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ABSTRACT

An assessment of the efficiency of Federally funded community health centers (CHCs) in delivering ambulatory medical care to poverty populations reveals that the centers' input decisions reflect departures from cost-minimizing behavior. In particular, they employ too few physician aids (nurses and physician assistants) relative to primary care physicians and too many medical support and ancillary personnel relative to primary care physicians. The CHC system-wide cost reduction due to the elimination of allocative inefficiency is estimated at $32 million in 1978 dollars or 6 percent of total cost. This modest cost reduction and evidence that allocative inefficiency is not more widespread among CHCs than among private sector physicians seriously question the conventional wisdom that services in the public sector are produced less efficiently than in the private sector. Support is also reported for the hypothesis that, since grants are not tied to particular services rendered, centers who derive most of their revenue from this source relative to Medicaid and private insurance have a greater incentive to provide a given mix of services in the least-cost method.

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THE PRODUCTION AND COST OF AMBULATORY MEDICAL CARE IN COMMUNITY HEALTH CENTERS

Fred Goldman and Michael Grossman*

I. Introduction

Since 1965 a network of Federally funded community health centers (CHCs) has developed in the United States to deliver comprehensive ambulatory care, both primary and preventive, to poverty populations in medically underserved areas. The program to create and fund these centers, originally termed neighborhood health centers, was started by the Office of Economic Opportunity as part of the War on Poverty. By 1973 overall control of the centers had been shifted to the Bureau of Community Health Services (BCHS), Health Services Administration, U.S. Department of Health and Human Services, and the centers began to be referred to as community health centers. Funding authority for the centers rests in Section 330 of the Public Health Services Act. New and smaller variants of the basic CHC model were created in 1975 and 1978 by the introduction of the Rural Health Initiative and the Urban Health Initiative, respectively. Concomitant with these legislative developments, the number of CHCs increased from 51 in 1968 to 104 in 1974 and to approximately 800 in 1980.[1]

In some respects CHCs resemble prepaid group practice organizations, commonly termed health maintenance organizations (HMOs). CHCs deliver ambulatory care in a group practice setting with salaried physicians. Yet there are obvious differences between the centers and HMOs. The clientele of the centers primarily are poor. In addition, some services delivered by centers are billed to patients and third-parties, most notably Medicaid, on a fee-for-service basis.

CHCs are part of a larger Federal system for the direct delivery of ambulatory care to low-income groups throughout the U.S. The principal additional projects in this system are maternal and infant care projects, children and youth projects, and family planning clinics.[2] This system differs from Medicaid which is solely a mechanism for financing the ambulatory care services of poor people. Unlike the other members of the system, CHCs are not limited in terms of the types of services provided or the age classes of low-income people who receive services.

The purpose of this paper is to assess the efficiency of CHCs in delivering ambulatory medical care to poverty populations. In particular, we evaluate the extent to which centers select input mixes that minimize the cost of a given output. We focus on the employment of physician aids (nurses, physician assistants, and related personnel) because studies of the production of ambulatory care in the private sector suggest that aids are underutilized relative to physicians,[3] while the General Accounting Office (14) has criticized the centers for employing too many aids relative to physicians.

We estimate a transcendental production function, compute the marginal product of aids relative to physicians for each center, and compare it to the location-specific relative price of an aid. The ratio of the former to the latter equals one if a given center selects the cost-minimizing input mix. Hence, the average value of the ratio indicates whether the CHC system overutilizes or underutilizes aids.

We also examine the determinants and effects of departures from cost minimization by computing an index of inefficiency for each center. Since grants are not tied to particular services rendered, centers who derive most of their revenue from this source relative to Medicaid and private insurance should have a greater incentive to provide a given mix of services in the least-cost method. This hypothesis and others are tested via a multiple regression analysis of the index of departure from cost minimization. Moreover, the index is included as an independent variable in multiple regression estimates of average cost functions of ambulatory care. This procedure enables us to calculate the magnitude of the cost savings associated with movements toward a more appropriate input mix. In addition, it provides impacts of other variables on average cost net of their impacts on departures from cost minimization. Estimates of average cost functions are valuable in their own right because they convey useful information about the extent of economies of scale, the potential for exploiting these economies, and the characteristics of high cost centers.

The importance of our research is highlighted by the current policy debate with regard to the effectiveness, efficiency, and ultimate fate of the CHC system. The growth of this system has been curtailed sharply in real terms by the Reagan Administration's budget cutbacks. Although the centers were exempted from the block grant program in the fiscal 1982 budget, starting in 1983 individual states have the option to take over the CHC program or leave it in Federal hands. If a state chooses to take control, it must match a portion of the Federal support. In the proposed fiscal 1983 budget, CHCs are combined with family planning clinics, migrant health centers, and black lung clinics into a single block grant. Moreover, the state matching payment provision just mentioned is eliminated. If the CHCs are relatively inefficient producers of ambulatory care, the policies of the Reagan Administration have some merit. On the other hand, if the centers are relatively efficient, the wisdom of these policies can be questioned.

We have already mentioned that the General Accounting Office (14) has charged that CHCs use too many aids relative to physicians. Yet the GAO presents a very limited amount of data in support of its charges. In addition, it ignores the fact that one of the goals of the older centers in particular is to provide employment and job training to the members of the communities that they service. Moreover, it fails to mention that CHCs have been much more receptive than other delivery systems, especially private physicians, to the employment of new types of allied health manpower such as physician assistants and nurse practitioners. Finally, the GAO proposes no rigorous standards for efficiency.

