

# Introduction of a Vickers M300 analyser into the routine service of a hospital laboratory

## 1 Installation, staffing, logistics

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**SYNOPSIS** A Vickers M300 analyser has been successfully installed in a busy hospital laboratory. A permanent team of operators is used, but this introduces problems for staff rotation, particularly for educational purposes.

The vials used for the collection of samples are an essential feature of the system, but they present many difficulties and are no longer used for collecting samples from outpatients, or at remote sites.

Direct costs during 1974, excluding staff and depreciation, amounted to approximately £0.45 per patient sample: this is assessed on the rising workload during implementation. An increased workload could still be handled with existing staff.

The siting of such high-capacity analysers constitutes an important policy decision.

The Vickers M300 analyser is a high-capacity, multi-channel, discrete analysis system designed to carry out up to 20 different chemical tests on each blood plasma sample, operating at a rate of 300 samples per hour. The main features of the analyser have been described, and its performance in a formal evaluation programme reported, by Bick *et al* (1973).

In August 1972, the Middlesex Hospital accepted one of the first five M300 analysers to be installed in British hospitals for full service use, as part of a programme initiated by the Department of Health and Social Security (DHSS). The DHSS purchased the machines and then allocated them to hospitals willing to accept them and deemed suitable for their installation. The purpose of this paper is to report on the logistical and technical aspects of introducing the M300 into a hospital routine clinical chemistry service, and also to provide some data on actual running costs.

### Site Preparation and Installation

The M300 has been housed, with its associated working areas, in two small laboratories having a total area of 37.6 m<sup>2</sup> (405 sq ft): there is a small adjacent plant room. Site preparation included

installation of air-conditioning, double glazing, a raised floor, a false ceiling, and all services. This work took about three months and cost nearly £16000 (1973). Figure 1 shows the plan view of the M300 laboratory and adjacent areas.

The machine configuration consists of a main control console; distributor system; 10 reaction rotor units, each capable of carrying out two tests, or one test with a blank; an Instrumentation Laboratories flame photometer (IL343); 18 Mark IV colorimeters; a PDP8L computer (4K store) with control teletype, Sykes Compucord cassette magnetic tape drive, and a Potter LP3000 printer. In addition, a spare reaction rotor unit is held for backup; and a D300 service unit is available for checking individual reaction rotor units, and for development work.

The propane gas supply to the flame photometer comes from small capacity (8 hour) cylinders. To reduce the risk of a cylinder running out during a run, or the alternative wasteful disposal of partly used cylinders, an alarm-clock device has been designed and installed to monitor the running time of the flame: this has been described elsewhere (Stevens and Dawson, 1975).

### Staffing

Operation of the M300 probably requires only two

<sup>1</sup>Requests for reprints should be sent to ALM

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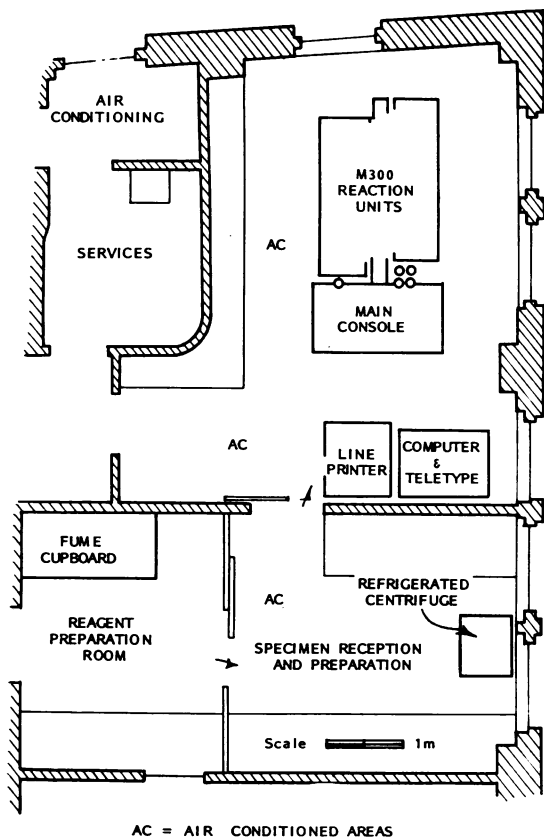


