UTILISATION OF BIOCHEMISTRY LABORATORY SERVICE - A TEN-YEAR REVIEW

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SYNOPSIS

This paper reviews the utilisation of biochemical laboratory investigations by the major users of laboratory services within the Ministry of Health, Singapore, over the period 1970 to 1979. It highlights the great disparity between the increase in demand for biochemical tests and the increase in any of the following: patient admissions, bed complement and laboratory staff complement. Several reasons for the dramatic rise in laboratory workload are given. The problems of emergency investigations outside normal office hours are discussed. Data on the utilisation of emergency biochemical laboratory service by the various hospitals and clinical disciplines as well as the percentage of abnormal results for several biochemical tests in various clinical conditions are presented. Several suggestions are recommended for the improvement and better utilisation of the biochemistry laboratory service.

As this paper concerns the biochemistry service in medical care in government health establishments as a whole, it is necessary to provide a brief summary on the organisation of the laboratory service in Singapore before reviewing the utilisation of the service over the last 10-year period and making recommendations on how greater efficiency and better utilisation of the laboratory service may be achieved.

Each government hospital in Singapore has a clinical laboratory to cater for a limited range of the most commonly required biochemical and haematological investigations essential for the routine and immediate diagnosis and management of patients. For reasons of economy, better utilisation of trained personnel and sophisticated equipment and more effective quality control of test procedures, the technically more demanding, more costly and less frequently required investigations are centrally carried out by the Biochemistry Section of the Department of Pathology which also serves as the reference and training centre for clinical biochemistry. Because of its proximity to the Singapore General Hospital, the Biochemistry Section of the Pathology Department also provides the hospital with the entire range of biochemical investigations normally undertaken by a hospital clinical laboratory. A 24-hour emergency biochemistry service is provided by all hospital clinical laboratories as well as the Biochemistry Section of the Department of Pathology. A detailed description on the provision of clinical biochemistry laboratory service in Singapore has been documented in a separate paper entitled "The Practice of Clinical Biochemistry in Singapore" (4).

Fig. 1 shows the laboratory workload, laboratory staff position, patient admissions, and bed complement in the 5 major hospitals, namely, Singapore General Hospital (SGH), Tan Tock Seng Hospital (TTSH), Toa Payoh Hospital (TPH), Kandang Kerbau Hospital (KKH) and Alexandra Hospital (AH), over the period

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1970 to 1979 (1, 2, 3). It is evident that there is a great disparity between the increase of laboratory workload and the increase in either laboratory staff or number of patients admitted or number of hospital beds. Bed complement and patient admissions in the 5 major hospitals went up by only 20% and 68% respectively over the 10-year period while the demand for biochemical investigations soared by 350%. The number of biochemical determinations per 100 patients admitted to the hospitals rose from 214 in 1970 to 570 by 1979. The individual data for the various hospitals for 1979 are: 778 for SGH, 600 for TPH, 564 for TTSH, 370 for AH and 229 for KKH. Patients admitted to SGH were found to have the highest number of biochemical tests carried out on them.

It is therefore not surprising that our Ministry of Health is concerned about this trend of rapid increase in demand for laboratory tests. In April, 1979, in his address to the Singapore Medical Association, the Minister for Health remarked that overuse and wastage of diagnostic and therapeutic services, particularly laboratory tests, have been shown to raise hospital cost in studies overseas (6). Either unnecessary tests were ordered or repetitive tests were made. The Minister said that the Singapore situation confirmed these findings and urged clinicians to exercise judgement over the use of various diagnostic or therapeutic procedures in order to prevent or control the escalation of the cost of health care.

In May of the same year, a feature article on medicine entitled "Health Costs: What Limit?" appeared in the "Time" magazine Time (5). The article reported that according to estimates made by the White House, medical costs will double every 5 years at the present rate of increase, a rise far in excess of inflation. It referred to the overuse and abuse of laboratory tests and radiological procedures and the unwillingness of users of diagnostic services to consider costs, as important contributory causes for the catastrophic increase in the cost of health care. Soaring bills have created a political issue and prompted a search for a cure. The article further reported that a growing number of policymakers, including Carter and Kennedy, are convinced that the nation must slow the surge in health costs as part of any effort to control the general inflation that saps the economy and erodes the dollar. The country is taking measures such as a hospital cost containment bill to control hospitals to hold down the increase in their cost. If we are not careful, we could end up with the same situation as occurring in the United States. It is therefore prudent for us to review our local trend in the utilisation of laboratory services and consider how any wastage may be prevented or reduced and our resources put to better use.