Proponents of the CHC system cite evidence by Reynolds (3), Davis and Schoen (5), and Link et al. (15) that utilization rates of ambulatory medical care by poverty populations who use CHCs are higher than utilization rates of similar populations who must rely on other sources of care. Davis and Schoen (5) suggest that the CHC per capita ambulatory cost is comparable to that in the U.S. as a whole once the national data are adjusted to reflect the exclusion of X-ray, laboratory, and pharmacy costs from routine private physicians' office visits. They present, however, very limited evidence in support of this position. Duggar et al. (16) find that Medicaid-eligible CHC users had lower per capita ambulatory cost than Medicaid-eligible non-users in each of three study sites. A problem with their study is that non-users typically obtained ambulatory care from hospital emergency rooms and outpatient departments. Therefore, the cost structures and staffing patterns of these sources reflect the joint production of outpatient and inpatient care by hospitals.

Since it is difficult, if not impossible, to compare CHC ambulatory care costs with ambulatory care costs of other institutions that serve poverty populations, we focus on the "internal" efficiency of the CHC system. Specifically, we examine the extent to which input decisions by centers reflect departures from cost minimization and the impact of these departures on the total cost of care. We compare our results with those of similar studies of the behavior of private physicians.

According to conventional wisdom, services in the public or non-profit sector are produced less efficiently than in the private sector because of the absence of a profit motive in the former sector. For example, the large literature on public utilities suggests that utilities are too capital intensive because the cost of capital is set at an artificially low level by regulators. In a similar manner, the public provision and/or financing of medical care often is characterized by cost-plus or fee-for-service reimbursement of providers. Both reimbursement schemes promote inefficiency if high cost producers are not penalized or penalized less than they would be in the private sector. Further, until fairly recently Medicaid reimbursement rules in many states failed to cover services provided by paramedical personnel and thus encouraged overutilization of physicians relative to such personnel. Currently, reimbursement rules in at least some states still are biased in favor of physicians.

Conventional wisdom notwithstanding, whether the production of ambulatory care in the public sector is less efficient than in the private sector is an empirical issue. In particular, although incentives in favor of inefficient production exist, it is not known how the agents in the public sector (the CHCs in our case) react to these incentives. Moreover, even if the incentives do cause departures from cost-minimizing behavior, the quantitative importance of these departures in terms of an increase in total cost is not known. Thus, in undertaking this study, we seek answers to three basic questions. What is the extent of departures from cost-minimizing behavior by community health centers in the production of ambulatory care? What are the determinants of such departures? What are their effects on total cost?

In addressing these issues, we recognize explicitly that incentives for inefficiency need not cause significant departures from efficient production. An analogy from the private sector is instructive here. Reinhardt (8) finds that private physicians, whose incentive structure clearly includes the profit motive, use less than the optimal number of aids. We also recognize that CHCs confront incentives for efficient production as well as inefficient production. Federal, state, and local government grants are the major source of funds to cover the expenses incurred by CHCs. These grants finance approximately 70 percent of the centers' costs, although this percentage varies considerably among centers (see Section III). The grants bear some resemblance to the capitation payments made by members of health maintenance organizations. Since the grants are not tied to particular services rendered, the centers, like HMOs, largely operate on fixed annual budgets. Hence, both types of organizations have incentives to provide a given mix of services in the least-cost method. Finally, we choose to address the three questions cited above because we do not appreciate policy which is not based on rigorous standards for the evaluation of efficiency.[4]

In general the analysis of the determinants and effects of departures from cost minimization in this paper represents a new innovation in the empirical literature on cost and production. Thus, we make a methodological as well as a policy contribution in the paper. Our contribution is particularly relevant because the issue of inefficiency in the not-for-profit public sector will continue regardless of whether CHCs are placed in a block grant and regardless of whether states gain more control of the centers, other health programs, and non-health programs. We develop a framework to evaluate and perhaps improve efficiency in one part of the public sector, but our framework can be applied to many other parts of this sector.

II. Analytical Framework

In the traditional economic theory of production, the firm is the fundamental behavioral unit. A firm's production function relates its output to various inputs and to a measure of the level of technology. A firm's cost function relates the total or average cost of output to output, input prices, and the level of technology. If the firm minimizes the cost of a given output, the cost function is the "dual" of the production function. By this is meant that all the properties of the cost function are known once the properties of the production function are known [for example, Shephard (18)]. Put differently, given sufficient information about the production function, the estimation of the cost function conveys no additional information.

We use the above concepts from the economic theory of production to organize our econometric work on production and cost functions of ambulatory medical care in community health centers. Since the assumption that centers are completely successful cost minimizers is questionable, we estimate both these functions. Indeed, important components of our research are to test the hypothesis that centers select the cost-minimizing combination of inputs, to develop an index of inefficiency or departure from cost minimization, and to examine the determinants of variations in this index among centers and the effects of inefficiency on average cost. Moreover, the estimation of average cost functions allows us to incorporate the impacts of indivisibilities, randomness of demand, and complexities of large scale operations (see below) which are not fully reflected in the production function.

Our basic methodology may be outlined as follows. Let the production function of output (x_t) for the t^{th} community health center be

$$x_t = f(y_{it}, y_{2t}, \ldots, y_{mt}) \quad , \tag{1}$$

let w_{it} be the price of input y_{it}, and denote the marginal product of y_{it} ($\partial x_{it}/\partial y_{it}$) by f_{it}. Then, provided factor supply curves faced by each center are infinitely elastic (centers take input prices as given), the cost-minimizing input mix satisfies

$$\frac{w_{it}}{f_{it}} = \frac{w_{2t}}{f_{2t}} = \ldots = \frac{w_{mt}}{f_{mt}} \quad . \tag{2}$$

Alternatively, for any two inputs (y_{it} and y_{jt})

$$\frac{w_{it}}{w_{jt}} = \frac{f_{it}}{f_{jt}} \quad , \tag{3}$$

or the absolute value of the slope of an isocost line must equal the absolute value of the slope of an isoquant between y_{it} and y_{jt} (the marginal rate of substitution in production between the two inputs).[5]

