Cost Analysis of the Developmental Phase of an Automated Multiphasic Health Testing Facility

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AUTOMATED multiphasic health testing is the utilization of automated equipment, computers, and allied health personnel to perform a battery of physiological and biochemical tests and measurements which, in combination with a self-administered medical history, lead to an integrated analysis of the data and a synthesized health report to a physician. The primary objective of this procedure is to help alter the natural course of an asymptomatic person's disease in a favorable direction by providing the physician with information that will lead to early detection of disease. Progress toward optimal refinement of this community service in preventive health is contingent on the program's ability to assess and control (*a*) the efficiency of the variety of services and tests, (*b*) the acceptance of such services by the health professions and the consumer, and (*c*) the ultimate effect of this complementary health delivery system on the well-being of the person served.

The objective of this study is to assess, through cost analysis, the efficiency of the battery of tests performed at the Tulane Health Maintenance Project—THMP(*1*). In its developmental phase, THMP's immediate goal was the establishment of an ongoing unit which would facilitate the application of multiphasic examinations professionally and efficiently to large numbers of asymptomatic adult persons of the metropolitan New Orleans area.

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Background

Previous studies (*2–9*) of the costs incurred in multiphasic health testing are difficult to compare because of (*a*) the varying numbers of participants, (*b*) the varying number of tests performed, (*c*) the different years of the testing, (*d*) different accounting techniques and marked differences in the extent of reporting costs, and (*e*) the different technological advantages of the various tests. Although yearly variation can be adjusted by using the Consumer Price Index for Medical Care, comparisons of the majority of the costs reported in the existing literature are of limited value.

The Kaiser-Permanente Medical Group has reported a comprehensive cost analysis for a full-year period on its two automated multiphasic screening clinics in San Francisco and Oakland, Calif. (*10*). The cost per multiphasic screening for each patient amounted to $21.32 based on a 40-hour work week and an average flow of 500 participants per week. On the basis of a similar average flow of participants, the California Cannery Workers Health Check-up Project planned for a cost of $29.96 per testing profile (*11*).

To understand the basic ingredients of cost accounting in multiphasic health screening, it is necessary to review Permanente's costing methodology, which will also be employed in this study. Permanente's direct costs include

salaries and wages (plus fringe benefits), supplies and equipment, and equipment depreciation (straight line, 1.5 percent per month, or an effective rate of 19.6 percent per year). Time and motion studies are used to allocate labor costs in some clinic stations. Direct costs also reflect other contracts with outsiders for maintenance, repair and maintenance supplies, and other outside repairs.

Indirect costs are allocated to each phase or test at a rate of 22.5 percent of salaries and wages. These indirect costs include accounting, payroll, personnel, purchasing, general maintenance (janitorial services, maintenance supplies, telephone and utilities), and "equivalent costs of ownership" such as building depreciation, financial charges, and interest expense. After the direct and indirect testing costs per

Table 1. Clinic costs for Tulane Health Maintenance Project, July 1, 1968–June 30, 1969

Clinic station and test	Per station		Costs per test			Costs per station			
	Personnel	Salaries and wages [1]	Depreciation of furniture and equipment [2]	Maintenance of equipment	Supplies	Direct	Indirect [3]	Total	Per participant [4]
General clinic station:									
Preparation, reception, medical history, and followup.					$10, 642				
and	1½ receptionists, 1 social worker, 1 followup worker, 3 R.N.'s (60 percent), and 1 assistant M.D.	$55, 322	$155	0	-------	$66, 665	$91, 519	$158, 184	$27. 75
Tetanus immunization.					546				
Special clinic stations:									
Electrocardiography			1, 707	$150	2, 040				
and	2 technicians and 1 M.D. reader.	22, 850				26, 760	37, 801	64, 561	11. 33
Blood pressure			13	0	0				
Tonometry			43	50	35				
and	1 R.N. (60 percent)	3, 600				3, 748	5, 955	9, 703	1. 70
Visual acuity			20	0	0				
Spirometry			199	120	620				
and	1 technician	4, 300				5, 260	7, 113	12, 373	2. 17
Anthropometry			21	0	0				
Papanicoloau smear	1 R.N. and 1 pathologist	17, 475	42	50	1, 003	18, 570	28, 909	47, 479	[5] 14. 88
Audiometry	1 technician and 1 M.D.	11, 100	792	250	90	12, 232	18, 363	30, 595	5. 37
Clinical laboratory	4 technicians	27, 800	4, 144	1, 007	35, 000	67, 951	45, 990	113, 941	19. 99
Chest X-ray	1 technician and 1 M.D.	17, 700	1, 250	50	6, 020	25, 020	29, 293	54, 313	9. 53
Total		$160, 147	$8, 386	$1, 677	$55, 996	$226, 206	$264, 943	$491, 149	------
Male									$77. 84
Female									92. 72

[1] Including fringe benefits.
[2] 10-year, straight line.
[3] 165.4 percent of salaries and wages.
[4] Based on 5,700 male and female participants.
[5] Based on 3,190 female participants.

participant are accumulated for each test, additional costs for overhead, computer room, and central staff (administrative, instrumentation, systems, statistical, and epidemiologic personnel) are added to yield a total multiphasic examination cost per participant. The cost of the physician's followup examination and of some screening activities (cervical smear and sigmoidoscopy) are not included in the analysis.

