5900	Urine—Sodium
052	0-4300	Glucose (AII)	129	5-0100	Urine—Transferrin
053	0-8400	Glucose (ASTRA)	130	0-6100	Urine—Urea
054	10-5500	Glucose 6PDH	131	1-3500	Urine—Uric acid
055	0-4500	Gamma glutamyl transferase (GT)	132	2-3800	Urine—Urobilinogen
056	0-3000	HBDM	133	3-3500	Urine—Xylose
057	3-9500	High density lipoprotein cholesterol	134	2-0400	Urine—Zinc
058	1-3500	Iron, Iron binding capacity	135	0-3100	Urine—Protein
061	0-8000	Lipoprotein electrophoresis	136	5-3800	Urine—Protein electrophoresis
062	0-6600	Magnesium	137	7-0800	Urine—PABA Excretion
063	2-4500	Methaemoglobin	138	0-9000	Urine—Electrolytes
064	1-5000	Methaemalbumin	140	0-4300	Miscellaneous fluid—Glucose
066	0-4500	Osmolality	141	0-2700	Miscellaneous fluid—Protein
067	0-2700	Phosphate inorganic	150	0-4300	CSF—Glucose
068	0-2700	Potassium (SMA)	151	1-6900	CSF—Protein
069	0-5100	Potassium (ASTRA)	152	3-7500	CSF—Globulin
070	1-3700	Protein total manual	161	7-5000	Faeces—Fat balance
071	3-4000	Protein electrophoresis	162	0-4200	Faeces—Occult blood
072	7-6500	Protein immunoelectrophoresis	163	0-3700	Faeces—Trypsin
073	4-5300	Protein IgG, IgM, IgA	170	4-7700	Renal calculi
076	10-1100	Protein immunofixation	183	2-4500	Drugs—Lithium
078	0-2700	Sodium (SMA)	184	4-4000	Drugs—Methotrexate
079	0-5100	Sodium (ASTRA)	185	4-4900	Drugs—Paracetamol
080	2-4500	Sulphaemoglobin	188	0-6200	Drugs—Rifampicin
081	2-8800	Transferrin	189	2-9500	Drugs—Quinidine
083	0-2600	Urea	190	1-6300	Drugs—Salicylate
084	0-4700	Urea (ASTRA)	191	6-3400	Drugs—Theophylline
085	1-0400	Uric acid			
086	4-0000	Xylose			

Fig. 1 Full test rate listing showing numerical test code and unit rates (£). SMA = Technicon SMA 6/60 - Vickers SP120 multichannel analyser; ASTRA = Beckman ASTRA multichannel analyser; AII = Technicon AII analyser.

(a)

Pathology tests: CLIN BIOCHEMISTRY
Report month 09

Printed: 05/10/85

Centre code and description Test code and description	No of tests	Unit rate	Value
326 Ward 26—Cardiothoracic Surgery			
011 Urea and electrolytes (prof) (SMA)	1	0.5700	1
012 Urea and electrolytes (prof) (ASTRA)	3	1.0400	3
014 Cardiac profile, CK + MB	4	1.7200	7
062 Magnesium	3	0.6600	2
138 Urine—electrolytes	3	0.9000	3
	14		16
328 Ward 27—Cardiothoracic Surgery			
011 Urea and electrolytes (SMA)	2	0.5700	1
012 Urea and electrolytes (ASTRA)	2	1.0400	2
013 Bone and liver profile & AST	2	0.6931	1
044 CK	1	0.4100	
052 Glucose (AAll)	2	0.4300	1
141 Misc fluid—protein	1	0.2700	
212 Urea and electrolytes (prof) (ASTRA) (on call emergency request)	2	4.8100	10
231 Calcium atomic absorption (on call emergency request)	1	4.2400	4
253 Glucose Astra (on call emergency request)	1	4.6100	5
262 Magnesium (on call emergency request)	1	4.2400	4
270 Protein total (on call emergency request)	1	4.4100	4
	16		32

