CASE STUDY (CS 5)

USING REGRESSION ANALYSIS TO ESTIMATE COSTS: A CASE STUDY

DIVISION OF FINANCIAL AND GENERAL MANAGEMENT STUDIES
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CHAPTER 1

INTRODUCTION

This report describes an instance in which a task force of regional and headquarters GAO staff members extensively used regression analysis to estimate the life-cycle costs of alternative methods of carrying out activities essential to the operation of a hospital. The analysis was a part of the work performed in a wide-ranging review of health care facilities costs.

PURPOSE OF CASE STUDY

This is the second case study on regression analysis in this series.[1] This report, as well as the previous study, shows how the technique has been used in carrying out an audit assignment and can serve as a reference in future use of the technique.

WHAT IS REGRESSION ANALYSIS?

Regression analysis is a statistical technique used to measure the extent to which a change in one quantity (variable) is accompanied by a change in some other quantity (variable). For example, increases in years of education received tend to be accompanied by increases in annual income earned.

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[1] "Regression Analysis As An Audit Tool: A Case Study," June 1972.

CHAPTER 2

THE AUDIT SITUATION

The staff assigned to the health facilities study needed a way to estimate the life-cycle (initial investment plus lifetime operation and maintenance) cost implications of innovative methods that have been developed and proposed for use in hospital operations so as to compare the costs of these alternative methods with those of more conventional methods.

LEGISLATIVE MANDATE FOR THE REVIEW

The Comprehensive Health Manpower Training Act of 1971 required the Comptroller General to study health facilities construction costs. The study was to include the feasibility of reducing the cost of constructing health facilities, such as hospitals. In addition, the Senate Committee on Labor and Public Welfare, which had initiated the requirement for the study, expressed interest in the operating cost of hospitals.

Recently innovations have been developed in several major hospital activities, including the dietary, pharmacy, clinical laboratory, and laundry departments and the material handling and waste disposal activities. In accordance with the mandate, the GAO staff wished to examine the costs of the innovations in these operations to ascertain the extent to which the innovations could reduce health care costs.

NEED FOR LIFE-CYCLE ESTIMATES

In examining the cost impact of these innovations, we wished to not limit the review to initial construction costs but to examine their impact on operation and maintenance costs as well. Thus the task force was interested in determining the impact of these innovations on the life-cycle costs of health care facilities.

In many cases the alternative approaches to a given hospital activity differ greatly in their initial investment cost, and the more costly often provide savings in operation and maintenance costs. Savings in operation and

maintenance costs frequently are the result of automation or of material handling methods which increase productivity of labor, that is, increase volume capability per employee. In such a situation the answer to the question of which alternative is least costly depends on the volume demanded of the activity in question.

In a large hospital, an innovation having an initial investment greater than that of the conventional method might prove less costly, on a life-cycle basis, because the volume demanded of the activity is sufficiently large that the saving in operation and maintenance costs exceeds the higher investment costs of the innovation. But this might not hold true for a small hospital. For this reason, the task force wished to estimate the life-cycle costs of each of the alternative methods over a range of hospital sizes.

CHAPTER 3

GAO ANALYSIS

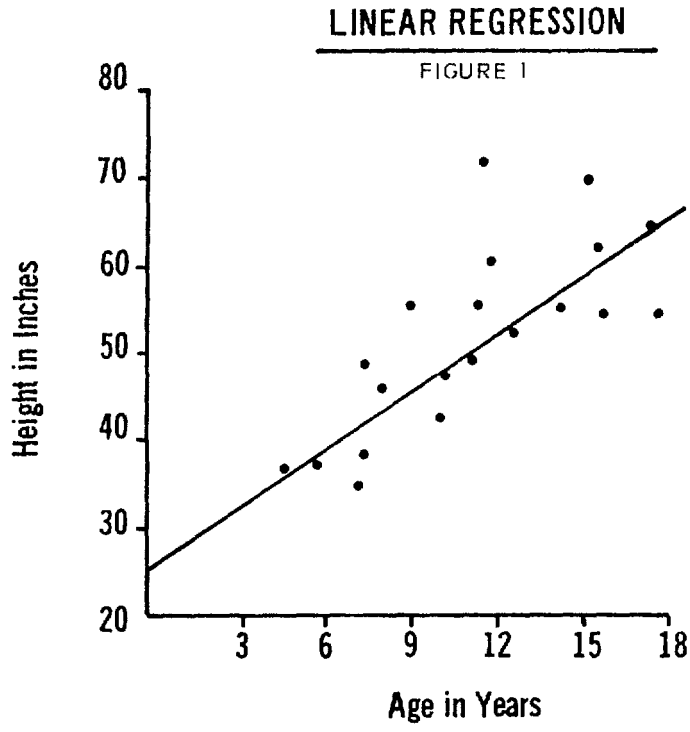
The task force used regression analysis to estimate the life-cycle costs of each of several alternative methods of performing several hospital activities.