Define r_{ijt} as the ratio of the marginal rate of substitution between y_{it} and y_{jt} (f_{it}/f_{jt}) to the relative price of input y_{it} (w_{it}/w_{jt}):

$$r_{ijt} = (f_{it}/f_{jt})\ (w_{it}/w_{jt})^{-1} \quad . \tag{4}$$

This ratio equals one if a given center selects the cost-minimizing combination of the inputs in question. A value of r_{ijt} greater than one indicates that the center uses too much of input y_j in the sense that the same output could be produced at a lower total cost by raising y_i and lowering y_j. Similarly, a value of r_{ijt} smaller than one indicates that the center uses too little of input y_j. Therefore, it is natural to define the absolute value of r_{ijt} minus one as an index of inefficiency in the selection of the two inputs:[6]

$$e_{ijt} = |\ r_{ijt} - 1\ | \quad . \tag{5}$$

Based on the above, we estimate a production function for ambulatory care delivered by CHCs, compute the marginal product of aids relative to physicians for each center, and obtain r_{ijt} using the location-specific relative price of an aid. When averaged over all centers the ratio $\bar{r}_{ij}$ $(\bar{r}_{ij} = \sum_{t=1}^{n} r_{ijt}/n)$ indicates whether the CHC system overutilizes or underutilizes aids. At the same time, we compute the inefficiency index (e_{ijt}) for each center and employ it both as the dependent variable in an investigation of the determinants of inefficiency and as an independent variable in multiple regression estimates of average cost functions.

A detailed description of the variables in the production and cost functions is contained in Section III. In the remainder of this section, some general comments are made about the methodology, including the interpretation of average cost functions, econometric considerations, and specific functional forms. Clearly, one does not have to assume cost minimization in order to fit production functions. The use of ordinary least squares, however, to estimate these functions has been criticized because outputs and inputs are jointly determined [Marschak and Andrews (19); Nerlove (20); Mundlak (21)]. If this is the case, then production functions should be fitted by simultaneous equations methods such as two-stage least squares. If ordinary least squares is employed, the resulting estimates may be subject to simultaneous equations bias. A number of persons have shown, however, that this bias is likely to be small in a wide variety of cases [Hoch (22); Konijn (23); Griliches (24); Reinhardt (8)]. For this reason and because almost all production function studies in the medical economics literature employ ordinary least squares, we do not estimate production functions by simultaneous equations methods.[7]

We estimate transcendental production functions. This function is given by

$$\ln x_t = \alpha_0 + \alpha_1 \ln y_{1t} + \alpha_2 y_{2t} + \alpha_3 y_{2t}^2 + \alpha_4 y_{3t} + \alpha_5 y_{3t}^2 , \qquad (6)$$

where y_{1t} is the physician input, y_{2t} is the physician aid input, and y_{3t} stands for other inputs (medical support and ancillary personnel such as medical secretaries and laboratory personnel).[8] This form, which was popularized in the health economics literature by Reinhardt (8), has the property that output can be positive even if inputs y_{2t} and y_{3t} are zero. This is an important property because many private sector physicians, as well as some CHCs, do not employ aids. Note that the marginal rate of substitution between aids and physicians is

$$\frac{f_{2t}}{f_{1t}} = \frac{\alpha_2 y_{1t} + 2\,\alpha_3 y_{1t}\, y_{2t}}{\alpha_1} . \qquad (7)$$

Equation (7) reveals that the transcendental production function is strongly separable in the sense that the marginal rate of substitution between any two inputs depends only on those two inputs. Moreover, the cost-minimizing input ratios depends on output and the absolute amounts of the inputs. This is in sharp contrast to the Cobb-Douglas and other homothetic production functions, whose cost-minimizing input ratios are independent of output. A priori, α_2 should be positive and α_3 should be negative. Although an isoquant between y_{1t} and y_{2t} could be convex to the origin even if α_3 were positive, the physician input would be an inferior factor of production (a factor whose employment falls as output rises with input prices held constant) if α_3 were positive.[9] Obviously, it is unrealistic for the physician input to be inferior.

In computing the ratio of the marginal rate of substitution between physician aids and physicians to the relative price of an aid for each CHC, we employ a location-specific relative price variable. This is because the centers are located throughout the United States and therefore face different input price ratios (see Section III). Observe that our procedure of computing r_{21t} separately for each center and then averaging the ratio over all centers yields a simple t-test of the hypothesis that $\bar{r}_{21}$ is significantly different from one:

$$\text{t-ratio} = (\bar{r}_{21} - 1) \,/\, (\sigma_r n^{-1/2}) \quad , \tag{8}$$

where σ_r is the sample standard deviation of r_{21}. Observe also that, if a center employs no aids, its marginal rate of substitution is $\alpha_3\ \alpha_1^{-1}\ y_{1t}$. Provided this rate is less than or equal to relative price of an aid (w_{2t}/w_{1t}), such a center is minimizing the cost of a given output, and r_{21t} is set equal to one.

It is worth mentioning that, even if each center faces the same relative input price, $\bar{r}_{21}$ differs from a measure computed at the sample means of y_{2t} and y_{1t} $(\hat{r}_{21})$. This follows because

$$\hat{r}_{21} = \alpha_1^{-1}\ (\alpha_2\bar{y}_1 + 2\alpha_3\bar{y}_1\bar{y}_2)\ (w_2/w_1)^{-1} \quad , \tag{9}$$

while

$$\bar{r}_{21} = \alpha_1^{-1}\ (\alpha_2\bar{y}_1 + 2\alpha_3\bar{y}_1\bar{y}_2 + 2\alpha_3\rho_{12}\sigma_1\sigma_2)\ (w_2/w_1)^{-1} \quad , \tag{10}$$

where ρ_{12} is the sample correlation coefficient between y_{1t} and y_{2t}, σ_1 is the standard deviation of y_{1t}, and σ_2 is the standard deviation of y_{2t}. Since α_4 is negative and ρ_{12} is positive (large centers use more of both inputs), $\hat{r}_{21}$ exceeds $\bar{r}_{21}$. Typically, estimates of $\hat{r}_{21}$ are given in studies of the efficient choice of aids by private sector physicians. [for example, Reinhardt (8); Brown and Lapan (13)].[10] In our view $\bar{r}_{21}$ is a more appropriate statistic because incentives for inefficient input decisions may vary greatly among firms, physicians, or CHCs.