Pathology tests: CLIN BIOCHEMISTRY
Report month 09

Printed: 05/10/85

Centre code and description Test code and description	No of tests	Unit rate	Value
512 A N Surgeon Cardio-surgery In patient			
011 Urea and electrolytes (SMA)	142	0.5700	81
012 Urea and electrolytes (ASTRA)	15	1.0400	16
013 Bone and liver profile & AST	86	0.6931	60
014 Cardiac enzyme profile, CK + CK - MB	12	1.7200	21
016 Albumin (SMA)	3	0.2800	1
018 Albumin manual	1	2.0700	2
032 Ionised calcium	1	3.5200	4
039 Cholesterol, triglyceride	2	4.8400	10
044 Creatine kinase	9	0.4100	4
052 Glucose (AAll)	8	0.4300	3
058 Iron, iron binding capacity	1	1.3500	1
066 Osmolality	1	0.4500	
070 Protein total manual	1	1.3700	1
120 Urine—Osmolality	2	0.4500	1
138 Urine—Electrolytes	23	0.9000	21
212 Urea and electrolytes (ASTRA) (on call emergency request)	13	4.8100	63
253 Glucose Astra (on call emergency request)	1	4.6100	5
266 Osmolality (plasma) (on call emergency request)	1	4.2000	4
308 Urine—Creatinine (on call emergency request)	1	4.2500	4
324 Urine—Potassium (on call emergency request)	1	4.2800	4
328 Urine—Sodium (on call emergency request)	1	4.2800	4
330 Urine—Urea (on call emergency request)	1	4.2100	4
	326		314
513 A N Surgeon—Cardio-surgery Out patient			
011 Urea and electrolytes (prof) (SMA)	3	0.5700	2
013 Bone and liver profile & AST	4	0.6931	3
044 CK	1	0.4100	
	8		5

(b)

Pathology tests: CLIN BIOCHEMISTRY
Report month 09

Printed: 05/10/85

Centre code and description Test code and description	Total tests	Total value
109 Nursing services	1	1
120 Biochemistry	57	303
126 Occupational therapy	5	5
300 Ward 1—urology surgery	11	18
301 Ward 2—urology surgery	12	27
302 Ward 3—urology surgery	4	12
303 Ward 4—nephrology	52	68
304 Ward 5—general/dental surgery	9	16
305 Ward 6—dermatology	5	20
306 Ward 7—	1	1
307 Ward 8—general/dental surgery	7	10
308 Ward 9—cardiology	10	13
309 Ward 9a—cardiology	69	118
310 Ward 10—general medical and geriatrics	35	103
342 General ITU	80	191
343 Emergency Admission Suite	53	78
346 Out patients—main department	46	89
522 Con A—cardiology Out patient	32	54
524 Con B—cardiology In patient	249	439
525 Con B—cardiology Out patient	24	43
527 Con C—cardiology In patient	198	288
548 Con D—chest medicine—In patient	147	275
549 Con D—chest medicine—Out patient	47	41
575 Con E—Gen med & geriatrics—In patient	418	693
576 Con E—Gen med & geriatrics—Out patient	168	172
578 Con F—Gen med & geriatrics—In patient	603	801
579 Con F—Gen med & geriatrics—Out patient	541	656
602 Con G—nephrology—In patient	785	1013
603 Con G—nephrology—Out patient	1345	1218

(c)

Pathology tests: CLIN BIOCHEMISTRY
Report month 09

Printed: 05/10/85

Centre code and description Test code and description	No of tests	Unit rate	Value
011 Urea and electrolytes (SMA)	5190	0.5700	2967
012 Urea and electrolytes (ASTRA)	461	1.0400	474
013 Bone and liver profile & AST	2914	0.6930	2025
014 Cardiac enzyme profile, CK + CK - MB	363	1.7200	627
015 Acid phosphatase	71	0.9500	69
016 Albumin (SMA)	18	0.2800	4
017 Alcohol	33	1.4600	43
018 Albumin manual	2	2.0700	4
019 Alpha fetoprotein	13	2.2600	29
021 Alkaline phosphatase isoenzymes	58	2.5600	153
023 Amylase	182	1.2700	227
024 Acid glycoproteins	23	1.5800	39
025 Antitrypsin	5	1.8800	10
029 Caeruloplasmin	1	3.0200	3
031 Calcium (atomic absorption)	21	0.6600	17
032 Ionised calcium	67	3.5200	244
036 Carotenoids	1	2.4400	2
039 Cholesterol, triglyceride	230	4.8400	1120

Fig. 2 Specimen section of monthly printout of workload related to request source showing: (a) breakdown of test workload and charges (£) related to request cost centre (wards and clinicians); (b) summary of total analysis requests and charges (£) to each cost centre; (c) summary of total numbers of each test. SMA = Technicon SMA 6/60 - Vickers SP120 multichannel analyser; ASTRA = Beckman ASTRA multichannel analyser; AAll = Technicon AAll analyser; CON = Consultant.