Over the last 10 years, the increase in laboratory staff has been insignificant compared with the rise in the number of analyses (Fig. 1). The total increase in staff complement at the end of 1979 was close to 100% while the workload increased by 350% over the corresponding period. This implies that laboratory staff are performing 2.3 times the volume of analyses they used to do in 1970. The contrast between the increase in workload and staff complement is even sharper when comparison of the observations is confined to the Biochemistry Section of the Department of Pathology. Laboratory tests increased by 375% while laboratory staff complement increased by merely 35%. This means that laboratory staff have to cope with 3.5 times the volume of analytical work they used to handle. This would have been impossible without the simplification and mechanisation of test procedures.

What are the reasons for the alarming increase in demand for laboratory tests? Firstly, increase in patient population partly contributes to a greater demand for tests. Secondly, as more sensitive and better laboratory tests are introduced as a result of advances in medical knowledge and technology, increasing use of new tests for patient diagnosis is also to be expected. Thirdly, with the availability of more sophisticated instruments for rapid performance of a variety of established routine biochemical tests such as estimations of glucose, urea, electrolytes, and tests for liver function, it is now practical to have these tests repeated more frequently on the same patients for monitoring the course of disease and treatment. However, these reasons cannot completely account for the dramatic rise in workload which is out of proportion to the increase in patient population and hospital beds. It appears that inadequate awareness of costs among laboratory service users, insufficient understanding of the proper use of laboratory investigations and research may be more important causes. While a lack of understanding in the usefulness and limitations of various tests can lead to unnecessary laboratory work, inadequate coordination and supervision of research can result in repetition of the same work and wasteful accumulation of laboratory data which are eventually neither analysed nor documented.

Figs. 2 and 3 show the workload pattern of several enzyme assays and measurements for several organic and inorganic constituents in patient sera. The increase in volume of analyses for the various tests over the 10-year period is noted to range between 123% and 6090%. The sharpest increase is observed for the 3 tests: triglyceride (1700%), CPK (3200%) and LDH (6090%). Some of the abrupt increases in the slope of the workload pattern curve for ALP, GOT and GPT are found to be associated with various large scale health surveys and research projects. The duration of the projects varied between several months to several years. Unfortunately, with the termination of the projects, laboratory work never returned to the pre-project levels. Once a project is completed there ought to be a careful analysis of clinical and laboratory data. After a thorough assessment of the results, only those tests or groups of tests proven to be more specific and useful for the diagnosis and management of the relevant disease states should be retained. This is obviously not the case. After a study, the entire range of tests continued to be used. Clearly, the conclusions of research projects have not been put to good use.

There can be no dispute that research, when properly conducted, will contribute towards better under-

standing of disease and hopefully better health care, and should be an important part of the work of any progressive medical institution and health establishment. However, if research is to be fruitful and fulfil the objectives for which it is conducted, it requires thoughtful planning and supervision. All parties involved in a research project must work together closely and be equally interested and committed throughout the study. There should be strict adherence to previously agreed criteria. Otherwise, the whole project can deteriorate to a mere collection of questionable data which cannot stand up to scrutiny in the final report. Several projects in which we participated had unfortunately fallen into this category.

From time to time, we have found individuals repeating research work which have already been carried out by others. We would discover unusually large number of requests for certain test or tests coming from a certain ward or department. Sometimes, most of the results were "normal" and the clinical conditions of the patients under study were not known to require such test or tests. If research work within the Ministry of Health can be better coordinated and if annually a list of published papers on various research projects can be made readily available to those contemplating research so that they could ascertain if their proposed project had already been carried out previously, there will definitely be a reduction in non-profitable repetitive work.

The establishment of specialist clinics such as that for the management of patients with myocardial infarction resulted in a rapid increase in demand for assay of cardiac enzymes. From the trend shown in Fig. 2, it appears unlikely that there would be any significant slowing down in the rate of increase in workload of enzyme determinations in the near future unless some form of control is imposed. Closer examination of tests requests revealed that there has been increasing requests for the simultaneous assays of CPK, LDH and GOT for patients suspected of having a myocardial infarction, and for these assays to be repeated for 2 or more days. The course of rise and fall of the cardiac enzymes with respect to time in myocardial infarction has been well-documented. The usefulness and necessity of simultaneous and repeated assays of the enzymes for all patients suspected of the cardiac condition is questionable. CPK is diagnostically useful on the first day of infarction while LDH or GOT is more useful for detection of the condition when the clinical episode has occurred more than a day prior to blood collection for laboratory investigation. The information given by GOT and LDH are almost identical and therefore the performance of either of these tests would be sufficient. For most cases, determination of CPK and one of the 2 other enzymes on the day of patient admission will provide adequate information. In the event that the ECG is equivocal and CPK and the other enzymes are not elevated even in the presence of strong clinical indication, only CPK assays will need to be repeated on the following days. If CPK is elevated on the first blood specimen, there is no need to repeat the assay nor request for the other enzyme tests. A blanket order of 3 enzyme assays for 3 successive days for all cardiac patients may mean that the laboratory has to perform 8 redundant tests when one would have been sufficient. When the junior medical officer was asked to explain the necessity of such a regime, the reply was that he just followed orders and carried out what he was told to do.