Cost Analysis of Tulane Project

The cost analysis of the Tulane Health Maintenance Project covered the fiscal year, July 1, 1968, to June 30, 1969; approximately 5,700 participants above age 20 were tested during this period. The tests were essentially the same as those performed at the Permanente clinic. In matching tests with costs, the first step involved dividing costs into direct and indirect categories. All central staff positions, data processing, building, office equipment, and supply costs were placed in the indirect category. For the sake of simplicity, all depreciation expenses were calculated on a 10-year, straight line basis, which allows for easy tabulation of the original asset costs; however, more rapid depreciation writeoff methods are allowable. Nonclinic supplies, equipment depreciation, and research expenses were included as indirect costs.

Item	*Indirect costs*
Central staff:	
General administration	$27,000
Research	12,000
Consultants	5,000
Travel	4,700
Data processing:	
Equipment rental	63,880
Depreciation of equipment (10-year, straight line)	38
Computing center fee	42,000
Programers and systems specialists	24,500
Supplies	1,607
Additional data processors	8,400
General overhead:	
Building rental	21,240
Building maintenance	6,488
Office supplies	400
Maintenance of office equipment	230
Depreciation of equipment and furniture (10-year, straight line)	575
Telephone	2,980
Books	70
Office postage	378
Laundry	800
Photocopying	2,100
University's overhead	40,557
Total	$264,943

To establish direct clinic costs it was necessary to match THMP personnel with the testing or clinic stations (see the first three columns of table 1). Some personnel performed more than one test, and two tests may also have been performed in the same facility area; rather than performing a time and motion study to separate labor costs, the tests were grouped together by clinic stations. The cost of equipment maintenance was estimated for several tests, but the total of $1,677 accurately reflects the amount spent on maintenance of clinic equipment for the period. Several tests required no maintenance or consumed no supplies.

Total indirect costs were allocated on the basis of 165.4 percent of salaries and wages. The total cost for each clinic station was divided by the number of participants (5,700) tested for the 1-year period. The cost per participant was $77.84 for men and $92.72 for women. These costs reflect such expenses as installation and debugging of new equipment (applied research) which require exceptional allocation of resources during the developmental phase of a complex medical project.

Table 2 shows the cost per detected abnormality at the various clinic stations. Abnormality criteria were established for each test on the basis of the project's predetermined "normal" ranges and a concurrent study of the participant's medical history as related to his health status. The total cost per clinic station as calculated in table 1 was divided by the total number of test abnormalities detected at corresponding clinic stations during the period. The cost per detected abnormality differed widely among clinic stations. The variation was particularly wide between stations in which the number of abnormalities detected was high and those in which the number was low.

Discussion

Lack of uniformity in cost accounting and in the extent of reporting costs in preventive medicine or any health area can result in misleading conclusions. It is difficult to adjust depreciation rates on the basis of the existing knowledge of the obsolescence and deterioration of highly

automated equipment. Rapid writeoffs of depreciation will produce high costs for the initial clinic years. Allocation of indirect costs on the basis of salaries and wages alone may inflate costs at some clinic stations since indirect costs are probably more closely related to the quantity of information originating from a station and to the amount and complexity of the station's testing equipment. Most costs appear to be fixed except those for the physician's interpretation of output. As the volume of participants increases, clinic stations with a large amount of variable costs will increasingly be burdened with large shares of indirect costs. Adequate control of testing efficiency may therefore be partially dependent on accurately

Table 2. Number of abnormalities detected and costs, by clinic station, Tulane Health Maintenance Project, July 1, 1968–June 30, 1969

Clinic station and test	Criteria for abnormality	Number of abnormalities detected	Total cost per station	Cost per detected abnormality
Heart		**1,540**	**$64,561**	**$41.92**
Electrocardiography	Definite evidence of moycardial disease	367		
Blood pressure	1 or more of following: Systolic ≥160 mm. Hg. / Diastolic ≥95 mm. Hg. / Pulse ≥130 per min.	1,173		
Vision		**639**	**9,703**	**15.18**
Tonometry	Right or left eye or both eyes ≥26 mm. Hg.	51		
Visual acuity	Right or left eye or both eyes, distant or near vision, >20/50.	588		
Breathing: spirometry	1 sec. <50 percent or peak flow <100 percent, or both criteria.	**211**	**12,373**	**58.63**
Cervical cytology: Papanicloaou smear.	Class III, IV, or V	**4**	**47,479**	**11,869.75**
Hearing: audiometry	Evidence of complete hearing loss or hearing loss from noise exposure.	**334**	**30,595**	**91.60**
Radiology: chest X-ray	1 or more of following: Emphysema / Enlargement of left ventricle. / Enlargement of both ventricles. / Cardiac enlargement.	**197**	**54,313**	**275.70**
Laboratory		**4,113**	**113,941**	**27.70**
Hematology	1 or more of following: Hematocrit <30 or >55 percent / Hemoglobin <10 or >17.5 gm. / White cells <4,000 or >12,000.	79		
Thyroid activity	T-3 <10 or >40 percent	11		
Serology	RPR (syphilis) positive	42		
Urinalysis	1 or more of following: Protein 3+ or 4+ / Ketone moderate or large. / Bacteria ≥100 (K).	170		
Serum chemistry	1 or more of following: Cholesterol ≥350 mg. / Calcium <8 or >11 mg. / Inorganic phosphates <2 or >5 mg. / Total bilirubin >1.5 mg. / Uric acid ≥10 mg. / Blood urea nitrogen >35 mg. / Glucose, random or fasting, ≥300 mg. / Total protein <5 or >9 gm. / Albumin <3 or >6 gm. / Alkaline phosphatase >20 KAU. / Serum glutamic oxalacetic transaminase >50 KU.	3,811		