Current Month					Expense codes		Year to Date				
Budget	Actual	Flex Budget	Variance	%		Budget	Actual	Flex Budget	Variance	%	
					DIRECT COSTS						
2548	2548	2548			221 Total medical staff costs	7644	7644	7644			
1017	714	674	40	5.9	894 Biochemistry	3051	2732	2335	397	17.0	
1130	1097	749	348	46.5	892 Haematology	3390	3256	2593	663	25.6	
1155	826	766	60	7.8	890 Histopathology	3465	2586	2652	-66	-2.5	
708	630	469	161	34.3	888 Microbiology	2124	1963	1625	338	20.8	
2006	831	1329	-498	-37.5	923 Main x-ray	6018	4525	4603	-78	-1.7	
6		4	-4	-100.0	921 Cardio x-ray	18		14	-14	-100.0	
2320	2320	1537	783	50.9	886 M + SE wards	6960	6961	5324	1637	30.7	
442	260	293	-33	-11.3	904 Physiotherapy	1326	817	1015	-198	-18.5	
149	137	99	38	38.4	915 Occupational therapy	447	338	343	-5	-1.5	
124	49	83	-34	-41.0	917 Dietetic	372	98	287	-189	-65.9	
7	9	5	4	80.0	885 Chiropody	21	12	17	-5	-29.4	
487	487	487			931 Medical Secretary + other clerical	1461	1461	1461			
11481	9363	8468	895	10.6	Total costs shared direct	34443	30822	28148	2674	9.5	
					COSTS FROM WARDS, THEATRES, ETC						
12619	12219	8361	3858	46.1	805 General theatre costs	37857	42731	28953	13778	47.6	
2852	2759	1890	869	46.0	812 General anaesthesia costs	8556	9657	6545	3112	47.5	
					820 Ward 1 costs		25		25		
19		14	-14	-100.0	824 Ward 5 costs	57		47	-47	-100.0	
666	1197	493	704	142.8	827 Ward 8 costs	1998	2893	1645	1248	75.9	
					829 Ward 10 costs		287		297		
16210	18785	11924	6861	57.5	830 Ward 11 costs	48630	54517	40788	13729	33.7	
					837 Ward 18 costs		27		27		
24		17	-17	-100.0	838 Ward 19 costs	72		57	-57	-100.0	
24		17	-17	-100.0	839 Ward 20 costs	72		57	-57	-100.0	
471		349	-349	-100.0	840 Ward 21 costs	1413	602	1165	-563	-48.3	
320	95	200	-105	-52.5	842 Ward 23 costs	860	570	683	-113	-16.5	
7010	951	5336	-4385	-82.2	872 General ITU costs	21030	2139	17646	-15507	-87.9	
651	651	432	219	50.7	900 Pharmacy overhead	1953	1953	1496	457	30.5	
4348	4348	4348			936 General hospital overheads	13044	13044	13044			
45214	41005	33381	7624	22.8	Total costs charged indirectly	135642	128455	112126	16329	14.6	
56695	50368	41849	8519	20.4	Total costs	170085	159277	140274	19003	13.5	

Fig. 3 Specimen monthly budget statement for consultant surgeon.

assessed, that proportion of labour costs recovered as part of direct costs of tests can be ascertained. This figure can be compared with the proportion of staff costs, which, it was agreed, are recoverable in the form of charges on direct costs. This includes all medical laboratory scientific officer salaries below the level of chief medical laboratory scientific officer plus a proportion of each senior member of staff's salary, which, it was agreed, would be a direct charge on tests for supervisory roles of routine analysis functions. This total labour charge to be assigned to test costs will exceed the labour costs actually recovered from test costs because of two factors: no cost element has as yet been allowed for the supervisory role of senior staff; of the 7.4 hour working day, six hours had been estimated as the time available for actual analysis, and 1.4 hours of work time per day therefore remain unaccounted for.

Again, any shortfall in recovery of labour costs seen as a charge on test costs will be overcome by applying a percentage uplift factor to adjust the labour charge of each test, so that full recovery is achieved.