Fig 1 Scale plan of the laboratories housing the M300 analyser, and associated activities.

persons, but this simple statement has little relevance to the actual numbers and types of staff required to run an M300-based routine service. In the first place, sample handling and vial coding (see below) are labour intensive operations and, with reagent preparation (which takes about 1½ hours per run even with most reagents purchased ready-made) and the need to have cover for the absence of either operator, justify a third member of the team. In addition, an engineer is employed to work about half-time on the correction of mechanical and electrical faults, and on providing a first-line servicing facility ahead of the manufacturer's engineers. Such an engineer will also have other duties in a major clinical chemistry laboratory.

It is highly desirable that the team be permanent, and this poses problems for junior and middle-grade staff who normally require to rotate through the various sections of the laboratory to meet educational needs. Furthermore, the dependence of a large part of the routine service on the M300 and the normal

turnover of staff mean that those not on the permanent team must rotate through the M300 unit for basic training; such persons are supernumerary to the team. In practice, therefore, a team of three operators, one trainee operator, and the half-time services of an engineer are usually involved in the daily maintenance and running of the machine, given a Monday to Friday schedule. We have not solved the problem of keeping sufficient staff sufficiently trained to have a rota for a weekend service.

### Logistics of the Routine Service

The overall process flow is shown in fig 2, to which the following sections refer. This method of operation has been termed the 'sticky-label system'.

#### PATIENTS' SAMPLES/VIALS

A particular feature of the M300 system is the collection of samples into heparinized vials, which are loaded onto the analyser after centrifuging, but without preliminary removal of the plasma. These vials may be coded with machine readable information by indenting their foil surfaces; this provides unique sample identification within the laboratory. The coding procedure must be carried out manually since no satisfactory mechanical means has yet been devised. It is a simple technique but one which must

SAMPLE AND REQUEST ARRIVE IN LABORATORY  
IN TWO - COMPARTMENT PLASTIC BAG

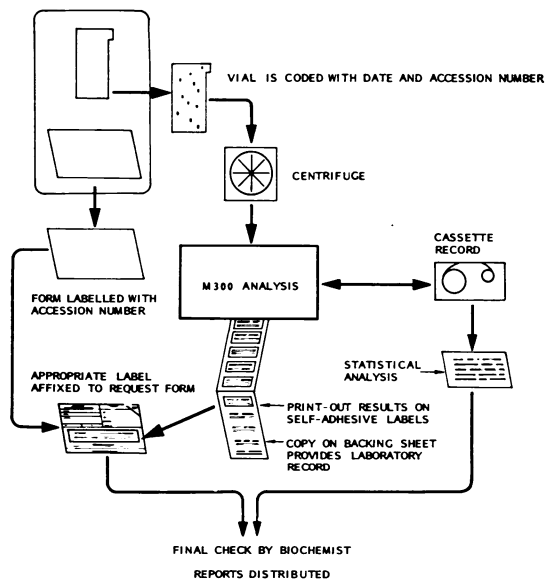


Fig 2 General outline of the process flow showing vials, forms, affixed reports, and statistical analysis procedures.

be carried out properly. For this reason we ruled out the possibility of coding at the bedside using, for example, the patient's record number: instead, all coding is carried out in the laboratory using sequential accession numbers. Three-digit accession numbers are prefixed by a two-digit day-of-the-month, and an indexing stamp is used to put matching codes onto the request form (see below) and the daily work-sheet. All forms and samples are kept in accession number order throughout, so that printed reports match to the request forms during the analytical run. As the printout includes the accession number read from the vial, this is checked with the number stamped on the form.