measuring and assessing this cost performance against testing objectives.

The yield for a multiphasic health testing facility is measured by the number of previously unknown abnormalities that are detected in the testing population. This yield and the cost per detected abnormality at the various clinic stations are directly related to (*a*) the prevalence of the condition in the population and (*b*) the testing level as specified by the criteria for abnormality (*12*). THMP's testing frame draws heavily upon the white, middle-class population of New Orleans, and therefore a relatively low yield and a high cost per detected abnormality for various clinic stations, for example, for cervical cytology, can be expected. If yield were computed by age categories, the older age groups could be expected to have a lower cost per detected abnormality.

Three additional costing concepts are relevant to the cost analysis of a multiphasic health testing facility. THMP's calculated costs did not reflect any cost of capital which, in the case of private medical facilities, is the cost of debt and equity (Permanente's "equivalent costs of ownership"). For government-financed projects, the cost of capital is a combination of (*a*) the interest on the national debt or the government bond rate and (*b*) the cost of taxes (equity). A determination of the cost of taxes, a cost which involves the expense of moving this capital out of the private sector of the economy, requires, in turn, calculating the cost of the facilities and manpower needed to collect the taxes. Secondly, THMP's calculated costs did not reflect certain opportunity or differential costs which measure the sacrifices of alternatives surrounding a decision. Future cost analyses should reflect the varying availabilities of idle capacity, such as the 128 hours per week that THMP's computer, serum analyzer, and X-ray equipment were not in use. A third area of analysis in cost efficiency entails a determination of the cost of similar medical services in the community.

Considerable interest has been generated in measuring the long-term effects of automated multiphasic health testing through the use of economic (*13*) and noneconomic (*14*) models. Two ingredients of these and similar models are the cost per battery of tests and the cost per abnormality detected. When followup information is integrated with these data, it becomes feasible to calculate the cost per diagnostically confirmed case of disease. Further analysis will provide the matching of the total economic cost of illness (*15*) (including estimated direct expenditures, indirect costs of morbidity, and the present value of discounted lifetime earnings) with the benefits derived from early detection testing.

Summary

A cost analysis was performed on a variety of medical services and tests which were conducted at the Tulane Health Maintenance Project during its developmental phase. This project is an automated multiphasic health testing facility in New Orleans, La. The analysis was designed to assess the efficiency of the system during the first year's operation of the project. On the basis of 5,700 participants, the cost per participant was $77.84 for men and $92.72 for women. The cost per detected abnormality ranged among clinic stations from $15 (vision) to $11,870 (cervical cytology). The variation was apparently due in part to the widely different yields for various tests. The cost-efficiency performance depended upon the number of participants, depreciation accounting techniques, testing equipment, labor intensity, testing levels, and the population at risk.

Future cost analyses of governmental health testing projects should include calculations of (*a*) the cost of capital, (*b*) opportunity costs, and (*c*) the costs of similar medical services in the community. Economic model building and cost-benefit analyses will require at least a partially closed system for retrieving followup data.

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Tearsheet Requests

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New Antituberculosis Drug Effective Against Other Pulmonary Disease

Rifampin, one of the most promising new drugs in the treatment of drug-resistant tuberculosis in people, may also be helpful in the treatment of certain stubborn and often serious tuberculosis-like pulmonary infections. This evidence was uncovered by a group of investigators at Case Western Reserve University, Cleveland.

Dr. E. Wolinsky, the principal researcher, reported that in laboratory and animal studies, colonies of at least one variety of atypical mycobacteria were reduced substantially by rifampin alone or in combination with isoniazid, another effective antituberculosis drug.

Resembling the tuberculosis germ, atypical mycobacteria can inflict fatal cavitary lung disease. Since patients infected with these organisms do not respond well to the standard tuberculosis drugs, they may present a grave clinical problem.

Experiments currently reported showed the drug to be effective in vitro and in vivo against some of the most threatening mycobacteria, including most of the strains of *Mycobacterium kansasii* that are implicated in human infection. Futher studies are needed to evaluate the full potential of the drug at different dosages.