DATA INPUT

Each costed test or test profile was identified by a three figure numerical code. Fig. 1 shows a specimen section of the test rate listing. A similar series of three figure numerical codes was used to identify each cost centre location. Thus each consultant had two codes, one for inpatients and one for outpatients. Each ward and outpatient department also had its own specific code, which permits analyses to be charged against the patient's ward if the consultant is not known. Similarly, other departments and hospitals within the district or region that use Freeman Hospital biochemical services were also provided with a code. For each request for biochemistry analysis received by the department the appropriate cost centre code was written on to the analysis worksheet with the patient details. After analysis the test code and its associated cost centre code—that is, source of request—were input via the VDU's to the computer data base from the worksheets, with the laboratory generated patient identification number. At the end of each month a summary of analyses, requests, and request sources were printed out on the matrix printer situated in the

clinical biochemistry department. The printout follows the format of:

- 1 Tests requested by ward and consultant and costs incurred.
- 2 Summary of total number of tests and requests and costs for each cost centre.
- 3 Summary of total numbers of each test or test profile.

Fig. 2 gives relevant examples.

The ICL DRS computer network system installed to run the management budgeting system uses a "stand alone" pathology network based on a DRS model 50 minicomputer system with 180 kilobyte random access memory and dual 27 megabyte sectioned hard disc files, which means that each department within pathology can access and sort its own data independently. The monthly summary of cost data is downloaded on to 8 inch floppy discs, which are passed to administration to be reloaded on to their Model 50 minicomputer linked to a 27 megabyte disc. The DRS model 50 in pathology is linked to two DRS model 10 "intelligent" VDU's and a 120 character per second matrix printer in the clinical biochemistry department. Radiology also has its own stand alone minicomputer from which information is transferred to the administration system via floppy discs. Costing data from other service departments, such as occupational therapy, dietetics, catering etc are loaded into the administration minicomputer through the associated terminal once a week from daily worksheets.

The unit accountant responsible to the unit general manager will collate this information and produce the monthly budget spread sheets for clinicians and service departments. These budget statements detail costs of services actually used against the allocated budgetary figure for that service, based on expected patient treatment rates. Where the actual patient treatment rate differs from the expected treatment rate, the budget figure is "flexed" to provide a new target figure. The difference or variance in actual expenditure from the flexed budget figure represents an efficiency indicator. A negative variance reflects efficiency gains in terms of provisions of a range of services for less expenditure. Fig. 3 shows a specimen budget statement. Where planned savings accrue through positive management action a percentage return for reuse will be negotiable with the unit general manager, as will virement between budget headings by a cost centre head.

Discussion

The initial data collection system had several problems: the software was unable to merge patient files with the same laboratory identification number; disc

storage was limited (16 megabytes for the whole hospital system), necessitating repeated culling of the data base to avoid disc storage saturation, resulting in data sort and print programmes becoming inoperative; data sort and print processes could only be initiated for the pathology department as a whole and not for individual departments, so that recovery of information was excessively laborious.

The revised version of the system allows each department in pathology to access and sort its own files independently and allows the user to record test data, update requests as more test information becomes available, and printout request reports. It should be noted that this is not a laboratory data management system, nor does it claim to be. Manual input of test data is the only option, and no interfacing to automated instruments is envisaged. This factor militates against the use of the data base for recording test results in departments with large workloads.

Within the time scale of the exercise we were unable to consider the detailed timings of analysis suggested by Broughton and Hogan² and Stilwell.³ Despite the less sophisticated approach to assessment of labour time used in this study a comparison of direct labour times arrived at in the present exercise with those of Broughton and Hogan shows broad comparability (Table 5). Appreciable differences sometimes did occur, and these could have been due to improvements in methodology and instrumentation over the past four years.

Stilwell's methodology incorporates both direct and indirect costs in a total cost per test, in contrast to that of Broughton and Hogan where indirect costs are assigned uniformly to each request as a "handling charge". As Broughton and Hogan state their approach facilitates comparison of direct costs of different analytical methods or laboratories without distorting relativities or masking the direct cost components.

The AYMM system developed at the Freeman Hospital incorporates elements of both systems. A major proportion of overhead costs are applied as a uniform charge per request, thus avoiding undue distortion of relativities in test costs. A certain proportion of indirect labour costs, however, are assigned as a charge on tests.