Since it follows that vials arrive in the laboratory uncoded, the problem arose of identifying vials during transit, because we could not allow writing on the vial which might damage the vial surface. However, as each heparinized vial has a protective cardboard sleeve, this may be used for identification information, always provided that the vial is never removed nor becomes accidentally separated from its sleeve. To ensure these last requirements, and also to minimize risks from leaking vials (which in practice has not proved to be a serious problem), vials are sent to the laboratory in individual plastic bags. The Minigrip bag<sup>1</sup> has been found suitable. It consists of two bags fixed along their edges: the smaller bag is self-sealing and is used for the vial; the larger bag is used

<sup>1</sup>Minigrip bags: order code SB50: Henley's Medical Supplies Ltd, Clarendon Road, Hornsey, London N8

<sup>2</sup>Vacutainers: Order code 4512: Beckton-Dickinson and Co, Rutherford, New Jersey, USA.

for the request form. This system also simplifies sample reception because sample and form remain linked in transit.

While the loss of one or two channels of analytical information is seldom a serious matter for inpatients, it can be extremely serious for outpatients, since the patient is then inaccessible, and insufficient plasma remains in the vial for a second run. We therefore began by collecting a spare heparinized blood sample from all outpatients in addition to the vial. However, while it is possible to insist that local inpatient samples reach the laboratory by noon, for analysis on the same day, it is clearly impossible to insist on the same arrangements for outpatients, or for inpatients at remote sites. Whole blood cannot be stored overnight in vials without deterioration, so that such samples must be centrifuged and the plasma transferred to a second vial (half-size, 2½ ml): the use of two vials is expensive, nor is there always enough plasma for this to be done. Our present solution is to abandon the use of vials for outpatients and to collect a 10 ml heparinized blood sample, which undergoes preliminary separation into half-size vials within the laboratory. Although not entirely satisfactory, this solution has the advantage that it is compatible with the use of Vacutainers<sup>2</sup> for venesection.

#### REQUESTS

A request form was designed for the M300 service: this is shown in figure 3. Instructions about the collection of samples are included, and the back of the form (not shown) gives details of the tests available, with the abbreviations for test titles and units.

Date		Investigation		<b>C/V</b>	
Consultant (Name in full)		No.			
Clear name of Medical Staff for enquiries		Surname OTHER		Ward/Dept.	
Return form to		First Names A.M.			
Lab. No.		Time Collected		Date of Birth	
		AM/PM		Fasting?	
				YES / NO	
Diagnosis and Clinical Abstract					
DEMONSTRATION					

Fig 3 Request form with an attached report. The quality of the report printing is for demonstration only.

25/04/75	15	13										
CHOL	215	M%	PROT	7.8	G%	0	U.A.	4.9	M%			
ALKP	8.9	KA		0		0	....	.96	M%			
BIL	.2	M%			AST	5	IU	0				
CA	9.8	M%	ALB	3.9	G%	CL	98	MM	UREA	36	M%	
....	0	..	PO4	2.9	M%	NA	137	MM	K	3.8	MM	

## REPORTS

The results generated by the M300 analyser during a run are not suitable for direct transmission to the wards and clinics as reports since their patient identification information is inadequate outside the laboratory. This laboratory has no general purpose data-processing equipment, and it was therefore decided that results would be printed onto adhesive labels, which provide a copy on the backing paper suitable for filing with the daily work-sheet as the laboratory record. The printed label is stuck onto the original request form (where it overlies the instructions for taking the sample) to provide the final report. A fictitious sample report is shown in figure 3. Labels are  $7\frac{1}{2} \times 1\frac{1}{2}$  inches and are obtained on pressure-sensitive, fan-folded backing paper<sup>1</sup>.