This type of wastage of laboratory investigations has arisen because (a) senior clinical staff find it more convenient to give general orders rather than specific, selective ones, (b) junior staff do not know the reasons for requesting the tests, and (c) junior staff take a defensive stand in requesting more tests than the patient actually requires, for fear of being reprimanded by their seniors for omitting any test; after all, he only needs to use his pen. We have come across many junior officers who do not know the rationale for asking for a test and how the result of the test would influence his clinical decision or management. For example, no explanation could be given for sending hourly or 2-hourly blood and urine specimens for salicylate measurement when the first specimens of blood and urine already indicated low levels or absence of salicylate. No satisfactory answer could be given for the 2-hourly follow-up of diabetic patients when two or three consecutive specimens have shown the blood glucose and other biochemical parameters to have been stabilised at reasonable levels. Protein and lipoprotein electrophoresis studies were requested when total protein, albumin, globulin, triglyceride and cholestrol levels are already known to be well within the reference or normal range.

We would now like to turn to a bigger problem area for the laboratories. This is the emergency biochemistry service provided after normal office hours when only very limited number of laboratory personnel could be put on duty. Apart from Sundays and public holidays when more than one staff are rostered for emergency work, only one person is on duty in each laboratory during the night. Unlike the ordinary day duty, the staff has to attend to each in-coming specimen as soon as it arrives as it is supposed to come from a patient in a life-threatening situation. There is continuous pressure on the staff throughout the night duty period.

Fig. 4 shows the pattern of emergency workload after normal office hours in the Biochemistry Section of the Department of Pathology. In 1971, the total number of analyses for night duty and Sunday day-duty averaged 37.5 and 173 respectively. By 1979, the numbers have increased to 133 and 430 respectively. When the hospital was notified about this alarming trend, the Director of the SGH reminded ward staff of the need to use greater discretion in making emergency test requests. Consequently, the first two months of 1980 saw a steep plunge in the number of analyses to about 1977 level. There was a reduction by almost 30 tests per night. A comparison of the total emergency workload for the 5 laboratories, over the same period in early 1980, is given in Table 1. The workload during the night and Sunday emergency work periods is noted to be heavy for all the 5 laboratories, especially the Biochemistry Laboratory in the