Using the annual workload per test in 1985, total direct cost of each test in that year was determined using the unit cost rates per test currently in operation (Table 6). Forty three per cent of consumable costs and 67% of labour costs were seen as indirect when considering the routine analysis function alone. Including consumable and labour cost of sample reception and separation, the corresponding figures were 38% and 57%, respectively. Broughton and

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Table 5 Direct labour time per test

Analyte	Mean labour time (minutes)	
	Broughton and Hogan	Freeman-AYMM system
Serum sodium, potassium (emergencies)	3.5	3.0
Plasma glucose	4.0	4.0
Serum urea	4.5	3.0
Serum amylase	10.0	10.0
Serum osmolality	11.6	5.0
Cerebrospinal fluid protein	13.0	20.0
Serum lithium	17.6	20.0
Urine metanephries	66.0	30.0
Serum sodium, potassium	0.9	2.0
Serum creatinine	3.6	2.0
Serum cholesterol	3.8	5.5
Serum triglycerides	6.4	7.5
Serum creatine kinase	11.3	1.6
Serum SMA 12 test profile	3.9	6.5*

*Composite time for six test electrolyte and seven test bone and liver profiles on Technicon SMA 6/60; Vickers SP 120 instruments (120 profiles per hour).

Table 6 Budget recovery as function of test and request costs

	Staff (£)	Non staff (£)
Departmental budget (1985) (A)	268 316	161 685
Elements recoverable as overhead charges (B)	74 088	35 034
Elements recoverable as request handling charges (C)	27 506	8 090
Elements to be recovered as test charges (D) = (A - (B + C))	166 722	118 561
Cost recovery applying current test unit rates to 1985 test workload (E)	88 266	92 203
Required uplift factor $\frac{(D)}{(E)}$	1.89	1.29
Test costs as a percentage of total costs $\frac{E}{A} \times 100$	32.9%	57.0%
Test costs and request handling costs as a percentage of total costs $\frac{E + C}{A} \times 100$	43.1%	62.0%

Table 7 Consumables as a percentage of total cost

Test	Total cost (£) including request charge (£0.89)	Test consumables (actual) as a percentage of current total cost	Total cost (£) with uplifted consumables (29%) and request charge (£0.89)	Test consumables (actual) as a percentage of revised total cost	Test and test profile workload per annum (1985)
Electrolyte profile (SMA)	1.46	11.6	1.87	9.1	55719
Electrolyte profile (ASTRA)	1.93	38.9	2.41	31.2	8329
Bone and liver profile (SMA)	1.58	19.2	2.02	15.0	34374
Cardiac enzyme profile (creatinine kinase (CK) + CK-MB isoenzyme)	2.61	37.3	3.56	27.4	3719
Creatinine kinase	1.30	17.5	1.52	15.0	5753
Glucose (AAIL)	1.32	4.6	1.67	3.6	10417
Amylase	2.16	26.3	2.95	19.3	2427
Iron and iron binding capacity	2.24	13.7	3.27	9.4	2187
Digoxin	3.53	46.8	4.89	33.8	2681
Thyroxine	1.88	27.8	2.45	21.3	5942
Thyroid stimulating hormone	2.85	42.9	3.87	31.6	5986
Urine electrolytes (SMA)	1.79	12.5	2.48	9.0	2167
Mean	2.05	24.9	2.75	18.8	93.1% of total test workload

Hogan found 57% of consumable-costs and 74% of labour costs to be indirect. Stilwell's study suggested that 52% of costs could be seen as indirect.

By calculating the shortfall between direct costs calculated from annual workload for 1985 and the proportion of annual budget that can be assigned under test costs, percentage uplift factors can be cal-

culated to uniformly adjust consumables and labour portions of each test cost for full recovery of budget. Table 7 shows that uplift factors of 1.89 for labour and 1.29 for consumables applied to test costs would achieve full budget recovery.

Stilwell's study (1981) shows an average total cost per test of £1.91 for a range of 60 analytes, with 75%

of these costs being less than or equal to £2.00. At the Freeman Hospital in 1985 the mean cost total was £3.19, with 76% being less than or equal to £4.00 for a range of 66 regularly requested tests. For that group of 12 tests or test profiles, which comprise 93% of the laboratory workload, the average total cost per test or test profile is £2.05 at the time of writing. Applying uplift factors of 1.89 and 1.29 for labour and consumables, respectively, would increase the average total cost from £2.05 to £2.75 (Table 7).