## Reagents

Tenders for the supply of prepared reagents were obtained from a number of companies. The one selected<sup>2</sup> gave a competitive quotation and was also located so that delivery at short notice was simplified. The commercial supply of reagents has been efficient and satisfactory, but it has been found preferable to prepare certain reagents in the laboratory daily (although sometimes from supplied stock reagents), notably those for cholesterol, uric acid, AST, and phosphate.

## Implementation

Mechanical and chemical trials were completed under the supervision of Vickers' engineers during the commissioning period, which lasted three months. An educational programme within the hospital familiarized potential users with the new request forms, with the use of vials for sample collection, with the report format, and with the service schedule.

It was decided that, initially, the M300 would run in parallel with existing laboratory procedures, most of which used Auto Analyzer methods. Clinicians were free to use either system of analysis during a period in which they could develop increasing confidence in the reliability and comparability of the M300.

From 20 September 1973, a pilot study provided a service for the professorial medical and surgical units, carrying out 15 tests on each sample (Buckley-Sharp *et al*, 1976). This showed that the procedures specified for sample handling, machine operation, and reporting were all satisfactory and confirmed

that no immediate modification of published normal ranges (Courtauld Institute, 1970) was needed. On 25 October 1973 the service was extended to all wards; the profile was reduced to 13 tests (Buckley-Sharp *et al*, 1976) but no other modifications were made. Thus, at the start of our own period of formal review on 2 January 1974, the M300 service was receiving samples from the full spectrum of inpatients from the main Middlesex Hospital site. On 11 March 1974, the full service was extended to all other hospitals in the Middlesex Hospital Group, to outpatients, and to patients referred from general practitioners. Full implementation therefore took approximately one year from starting the building alterations.

The routine operation of previous analytical methods has been gradually discontinued. In February 1974, the alternative urea and electrolyte service was discontinued, and in June several other tests followed suit. In February 1975, urine calcium and phosphate determinations were transferred to the M300, making the corresponding AutoAnalyzer channels redundant. At present some 70% of the total workload (by tests) is done on the M300 analyser, although there has been a new emphasis on one-off tests. The growth of the service over 1974, affected by the factors noted above, is shown in figure 4. A total of some 29000 patient samples was received during the year.

## Costs

Before the service was instituted, the estimated direct costs (under the headings of the table, and therefore excluding staff, amortization, and housing) were

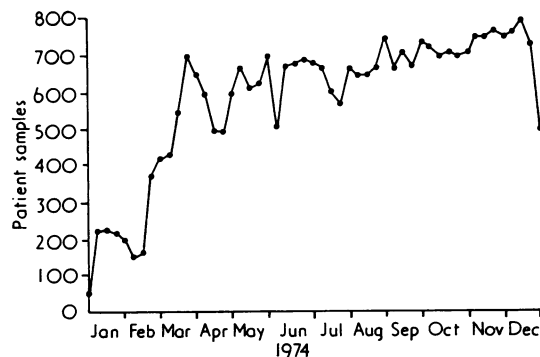


Fig 4 Workload of patients' samples by week for the period January-December 1974. The first entry covers only two days: the last entry covers four days from the two weeks around Christmas. During the year the workload is affected by the phases of implementation (see text) and by the normal public holidays.

<sup>1</sup>Pressure Sensitive Materials Ltd, Seven Sisters Road, Finsbury Park, London N4

<sup>2</sup>Clin-Tech Ltd, Bowater Road, Westminster Industrial Estate, London SE18

£7200 for *six* months: this allowed for a 2-hour run on each of *six* days per week (25-day working month).

Actual running costs for a *five*-day week, over the year January to December 1974 have been obtained simply by totalling the costs of all goods and services ordered and received in the period. These costs are shown in the table. No allowances have been made for stocks in hand, but special mention is appropriate for the NCR sticky labels. The present price of these is about £10 per thousand, *but during 1974 we were still using an initial batch of 50 000 purchased in 1973 which is therefore not included in the table.*

Items	£	Note
Spares and services	2090	
Reagents	7858	
Calibration and control sera	1280	
Vials	1541	1
Stationery	331	2
Training course	55	
Total	13155	

Table Total invoiced amounts for all orders issued, and subsequently delivered, in the year January to December 1974

No account has been taken of stocks in hand at the start and end of the period.