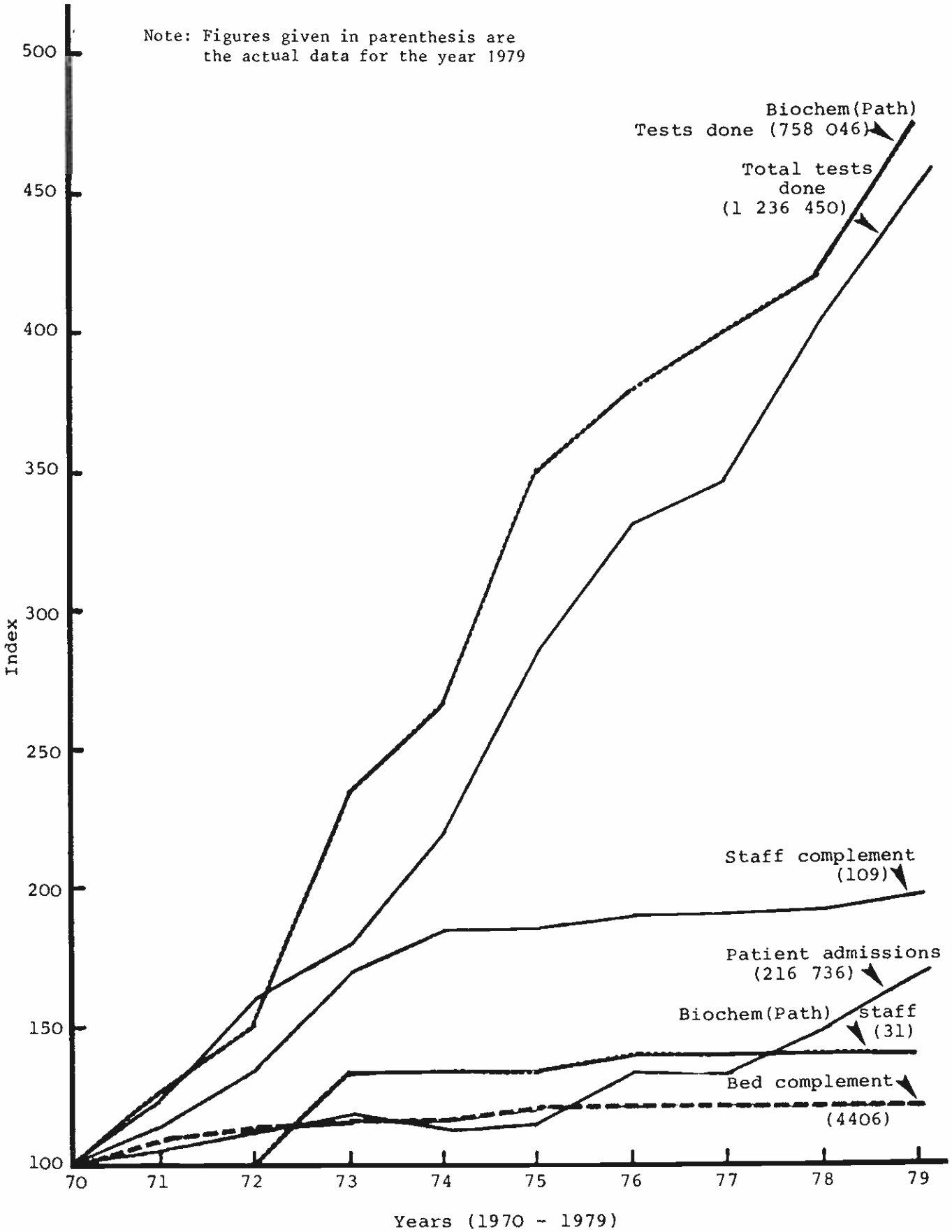


Fig. 1 Indices of Workload, Staff, Patient Admissions and Bed Complements for Five Major Hospitals from 1970 to 1979 (SGH, AH, TTSH, TPH & KKH)

Fig. 2 Workload Pattern for Four Enzyme Assays (ALP, GOT, LDH, CPK) over the Period, 1970 to 1979