Stilwell, Broughton and Hogan, and others⁴⁻⁶ incorporate capital cost elements into their costing systems, and a DHSS working party on costing activity in pathology departments in 1983 recommended that capital costs should be included in the aggregation of test costs.⁷ The AYMM system developed at Freeman Hospital, however, is designed to recover each service department's annual budget as income charged to users of services. Annual provision for capital replacement is not incorporated into NHS departmental budgets at present and is therefore not incorporated into the Freeman-AYMM system. The current value of capital equipment whose replacement value equals or exceeds £1000 in the clinical biochemistry department at Freeman Hospital amounts to £440 000. Based on amortisation over ten years this would add £44 000 to the current annual budget of £430 000—that is, an enhancement of 10% to be passed on as test costs to the user. On a cost per test basis the lack of incorporation of capital depreciation does not therefore unduly distort test costings in favour of automated tests as opposed to manual tests.

Heads of departments need to be aware of the possibility of simplistic deductions, which might be made once laboratory costing data are freely available. If budgetary constraints on clinicians lead them to radically reassess their need for clinical biochemistry services, resulting in, to take an extreme case, a 20% reduction in laboratory workload, every effort must be made to impress on unit general managers and unit accountants that this does not mean a 20% cut in costs incurred by the laboratory.

For those tests or test profiles that generate 93% of the clinical biochemistry workload at Freeman Hospital, the mean percentage of total costs per test that can be designated as consumable costs and therefore, to some extent, recoverable with reduction in workload is 24.9% (Table 7). Thus for a 20% reduction in income consequent on a 20% reduction in workload, only 24.9% of this—that is, 5%—is a budgetary saving. Even this saving may be diminished by loss of discounts on bulk reagent purchases in certain cases. Adjusting current test costs by uplift factors to maximise recovery of laboratory budget reduces direct consumables contribution to an average of 18.8% of total cost per test, which would produce

only a 3.8% budgetary saving with a 20% reduction in workload. Lundberg and Westlake⁸ observed this lack of direct response of laboratory operating costs to fluctuating workload to be one of the major elements which might lead, paradoxically, to increased charges per test if laboratory workload fell dramatically. In a detailed financial examination of an American laboratory Winkelman⁹ showed that a 10% reduction in workload would lead to a mere 1.8% reduction in direct costs for high volume automated tests and only a 4.9% reduction in direct test costs overall.

In a subsequent paper Winkelman and Hill¹⁰ outlined various strategies for coping with reduced funding consequent on declining workload. Of the strategies suggested, optimisation of the cost effectiveness of internal laboratory procedures without degradation of provision of services seems to be the most appropriate option for United Kingdom laboratories. It should be noted that the DHSS circular HN (85) 3 (1) (DHSS health notice (85), January 1985) on management budgeting recognises that reduction of the use of diagnostic tests will not lead to savings in manpower and overhead elements of test costs. Nevertheless, the onus is on laboratory staff to emphasise this vital point.

The AYMM system provides a valuable cost analysis tool that permits the identification of fluctuations in the variety and the number of requests per clinical team, changes in the overall volume of work per test, and the effects of these variables on costs incurred by the laboratory. The generation of an awareness of the relative cost of test procedures in the light of prevailing budgetary restrictions encourages rigorous laboratory assessment of the cost effectiveness of any new or modified analytical procedure in relation to its clinical utility.

In the post Griffiths era management budgeting systems are inevitably becoming widespread. The importance of the AYMM system lies in its current application as a working system rapidly being adopted by many hospitals in the United Kingdom. It is therefore in the interests of every head of a pathology department to understand the financial workings of his or her own department and to be aware of the elements that should be incorporated into a laboratory costing system. The cost of implementing management budgeting systems for a new site is estimated at £90 000–£100 000, with annual running costs totalling £25 000 per unit (DHSS health notice (85), January 1985). It would therefore be naive not to assume that revenue savings will be expected to recover this expenditure.

At present, the management budgeting process is directed at the clinician end user, but eventually, close scrutiny must be given to laboratory budgets, particu-

larly as performance indicators are refined and applied more extensively. Each laboratory head of department must therefore be prepared (with detailed costing information) to correct any misinformed ideas and convince unit and district general managers, when necessary, of the need to maintain and improve laboratory budgets. Detailed and thorough cost analysis of a laboratory's functions can only strengthen the case.

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