It is also worth making a distinction between the efficient choice of inputs or allocative efficiency and technical efficiency. The latter pertains to the amount of output obtained from a given quantity of inputs.[11] An evaluation of the technical efficiency of CHCs requires a comparison between this system and another health care delivery system. Technical efficiency is not studied here because the goals, structure, and clientele of the CHC system are unique. Put differently, in a fundamental sense the comparison involved is between "apples and oranges."

By fitting an average cost function, we address directly the issue of the extent of economies of scale. If average cost falls as output rises, the average cost function is said to exhibit economies of scale. If average cost rises as output rises, the cost function is said to exhibit diseconomies of scale.[12]

Most economists posit a U-shaped average cost function [for example, Johnston (30); Friedman (31); Walters (32); Stigler (33); Becker (34)]. Given this function, average cost first declines as output rises, reaches a minimum value at a certain output, and then begins to rise as output rises. The declining segment of the average cost curve is attributed to the fixed costs of hiring and training labor and installing and warming up machines. In a basic sense, these fixed costs can be traced to "indivisibilities": community health centers, for example, cannot hire half a physician or buy half an X-ray machine. Of course, the centers can hire a half-time physician or buy an X-ray machine and keep it idle half the time. These options, however, entail higher costs per physician hour or machine hour than if the inputs are utilized on a full-time basis. Average cost also may fall initially if the production function has a range of increasing returns to scale (see note 12). Another source of declining average cost is randomness of demand [for example, Chiswick (35)]. For instance, on any given day, the administrator of a community health center cannot predict with perfect certainty the number of patients who will desire services. Hence, in order to treat a certain percentage of potential patients, some amount of excess capacity is required. As output and the average number of patients treated rises, the variability in demand tends to decline and less excess capacity is required.

The increasing complexity of large scale operations is the basic cause of an increase in average cost with output beyond some point. In the case of CHCs, average cost may rise beyond some point because of a fixed amount of the own time input of the chief administrator or project director of the center. Another consideration is that, if the administrator is a non-physician, he may find it very difficult to monitor the activities of a large number of highly skilled physicians [DuBois (36)]. Moreover, the objectives of the administrators of CHCs may differ from the objectives of the board members. To paraphrase an example by Becker (34), administrators have incentives to increase their incomes and can do this in spite of policing efforts by board members via large expense accounts, pleasure trips, and fancy offices. As centers get larger, it is more difficult to prevent administrators from engaging in these actions because the board members have other responsibilities. A final source of rising average cost is a segment of the production function that exhibits diminishing returns to scale.

In assessing the extent of economies of scale, it is important to keep in mind that all relevant costs should be included. One type of cost that often is ignored is the direct and indirect transportation costs incurred by patients and employees to travel to and from community health centers. The former pertain to direct or imputed outlays on cars, buses, taxis, or trains. The latter pertain to travel time multiplied by the opportunity cost of this time. It is possible that average cost inclusive of transportation cost rises as output rises, while average cost exclusive of transportation cost falls.[13]

A finding that average cost begins to rise beyond some output (economies of scale are exhausted beyond some output) conveys useful information to policy makers with regard to the optimal size of CHCs. For example, suppose that two centers in the same area are each operating on the declining segment of their average cost functions and that their combined output is smaller than or equal to the output that minimizes average cost. Then the combined output could be produced at a smaller total cost if one center closed or if the two centers merged. To cite another illustration, suppose that the CHC program is to be expanded in a given area. If centers in that area are operating at outputs beyond the minimum average cost output, a new center should be built. If not, existing centers should be increased in size.

It should be noted that the existence of a U-shaped average cost curve does not imply that each community health center should operate at the output where average cost is at its minimum value. Economically efficient firms minimize the average cost of given output rather than average cost per se. Moreover, one would hardly recommend that high average cost CHCs in medically underserved and sparsely populated rural areas should be closed. Indeed, if transportation costs are added to production costs, these centers might not be operating on the declining segment of their average cost functions (see note 13).[14] Put differently, the closing of these centers might raise transportation costs by more than it lowers production costs.

In its most complete specification, the average cost function estimated in Section IV has a quadratic form:

$$ac = \beta_0 + \beta_1 x + \beta_2 x^2 \quad . \tag{11}$$

If the true average cost function is U-shaped, then β_1 is negative, β_2 is positive, and ac is at a minimum when $x = - \beta_1/2\beta_2$. Since there are no data on transportation costs, any finding with respect to a minimum average cost output is interpreted with caution.

A problem encountered in the estimation of average cost functions is that of the "regression fallacy" [for example, Friedman (38); Johnston (30)]. From an econometric point of view, suppose that output (x) contains measurement error. Then so does average cost (ac) since ac is computed in part from x. Hence, errors of measurement in the dependent variable are correlated with errors of measurement in the independent variable. It follows that the parameter estimate of β_1 is biased away from zero (biased upward in absolute value), while the parameter estimate of β_2 is biased toward zero. Therefore, the computed output that minimizes average cost <u>exceeds</u> the theoretical output at which this occurs. That is, the estimated regression overstates the extent and importance of economies of scale.[15]

Theoretically, Friedman (38), Johnston (30), and others stress that input decisions of firms will take account of random fluctuations in the demand for output. To accommodate these fluctuations, inputs will be underutilized in periods when demand is unusually low and overutilized when it is unusually high. Even if average cost is independent of expected (average) output, average cost will be relatively high when output is unusually small and vice versa.