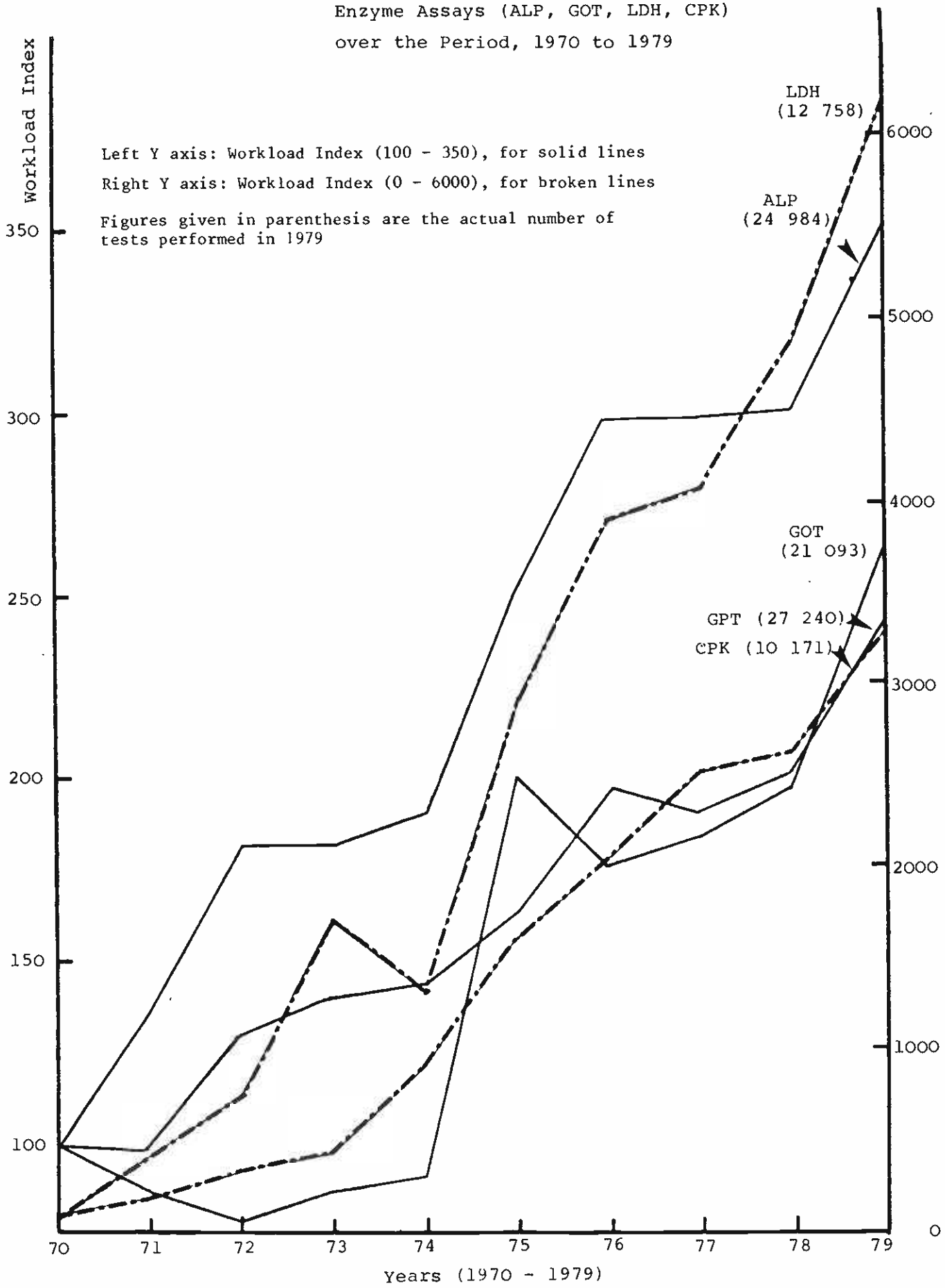
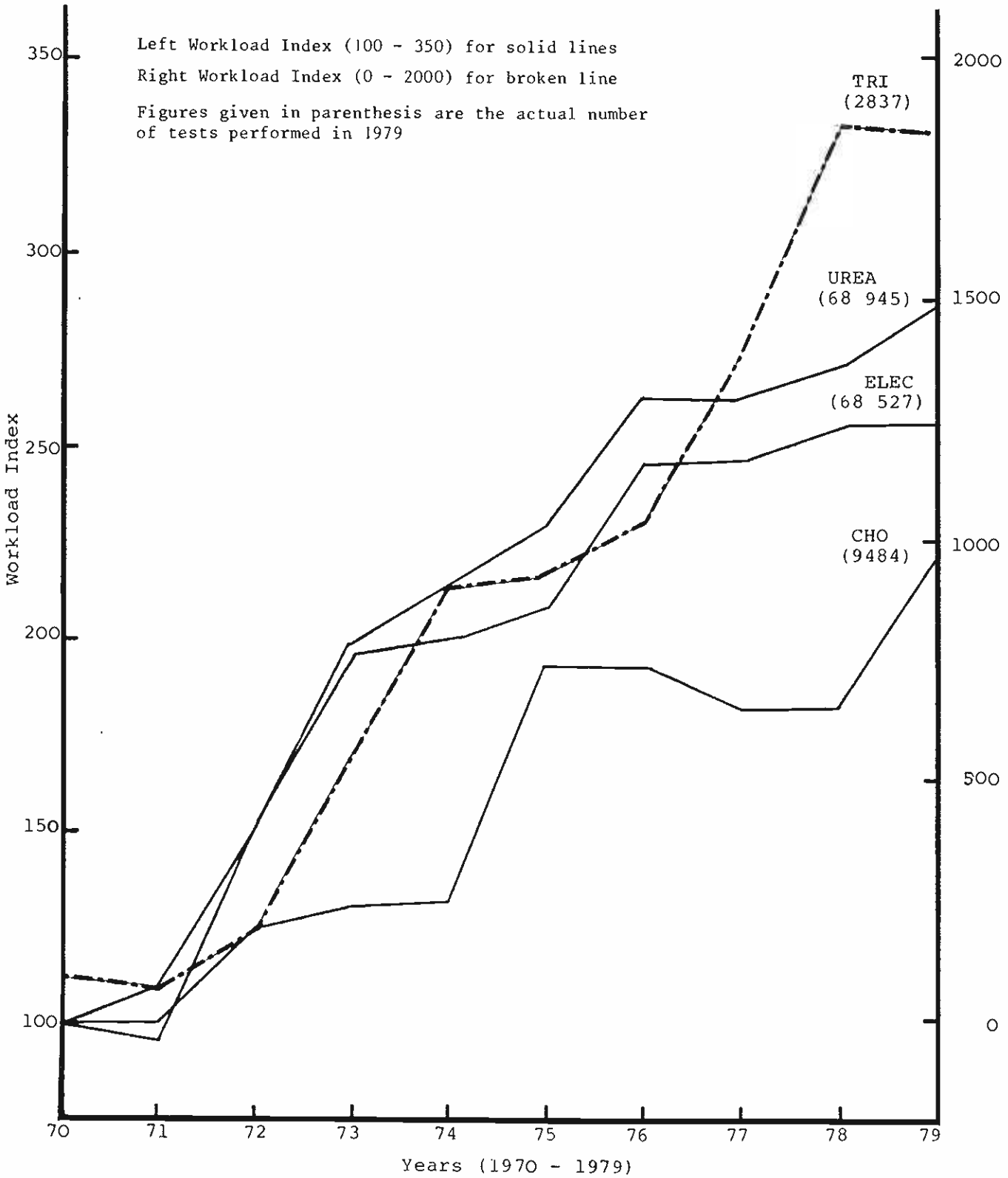


Fig. 3 Workload Pattern for Triglyceride, Cholesterol, Urea and Electrolytes over the Period, 1970 to 1979