Note 1 Does not reflect recent doubling of price

2 Does not include a batch of NCR paper purchased in 1973 (text)

Spread over 29000 samples (see above and fig 4), these costs amount to about £0.45 per sample or about 3½p per test result. Forward projections of cost inflation and increased workload suggest that this cost *per sample* may be maintained for 1975.

## Discussion

The M300 is capable of providing an efficient routine service in a busy hospital laboratory.

The vials, at first sight a most attractive feature of the system, provide many problems. Accurate filling of the vials is critical, and coding remains a time-consuming manual operation. Since whole blood cannot be stored overnight in the vials, samples received after the daily M300 run begins must be separated and the plasma stored; the risk of error at sample transfer time is re-introduced and the vial becomes a very expensive 'disposable' analyser cup. The plasma monitor on the M300, installed to check filling of the vials and to detect abnormal opacity of the samples, cannot be used since it rejects all samples in which no upper level of packed red cells is sensed: this includes all water baseline samples, all reference and quality control samples, and all previously separated patients' plasma samples. A simple template, used beside the vials before they are

loaded into their magazines, provides the main visual check on vial filling. A channel is also dedicated to monitoring the optical density of diluted plasma to check for haemolysis and turbidity. This check is known locally as the 'BUI', and the result is printed without heading or units (bottom left, fig 3).

There is general agreement among users of the M300 that the computer facilities of the PDP8L provided as the process controller in the standard package are inadequate for efficient use of the machine. Additional facilities are necessary—for multipoint calibration, which we believe to be desirable for improved analytical performance; to allow results obtained during a run to be held for modification after review of the quality control and drift data; and to allow for a more intelligible and attractive report format. Some of these facilities can be provided, and perhaps are better provided, by a general purpose laboratory data-processing system: however, we have no such equipment. It is intended to supplement the present computer when funds are available using a separate mini-computer: plans for this are well advanced.

The costs of operating the M300 are high, and we are by no means convinced that repetitive profiling of inpatients is a worthwhile exercise although the alternative in our case, of keeping duplicate methods fully operative, is out of the question. In most laboratories, requests for 'electrolyte' determinations constitute a very large part of the total work-load: if these requests are transferred to the M300, wasteful repetitive profiling occurs; if they are not, then wasteful duplication of methods occurs. Clearly, the M300 has a special role for profiling outpatients and new admissions to hospital, or as part of a multiphasic health screen. Our aim should be to site such analysers only where there is an adequate *outpatient* workload (perhaps for several hospitals), making the use for inpatients in the hospital where the analyser is installed a valuable secondary function.

Direct costs clearly increase with increasing numbers of samples. Until the total number of patient and quality control samples reaches about 400 (limited by the track capacity of the magnetic tape cassette) such samples can be analysed on the same run, without increase in the costs of setting up and calibrating. Direct costs *per sample* will therefore decrease as the number of samples analysed in a single run increases. Even more significant, there is little doubt that twice the present number of samples could be handled with minimal extra help: staff costs *per sample* would therefore fall sharply if the workload increased. If other factors are taken into account, including amortization, then it becomes apparent that cost-effective operation of this high-capacity analyser demands an adequate workload. It is not

our purpose to generate a workload where none previously existed, if that workload cannot be separately justified. It follows that the siting of such analysers, in relation to the opportunities for the centralization of laboratory services, involves important policy decisions.

We thank the Medical Illustration Department of the Middlesex Hospital (Mr P. Drury) for drawing the figures; also the staff of our M300 unit for their hard work; and our clinical colleagues for their forbearance throughout a period of rapid procedural change.

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