To deal with problems associated with the regression fallacy in particular and to reduce errors of measurement in all variables in general, costs, outputs, and inputs are averaged over the two-year period of 1978 to 1979. Moreover, at one point we employ the technique of instrumental variables to fit average cost functions. This is a standard technique for treating measurement errors in independent variables in a multiple regression. To implement this estimation method, we fit a regression of x on a set of instrumental variables. From the regression, we obtain the predicted value of x for each community health center and the square of the predicted value. Finally, we fit the average cost function using the predicted values of x and their squares rather than the actual values of x and their squares. If the instrumental variables are uncorrelated with the errors in actual output and average cost, the resulting estimates of the cost function are unbiased.

Average cost functions are obtained with and without the inefficiency index (e_{ijt}) as one of the independent variables. The inefficiency index equals zero if the actual input mix selected corresponds to the cost-minimizing input mix. Hence, the regression coefficient of the inefficiency index multiplied by its mean value gives the magnitude of the cost savings associated with movements toward a more appropriate input mix. In addition, when inefficiency is held constant in the average cost function, one obtains impacts of other variables on average cost net of their impacts on departures from cost minimization. When efficiency is included as an independent variable, the average cost function bears some resemblance to a long-run average cost function. In the long run, the fixed factor, say capital, is fixed at its optimal level; the ratio of the marginal product of capital to that of labor (the variable factor) equals the relative price of capital; and our inefficiency index is fixed at zero. Our estimated function is not perfectly analogous to a long-run average cost function because the inefficiency index, while fixed, is not fixed at zero.

III. Empirical Implementation

A. Data

The basic data set employed in this paper is the Bureau of Community Health Services Common Reporting Requirements data tape (hereafter termed the BCRR tape). This data tape consists of reports filed with the BCHS on a semiannual basis by community health centers and all other grantees receiving support from additional BCHS programs such as Title V children and youth projects, Title V maternal and infant care projects, and Titles V and X family planning clinics.[16] We limit our analysis to the community health centers on the tape and employ data for the years 1978 and 1979. In certain cases we have augmented the tape with data from other sources; these sources are discussed below. This is possible because the location of each center (specific address, county, state, and region) is given. For reasons indicated in Section II, most of the variables in our analysis are two-year averages for the years 1978 and 1979. This period is selected for detailed study because it enables us to include in the production and cost functions the original neighborhood health centers as well as those funded as part of the Rural and Urban Health Initiatives and other CHC program designs (see note 1).[17]

A detailed discussion of the measurement of variables in the production and cost functions is contained in Section III.B. Here it is useful to point out the nature of the ambulatory medical care output, input, and cost variables. The basic output proxy is a medical encounter, defined as an encounter between a medical user (a patient) and a provider of medical care who is employed by a community health center. A medical encounter may be cross-classified as a primary care physician encounter, a medical or surgical specialist encounter, a midlevel practitioner encounter, and a nurse encounter.[18] According to the BCHS glossary (41, p. 40): "To meet the encounter criterion, the provider must be acting independently and not assisting another provider. For example, a nurse assisting a physician during a physical examination by taking a patient's history or by drawing a blood sample is not credited with a separate encounter. The nurse in this instance is simply participating in a physician encounter. An encounter does not encompass such services as a laboratory technician drawing blood or collecting urine specimens nor does it include an X-ray technician taking an X-ray film." During any one visit to a CHC, a patient may have more than one medical encounter. This would occur, for instance, if he sees a physician and then sees a nurse who is acting independently of the physician.

Primary care physicians consist of general practitioners, family practitioners, internists, pediatricians, and obstetricians/gynecologists. Medical or surgical specialists are physicians with a specialty other than those included in the preceding category. Psychiatrists are excluded from this category. Midlevel practitioners include physician assistants, physician associates, nurse practitioners, and certified nurse-midwives. Nurses include clinical nurse specialists, registered nurses, licensed practical nurses, and licensed vocational nurses. For each type of provider, the number employed in the center is given on a full-time equivalent basis. This is obtained by dividing the sum of total annual hours worked by each type of provider by 1,600 hours. In addition, the number of full-time equivalent medical nonproviders is indicated. This category consists of medical support and ancillary personnel. It includes nurse aids, medical clerks, medical secretaries, laboratory technicians, X-ray technicians, pharmacists, and pharmacist assistants. The centers utilize salaried personnel, National Health Service Corps (NHSC) personnel, Comprehensive Employment and Training Act (CETA) personnel, and non-salaried personnel whose services are obtained on a consultational, contractual, or donated basis. All such personnel are included in the input measures on a full-time equivalent basis.

Total medical care costs are costs directly associated with medical encounters as well as ancillary costs for laboratory tests, X-rays, and drugs. Total costs can be divided into direct costs and indirect or overhead costs. Direct costs primarily consist of personnel costs (salaries, fringe benefits, and related costs), drug costs, laboratory supply costs, and depreciation or rental of medical equipment. Indirect costs are administrative costs and facility costs. The latter pertain to the costs of using and maintaining a center's plant--utilities, space rental, and building depreciation.

Personnel costs include consultant costs and contractual services as well as the costs of salaried personnel. Estimates of the dollar values of any donated labor and material are made by each center. These estimates primarily pertain to the salaries of NHSC and CETA personnel which are paid, at least in the first instance, by the Federal government.[19] Many centers deliver dental care and social and community services as well as medical care. This means that indirect costs must be allocated among a variety of services. Therefore, the well-known problem of the allocation of joint costs arises. Facility costs are distributed to medical care based on the percentage of square footage occupied by medical facilities. Administrative costs are distributed based on the percentage of all direct costs accounted for by medical care. Although these allocation rates are somewhat arbitrary, medical care is by far the most important service delivered by CHCs and the one that absorbs the largest percentage of resources.