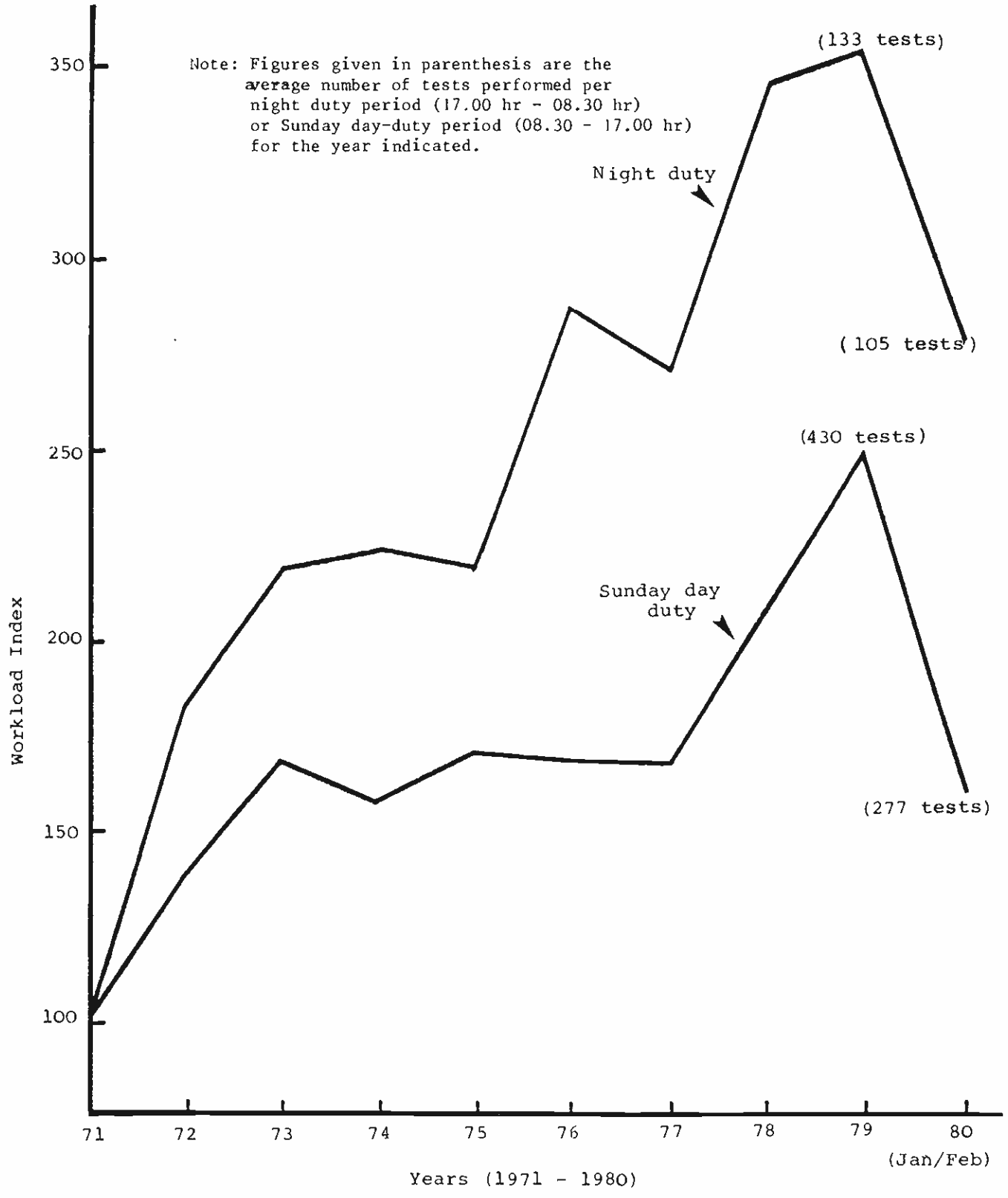


Fig. 4 Emergency Work After Normal Office Hours

TABLE 1

Comparison of Number of Emergency Tests Performed in 5 Laboratories After Normal Office Hours

Laboratory	Biochem. Dept Path.	AH	TPH	TTSH	KKH
Night Duty (1700–0830 h)	119 (100%)	76 (22.4%)	54 (11.1%)	146 (40.4%)	75 (12.1%)
Sunday Duty (0830–1700 h)	341 (100%)	144 (30.6%)	99 (13.0%)	259 (40.9%)	298 (36.6%)

Note: Data obtained over a 3-week period in early 1980. The number of tests for AH, TPH, TTSH, and KKH laboratories includes biochemical, haematological and blood bank work.

Figures in parenthesis are the percentage of biochemical investigations.