As defined in the GAO glossary for systems analysis, dated October 1969, regression analysis is:

> "Analysis undertaken to determine the extent to which a change in the value of one variable, the independent variable, tends to be accompanied by a change in the value of another variable, the dependent variable. Where only one independent variable is involved in the analysis the technique is known as simple regression analysis; where two or more independent variables are involved the technique is called multiple regression analysis.* * *"

If there is evidence that change in one variable causes change in the second variable, the relationship disclosed by the regression technique can be used to estimate the magnitude of the second variable from information concerning the magnitude of the first variable.

If the relationship between the independent and dependent variables disclosed by the analysis is one that can be represented by a straight line, the relationship is referred to as linear. Figure 1 on page 5 illustrates a simple linear regression. The plotted data points in the illustration represent the heights of girls of various ages. The straight line represents the relationship between height (the dependent variable) and age (the independent variable) as disclosed by regression analysis. If the change in the dependent variable associated with a change in the independent variable does not occur at a constant rate, the relationship can be represented by a curved line and is referred to as curvilinear.



ANALYTICAL PROCEDURE

For each alternative method considered, the task force used regression analysis to examine the relationship between the volume of the hospital activity involved (independent variable) and the life-cycle (initial investment plus lifetime operation and maintenance) costs (dependent variable). The hope was that the statistical relationship disclosed by regression analysis would permit estimation of the life-cycle costs of each alternative over a range of possible volumes of the activity in question and thus over a range of possible hospital sizes. Such estimates would permit a comparison of alternative methods in terms of their discounted life-cycle costs for specific hospital sizes.

The task force selected the following hospital departments and activities and their alternative methods of operation for the analyses described above.

Department or activity	Methods compared
Dietary	Conventional Convenience foods
Pharmacy	Conventional medication distribution Unit dose distribution
Material handling	Manual Semiautomated Automated
Waste disposal	Unprocessed Shredding Compacting Pulping
Laundry	In-house Contracted Rental of linens Centralized for several hospitals

The first step was to gather data on initial investment costs, annual operation and maintenance costs, and volume of the hospital activity being analyzed. To accomplish this the regional office task force staffs visited 67 hospitals and obtained written responses from 39 manufacturers of health care systems and equipment and 6 trade associations. The data was then furnished to the Washington headquarters where a time-sharing computer system was used for the regression analyses.

For each of the 16 alternative methods, separate regression analyses were performed to derive the relationship between each of several categories of cost--personnel, equipment, etc.--and volume of the hospital activity being analyzed. Next, using these relationships, the staff estimated the discounted life-cycle costs, by category, for various volume levels. These individual estimates were then combined to produce a total estimate of the discounted life-cycle cost of the method for each of several volume levels.

EXAMPLE: ANALYSIS OF PHARMACY DEPARTMENT

The application of regression analysis by the task force can be illustrated by examining how it was applied to the pharmacy department.

The hospital pharmacy is part of a total medication distribution system which includes ordering and receiving medications at the hospital, filling physician medication orders, administering medications to patients, and recording results of medication therapy. In a conventional system, the pharmacy's responsibility relates primarily to procuring medications from outside the hospital and distributing them to patient floors. An alternative to the conventional system is the unit dose system. The distinguishing feature of the unit dose system is that pharmacy personnel are responsible for keeping records associated with dispensing and controlling medications; interpreting physicians' orders; maintaining patients' medication records; providing unit dose packages of medications at the time medications are to be administered; and, in certain instances, administering medications to patients. A unit dose package contains the exact dose, such as one tablet or one capsule, ordered by the patient's physician to be administered at a specific time.

For each of the alternative approaches, a separate regression analysis was performed for each of five cost categories. In each analysis, the number of prescriptions filled annually was the independent variable and the lifetime (20-year) costs for that category was the dependent variable. The costs categories used in these analyses were:

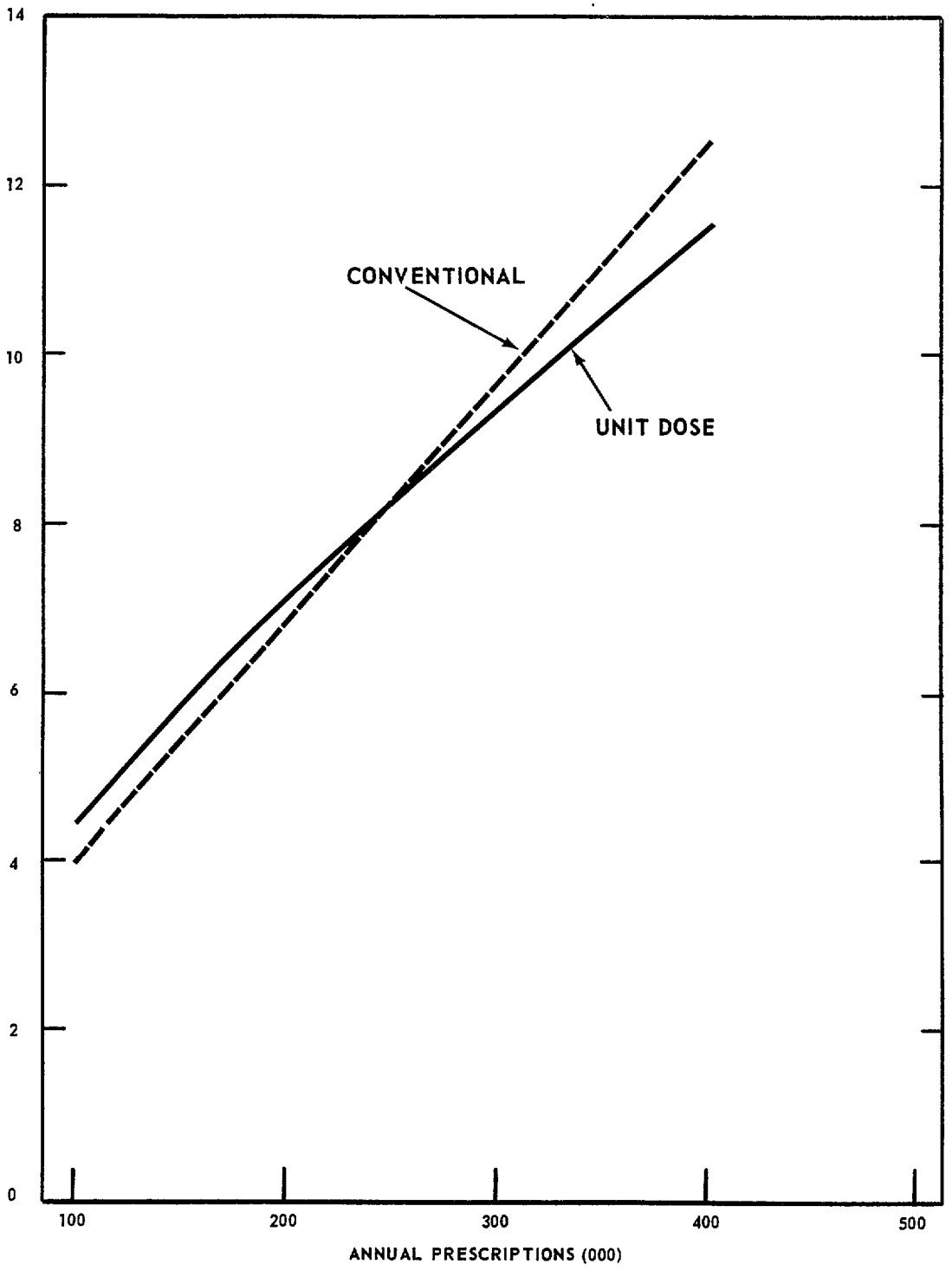
--Annual personnel costs.
--Annual medication costs.
--Annual supply costs.
--Equipment costs (including maintenance).
--Space costs (including maintenance).

It was assumed that operating costs would remain at their current level over the 20 years; that is, anticipated price changes would not affect the relationship between cost and the volume of prescriptions nor would productivity improve. The annual maintenance costs for equipment and space were estimated as fixed percentages of equipment cost and space cost, respectively.

The unit dose distribution system resulted in lower life-cycle costs than conventional distribution systems, for annual prescriptions above approximately 250,000. (See Figure 2.) The life-cycle savings are largely attributed to a reduction in nursing time for administering unit dose medications.

PHARMACY
TOTAL LIFE-CYCLE COSTS

FIGURE 2



CHAPTER 4

USE OF THE ANALYSIS

The regression analysis was used to derive a set of life-cycle cost estimates for each of the five hospital departments and activities analyzed. These estimates were presented in graphic form in the report issued at the completion of the task force's work: "Study of Health Facilities Construction Costs" (B-164031(3), Nov. 20, 1972.) The report concluded that our study had demonstrated "that potential exists to achieve significant life-cycle savings in construction of health facilities."

Because the GAO-derived cost estimating curves were based on data obtained at hospitals across the Nation, they were not considered precise representations of cost relationships in any specific geographic area. Nevertheless, we believed that they generally reflected the comparative costs of the alternative methods reviewed and the relationship between the magnitude of these costs and hospital size. Therefore we recommended that, pending the establishment of a central reporting of life-cycle operating data, the Department of Health, Education, and Welfare encourage health facility planners to consider the information in the report.