The centers aggregate encounters and costs to an annual basis in the second semiannual report filed in each year. Hence, only these reports are used, and input as well as cost and output data are taken from them. The universe of CHCs for inclusion in the production and cost function is limited to those with an initial service year (the year in which the center began to deliver services) of 1978 or earlier.[20] There are 518 such centers.[21] A frequency distribution of these centers by region and size of county is shown in Panel A of Table 1.

The actual number of centers in the production and cost functions equals 325. Centers are deleted if they failed to file a report in the second reporting period of 1978 or 1979. They also are deleted if any of the following key variables is missing in either year: medical users, primary care physicians, onsite primary care physician encounters, total direct medical care cost, total medical care cost, and total receipts.[22] Finally, centers are deleted if they had less than one-fifth of a full-time primary care physician in either year or if reported total medical care cost was equal to or less than reported total direct medical care cost in either year. The former exclusion eliminates very small centers

TABLE 1

Frequency Distribution of Community Health Centers by Region and Size of County[a]

Size of County / Region	All Counties	Greater Metropolitan[b]	Lesser Metropolitan[c]	Adjacent[d]	Semirural or Rural[e]
Panel A: All CHCs with Initial Service Date of 1978 or Earlier (n = 518)					
Northeast	19.51	7.34	6.18	2.32	3.67
North Central	17.57	5.41	2.70	3.09	6.37
South	41.31	4.44	11.97	9.46	15.44
West	21.61	6.56	4.63	3.86	6.56
All Regions	100.00	23.75	25.48	18.73	32.04
Panel B: Sample of CHCs Studied in this Paper (n = 325)					
Northeast	21.53	8.00	7.38	2.77	3.38
North Central	16.62	5.54	3.08	2.77	5.23
South	41.55	4.62	11.39	10.46	15.08
West	20.30	5.23	5.23	4.92	4.92
All Regions	100.00	23.39	27.08	20.92	28.61

(Footnotes on following page)

Footnotes to TABLE 1

[a]Each cell entry gives the percentage of all centers in that cell.

[b]Counties in Standard Metropolitan Statistical Areas (SMSAs) with population of one million or more in 1970.

[c]Counties in SMSAs with population of less than one million in 1970.

[d]Counties adjacent to the metropolitan counties and having easy access to the central city in the metropolitan area.

[e]Counties other than those in the first three groups.

who are open less than one full day per week. The latter exclusion eliminates centers who have reported inaccurate data. A frequency distribution of the sample of 325 centers by region and size of county is shown in Panel B of Table 1. A comparison of Panels A and B of the table reveals that the locational distribution of the sample is very similar to the locational distribution of the universe of 518 centers. Moreover, the percentage of neighborhood health centers (NHCs) in the sample (20.9 percent) is almost identical to the percentage in the universe (19.1 percent). It can be concluded that the sample is representative of all CHCs with an initial service year of 1978 or earlier.

Note that the Bureau of Community Health Services uses certain performance indicators when it reviews grants by CHCs for continued funding. Two of these pertain to onsite medical encounters per physician and cost per medical encounter. Since the BCHS standards for these indicators are contained in the reporting manual (39), the centers have an incentive to report inaccurate data. The possibilities that there are errors in our basic data are mitigated, however, because the centers compute and report the performance indicators in tables that are not used in our analysis. Nevertheless, we consider an empirical test of the accuracy of our data in Section IV.

B. Specifications

Table 2 contains definitions, acronyms, means, and standard deviations of all of the dependent and independent variables in the production and cost functions. The specification of these functions is discussed in the remainder of this section. A discussion of the specification of an equation to determine inefficiency in the selection of inputs is postponed until

TABLE 2

Definition of Variables in Production and Cost Functions[a,b]

Variable	Mean	Standard Deviation	Definition
			I. Production Function
A. Dependent Variables			
1. LNOME	9.482	.948	Natural logarithm of number of onsite medical encounters
2. LNWOME	12.580	.960	Natural logarithm of number of weighted onsite medical encounters; weights are the average costs of a primary care physician encounter, a physician aid encounter, and an encounter with a medical or surgical specialist other than a primary care physician
B. Independent Variables			
1. PCP	3.583	4.144	Number of full-time equivalent primary care physicians; includes general practitioners, family practitioners, internists, pediatricians, and obstetricians/gynecologists
2. LNPCP	.920	.800	Natural logarithm of preceding variable
3. PA	4.440	6.860	Number of full-time equivalent physician aids; includes nurses,nurse practitioners, physician assistants, and related personnel[c]
4. PASQ	66.626	386.683	Square of preceding variable
5. MS	.226	.617	Number of full-time equivalent physicians with a medical or surgical specialty other than specialties included in the primary care physician category; excludes psychiatrists
6. MSSQ	.431	2.325	Square of preceding variable

(continued on next page)

TABLE 2 (continued)

Variable		Mean	Standard Deviation	Definition
B.	Independent Variables (continued)			
7.	O	10.226	14.651	Number of full-time equivalent medical support and ancillary personnel; includes nurse aids, medical secretaries; laboratory technicians, X-ray technicians, pharmacists, and related personnel
8.	OSQ	318.576	1,162.823	Square of preceding variable
9.	FM04	.158	.087	Fractions of medical users ages 0 to 4, 5 to 9, 10 to 19, and 65 and over, respectively; omitted category is fraction of medical users ages 20 to 59
10.	FM59	.086	.029	
11.	FM1019	.200	.043	
12.	FM65	.088	.056	
13.	AGE	4.218	3.493	Number of years that a center had been in operation as of 1979
14.	OCH	.791	.407	Dichotomous variable that equals one if a center is not a neighborhood health center
15.	FPAE	.291	.221	Fractions of onsite physician aid encounters and medical-surgical specialist encounters, respectively; omitted category pertains to fraction of onsite primary care physician encounters
16.	FMSSE	.024	053	
	II. Average Cost Function			
A.	Dependent Variables			
1.	ADMC	21.399	7.484	Average direct medical care cost in 1978 dollars
2.	ATMC	28.667	9.575	Average total medical care cost in 1978 dollars