TABLE 2

Biochemical Tests Utilisation by Various Medical Disciplines in Five Hospitals

Hospital/Departments	(A) No. of Test per Night	(B) No. of Test per Sunday (day)	(C) Average Bed Occupancy per Day	(A)/(C) x 100	(B)/(C) x 100
SGH					
Med I (U)	19	25	113	17	22
Med II (U)	20	40	121	17	33
Med III	13	21	116	11	18
Surg A (U)	17	80	131	13	61
Surg B	11	46	115	10	40
Paed West (U)	11	21	82	13	26
Paed East	5	6	77	6	8
Orthop	8	28	170	5	16
Misc	1	10	134	1	7
Total	105	277	1059	10	26
AH					
Medical	12	16	102	12	16
Surgical	1	6	129	1	5
Paediatric	3	18	71	4	25
O & G	1	4	104	1	4
Total	17	44	406	4	11
TPH					
Medical	3	5	126	2	4
Surgical	2	7	103	2	7
O & G	1	0	73	1	0
Total	6	12	302	2	4
TTSH					
Medical	25	30	327	8	9
Surgical	10	32	216	5	15
Paediatric	4	10	70	6	14
Neuro	4	7	123	3	6
Cardio Thoracic	16	27	42	38	64
Total	59	106	778	8	14
KKH (O&G & Neonates)					
A Unit	2	3	150	1	2
B Unit	2	2	163	1	1
U Unit (U)	3	25	143	2	17
Neonate	2	79	139	1	57
Total	9	109	550	2	20

Note: (U) denotes university department

TABLE 3

Percentage of Results of After Office Hour Emergency Biochemical Investigations Outside the Reference or Normal Ranges

Test	D.M.	C.R.F.	C.C.F.	Ca.	G.I.	G.E.	Liver Disease	C.O.L.D.	Meningitis	Misc.	Total
Potassium	29 (65)	35 (82)	15 (71)	6 (36)	7 (96)	7 (44)	10 (20)	8 (25)	0 (3)	13 (193)	16 (635)
Sodium	23 (56)	25 (65)	13 (64)	9 (32)	9 (89)	14 (44)	11 (18)	29 (21)	0 (3)	15 (174)	16 (566)
Chloride	16 (55)	17 (65)	13 (64)	9 (32)	5 (87)	7 (44)	6 (18)	19 (21)	0) (3)	7 (174)	10 (563)
Urea	41 (51)	61 (64)	43 (65)	35 (31)	42 (86)	29 (45)	22 (18)	14 (24)	67 (3)	20 (168)	35 (196)
Glucose	69 (422)	47 (30)	49 (51)	38 (13)	41 (22)	25 (4)	25 (12)	47 (17)	60 (5)	26 (102)	57 (388)
Blood Gases	63 (30)	77 (13)	59 (34)	32 (28)	52 (21)	—	—	55 (141)	25 (4)	52 (75)	54 (347)
S. Amylase	—	—	—	—	6 (31)	—	—	—	—	13 (9)	8 (40)
U. Amylase	—	—	—	—	7 (27)	—	—	—	—	10 (10)	11 (37)
S. Salicylate	—	—	—	—	—	—	—	—	—	10 (10)	10 (10)
U. Salicylate	—	—	—	—	—	—	—	—	—	17 (6)	17 (6)
C.S.F.	—	—	38 (8)	0 (2)	—	33 (3)	—	0 (2)	33 (18)	6 (66)	14 (100)

Note: Actual total number of investigations, including those with normal results, are given in parenthesis.

Department of Pathology, TTSH and KKH laboratories.

Leaving aside half hour for a quick dinner meal, there is a total of 15 hours or 900 minutes working time during the period of night duty. When 100 tests need to be carried out only 9 minutes are available for each test. This means that within this short time, the staff has to check the correctness of specimen identification, centrifuge the specimen, separate the serum or plasma from the clot, carry out the test procedure, record the result on the request form as well as on a record book and inform the ward by telephone. In between, he also answers other telephone enquiries. When the number of tests increased to 133 in 1979, the entire procedure described above has to be completed in less than 7 minutes. On Sundays and public holidays, the Biochemistry Section of the Department of Pathology receives some 300 or more emergency test requests. With a total working time of 8 hours or 480 minutes, only about 1½ minutes is available for the completion of each test. When an average of 430 test requests reached the laboratory in 1979, the laboratory emergency service was at the breaking point, as barely 1 minute was available for each test. It must be emphasised that one serious adverse effect of performing unnecessary tests after normal office hours is that it would reduce the efficiency and accuracy of analysis. Analysis for the genuine emergency cases will have to be delayed because laboratory staff have to attend to cases which should have been investigated the following day. At a time when the accuracy and reproducibility of laboratory tests are most essential for critically ill patients, there is ironically less time for checking or repeating on analysis. If the emergency laboratory service is to fulfil its purpose, clinical staff will have to be more restrained in their use of the service so that the laboratory would not end up reporting erroneous and misleading results which could be worse than not doing the tests.