(continued on next page)

TABLE 2 (continued)

Variable	Mean	Standard Deviation	Definition
B. <u>Independent Variables</u>			
1. OME	21.283	31.301	Number of onsite medical encounters in thousands
2. OMESQ	1,429.705	9,643.793	Square of preceding variable
3. FPAE	.291	.221	See I.B, variables 15 and 16
4. FMSSE	.024	.053	
5. FOE	.083	.102	Fraction of offsite medical encounters
6. FM04	.158	.087	See I.B, variables 9-12
7. FM59	.086	.029	
8. FM1019	.200	.043	
9. FM65	.088	.056	
10. AGE	4.218	3.493	See I.B, variable 13
11. OCH	.791	.407	See I.B, variable 14
12. PCPNI	61.154	6.922	Annual net income of primary care physicians in private practice in thousands of 1978 dollars by region and size of county[c]
13. NE	11.132	1.070	Annual full-time earnings of nurses employed in hospitals in thousands of 1978 dollars by region and size of county[c]
14. OHPE	8.648	1.052	Annual full-time earnings of hospital personnel other than nurses, staff physicians, interns, residents, and other trainees in thousands of 1978 dollars by region and size of county[c]

(continued on next page)

TABLE 2 (concluded)

Variable	Mean	Standard Deviation	Definition
B. Independent Variables (continued)			
15. MEDICAID	.079	.108	Fractions of a center's receipts obtained from Medicaid, Medicare, private insurance companies, and patients, respectively; omitted category pertains to fraction of receipts obtained from Federal, state, and local government grants
16. MEDICARE	.027	.035	
17. PVTINS	.060	.111	
18. PATIENT	.135	.152	
19. MU	7.187	10.360	Number of medical users in thousands

[a]Means and standard deviations pertain to the sample of 325 centers described in the text.

[b]With the exception of AGE, OCH, PCPNI, NE, and OHPE, all variables are based on data for 1978 and 1979. Number of onsite medical encounters, number of medical users, and inputs are two-year averages. All ratio variables are obtained by the summing the numerator and denominator for the two years separately and then dividing.

[c]See text for a more detailed definition.

Section V. It should be realized that the average cost function specified in this section is one in which direct measures of inefficiency are excluded.

1. <u>Production Function</u>

Like other health care delivery systems, the ultimate or final output of community health centers takes the form of improvements in the health of its users. Encounters between users and health care providers may be viewed as the intermediate output of CHCs. In the estimated production function, this intermediate output--the natural logarithm of onsite medical encounters (LNOME)--is related to inputs. Onsite encounters are those that occur in CHCs themselves rather than in other locations. They are emphasized because the input measures pertain to the staff that work in CHCs.[23]

There are four input variables in the production function. These are the number of primary care physicians (PCP) and its natural logarithm (LNPCP), the number of medical and surgical specialists (MS) and its square (MSSQ), the number of physician aids (PA) and its square (PASQ), and the number of medical support and ancillary personnel (O, where the acronym denotes personnel other than those in the first three categories) and its square (OSQ). Nurses and midlevel practitioners are aggregated into a combined physician aid input for reasons indicated below. In Section V both the efficient choice of physician aids relative to primary care physicians and the efficient choice of medical support and ancillary personnel (other personnel) relative to primary care physicians are considered. The efficient selection of medical and surgical specialists relative to primary care physicians is not studied because only 37 percent of all CHCs employ specialists.[24]

The types of cases treated by centers may affect the output obtained from a given set of inputs. Since actual casemix differences are not available, four variables reflecting the age distribution of medical users are employed to control for casemix. These are the fraction of users ages 0 to 4 (FM04), the fraction ages 5 to 9 (FM59), the fraction ages 10 to 19 (FM1019), and the fraction ages 65 and over (FM65). The number of years that a center has been in operation (AGE) also may affect the output obtained from a given set of inputs. This is particularly true if technical efficiency in production is an acquired skill. A dichotomous variable that denotes a CHC that is not one of the original neighborhood health centers (OCH) is added because the NHCs deliver a somewhat broader range of services than the other centers. Whether this factor has an independent effect in the production function is an empirical issue.

An obvious problem with the number of medical encounters as the measure of output is that varying amounts of output may be associated with encounters with different providers. For example, it is reasonable to suppose that a physician encounter yields a greater amount of output than a physician aid encounter. If the proportions of encounters with various providers vary among community health centers and are correlated with the inputs, estimates of the production function are biased.

The problem of adjusting CHC ambulatory medical care output for "encounter-mix" is similar to the problem of adjusting hospital output for casemix. The latter problem has been considered in detail by Feldstein(25) in his study of the British National Health Service, and we use two of the adjustment techniques that he has developed. One technique is to include a vector of encounter-mix proportions in the production function. These are the fraction of onsite medical encounters with physician aids (FPAE) and the fraction of onsite medical encounters with medical-surgical specialists (FMSSE). The omitted category pertains to the fraction of on-site medical encounters with primary care physicians.