A comparison of the utilisation of emergency service by the various medical disciplines is shown in Table 2. After correcting for the size of the various departments, the cardiothoracic department was found to be the top user of laboratory investigations during night duty hours. This was followed by the medical, surgical and paediatric departments. On Sunday day-duty, cardiothoracic department continued to take the lead in requesting for laboratory tests, followed by the neonatal unit, surgical and medical departments. Compared with the government departments of the corresponding discipline, the University departments were noted to ask for much more tests.

Table 3 shows the percentage of results of the individual emergency biochemical test which lie outside the reference or normal range. The highest percentage of abnormal results was observed for glucose, blood gases and urea measurements. Electrolytes which account for a major part of after-office hour emergency work, gave a low yield of abnormal results, an indication that a number of patients did not really require the investigations so urgently. Although

the percentage of abnormal results for amylase and salicylate estimations were also low, requests for these assays are self-limiting and constitute only a small part of the emergency. The higher proportion of abnormal results observed for urine specimens compared with those for blood specimens suggests that urinary measurement may be the choice for conditions expected to give high amylase or salicylate results.

Because of the increasing reliance on laboratory investigations in patient care, we are conscious of the need to continuously upgrade the quality and efficiency of our laboratory service. Various measures have been taken to improve laboratory efficiency, accuracy and reproducibility of analysis, speed of test measurement, sensitivity and specificity of test procedures, reduction in specimen volume requirement, reduction in reagent requirement and cost of test. At various times over the 10-year period, work-saving devices, automated equipment and better analytical methods were introduced. Work-flow was reorganised and the data-processing bottle-neck relieved by the introduction of a mini-computer. Quality control programmes were implemented as an integral part of routine work to monitor and improve the standard of analytical work performance. However with various constraints, there is a limit to how far we can go on our own. The full potential of our efforts can only be achieved with the support of the health authorities and the understanding and cooperation of clinical staff who are the users of the service.

The following suggestions are therefore recommended for the improvement and better utilisation of our biochemical laboratory service:

(a) With a wide range of new sophisticated equipment now available in the region, serious consideration should be given to the replacement of some of the older instruments which have been stretched to the maximum limit of their capabilities and will soon be unable to meet the requirements of the laboratory. The new generation of equipment, mostly with built-in microprocessor control, are faster and more flexible, and often require far smaller volume of specimen and chemical reagents. These features would enable the laboratory to reduce the cost of analysis and utilise manpower more efficiently.

(b) Serious considerations should be given to a more systematic approach in the collection and despatch of patient specimens so that staff and machines may be used more effectively to give the desired maximum productivity. In most centres, non-emergency routine specimen collections are confined to specific hours of the morning so that better planning and performance of batch analysis can be made. The use of high-speed machines alone will not solve the logistic problems caused by specimens reaching the laboratories at odd times of the day. With some effort, the establishment of a proper system should not be difficult. As manpower problems become more acute, it is only a matter of time when the implementation of such a system becomes mandatory.

(c) Any effort to prevent the rapid escalation of medical cost can only succeed if the use of various costly diagnostic services can be more effectively controlled. Obviously, a more acceptable form of control is the practice of self-control. This means that users of these services need to exercise greater discrimination in making their requests. Before making out a request for laboratory investigation, it would be good discipline for clinical staff to ask themselves the following questions:

Why do I request for this test?

Do I request for the test because it is the fashion to do so?

What am I going to look for in the result?

If I find it, will it affect my diagnosis?

How will it affect my management of the case?

Will this ultimately benefit the patient?

When requesting for an emergency investigation after normal office hours, they should ask themselves whether the patient is in a life-threatening situation and the laboratory test result is critical for immediate diagnosis and management.

As most of the test requests and blood collection are made by junior medical staff, it is important that they are adequately trained in the proper use of laboratory service. In addition to asking the juniors why they have not requested for certain test or tests, it would be most constructive if their heads and seniors also ask the question why they have requested for the tests. This will help the juniors to develop a better sense of discrimination in their choice of tests. If we do not start asking the second question now, we will continue to see junior clinical staff sending as many tests to the laboratory as they can to avoid being caught out. When their seniors ask if they have done this or that test, they would like to say, yes. This is particularly obvious whenever a new batch of house-officers began work in the hospital.

(c) There should be better coordination in research. Prior discussion and planning with the laboratory before embarking on a research project and close collaboration throughout the study are essential as it will eliminate wasteful work and unnecessary repetition of work, prevent encroachment of laboratory funds allocated for patient care, allow the laboratory to plan its work, and permit the conclusions of the project to be utilised more effectively. If an annual list of titles and references of all research papers and reports by staff working in the Ministry of Health can be compiled, perhaps even as a part of the Ministry of Health annual report, it will help to prevent inadvertant repetition of research work.

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