The second technique is to replace the simple sum of medical encounters in the t^{th} CHC ($x_t = \sum_{i=1}^{3} x_{it}$) by the "weighted" sum of encounters. With the latter measure, more weight is given to encounters that yield more output. In the context of CHC data, Feldstein's procedure is to weight an encounter with the i^{th} provider by the sample average cost of an encounter with that provider ($\overline{ac}_i$). Hence, the weighted output of a given CHC (z_{it}) is

$$z_{it} = \sum_{i=1}^{3} \overline{ac}_i x_{it} \quad . \tag{12}$$

The natural logarithm of this measure (LNWOME) replaces LNOME as the dependent variable in alternative specifications of the production function.[25]

Although the average cost of all medical encounters in each CHC and in the sample as a whole easily can be computed, there are no data on the sample average cost of an encounter with a specific provider. Under the assumption that the ac_{it} are constant (independent of the number of encounters), the sample average costs can, however, be estimated from a multiple regression. Let ac_t be the average cost of medical encounters in the t^{th} CHC, and let p_{it} be the proportion of encounters with the i^{th} provider in that center. Then

$$ac_t = \sum_{i=1}^{3} \overline{ac}_i p_{it} \quad , \tag{13}$$

or

$$ac_t = \overline{ac}_1 + (\overline{ac}_1 - \overline{ac}_2)\, p_{2t} + (\overline{ac}_1 - \overline{ac}_3)\, p_{3t} \quad . \qquad (14)$$

Given observations for each center, the last equation specifies a regression of ac_t on p_{2t} and p_{3t}. The intercept of the regression is an estimate of $\overline{ac}_1$, and the regression coefficient of p_{it} (i = 2, 3) is an estimate of $\overline{ac}_i - \overline{ac}_1$.[26]

The actual regression equation is

$$\begin{array}{lllll} \text{ADMC} = & 23.087 & -\ 4.671\ \text{FPAE} & +\ 20.022\ \text{FMSSE} & -\ 9.912\ \text{FOE} \\ & (t = 29.22) & (t = -2.53) & (t = 2.62) & (t = -2.47) \end{array}$$

$$R^2 = .066, \qquad F = 7.50 \quad .$$

The dependent variable is average direct medical care cost (ADMC) because of the somewhat arbitrary accounting rules used to allocate indirect costs. The fraction of offsite medical encounters (FOE) is included as an independent variable because offsite costs cannot be excluded from total costs. Based on the regression, the average direct cost of an onsite encounter with a primary care physician is \$23.09 in 1978 dollars. The average direct cost of an onsite encounter with a physician aid is \$18.42, and the average direct cost of an onsite encounter with a medical-surgical specialist is \$43.11.[27]

2. Average Cost Function

Average direct medical care cost (ADMC) and average total medical care cost (ATMC) are employed as alternative dependent variables in the average cost function. Both are used because of the problem of allocating indirect costs among the services provided by CHCs. The numerator of average direct medical care cost equals total direct cost in 1978 plus total direct cost in 1979 in 1978 dollars. The 1979 data are deflated by the physicians' services component of the Consumer Price Index (CPI). The denominator of ADMC equals total medical encounters (onsite and offsite) in 1978 plus total medical encounters in 1979.[28] Offsite encounters are included in the denominator because offsite costs cannot be excluded from total costs. Average total medical care cost is constructed in a similar manner.

The number of onsite medical encounters (OME) and the square of this number (OMESQ) are entered into the cost function to explore the extent and importance of economies of scale. The weighted encounter variable is not used as an alternative output measure because it is derived under the assumption that average cost is constant. We want to test this assumption in the context of empirical estimates of average cost functions.[29] In the instrumental variable regressions, the number of medical users (MU) serves as the instrument for the number of onsite medical encounters. To take account of differences in casemix and in encounter-mix, the same age distribution variables (FM04, FM59, FM1019, FM65) and encounter-mix proportions (FPAE, FMSSE) included in the production function are included in the cost function. Since offsite costs cannot be subtracted from total costs, variations in the fraction of offsite encounters (FOE) among centers are held constant. The number of years that a center has been in operation (AGE) and whether or not it is one of the original neighborhood health centers (OCH) may have independent effects on average cost. These may be due in part to differences in casemix and in scope of services that are not reflected by other variables.

In Section I of this paper, it was indicated that alternative financing mechanisms have the potential to affect incentives to cost minimize and therefore average cost. CHCs receive approximately 70 percent of their receipts from Federal, state, and local government grants, although this percentage varies considerably among centers (standard deviation = 24 percent). Since the grants are not tied to particular services rendered, the centers largely operate on fixed annual budgets and have incentives to provide a given mix of services in the least-cost method. These incentives are diluted by increases in the proportions of receipts obtained from Medicaid (MEDICAID), Medicare (MEDICARE), and private health insurance companies (PVTINS). On the other hand, incentives to cost minimize may be expanded by an increase in the proportion of receipts obtained from patients (PATIENT). This is because most of the clientele of CHCs are poor. Therefore, centers that must rely on patients for a relatively large proportion of their receipts face a considerable amount of uncertainty with regard to whether and when these payments will be made.

Funds obtained from the above four sources include those received on a fee-for-service or prepayment basis, but fee-for-service funds cannot be distinguished from prepayment funds. The prepayment basis is relevant because the design of certain non-NHCs, especially those established in the early 1970s, emphasized the delivery of services on a prepaid capitation basis, with Medicaid as the source of prepayment where possible (see note 1). The centers were not, however, successful in attracting Medicaid funds for this purpose [Roemer (7)]. Therefore, the fraction of receipts obtained on a prepaid basis is likely to rise as the fraction of receipts obtained from patients rises. In addition the fraction of prepaid funds is likely to be larger in non-NHCs. Prepayment encourages cost minimization relative to fee-for-service payment, but its impact relative to funding from grants is ambiguous. If, however, centers anticipate that some portion of a potential current deficit can be financed by future grants, there is an additional factor that predicts negative effects of the fraction of a center's receipts obtained from patients and its status as a non-NHC on average cost.

The final set of variables in the cost equations pertains to the prices or wages of inputs employed by the centers. Input prices are not available on a center-specific basis on the BCRR tape because personnel costs cannot be disaggregated. Even if input prices could be estimated by, for example, dividing primary care physician costs by the number of full-time equivalent physicians, the value of the resulting measure would be questionable. This is because centers in the same local market area should pay the same price for physicians of a similar quality or skill level given perfect competition in input markets.[30] If the measure just described indicates that they do not, then it may reflect variations in skill levels of physicians among centers rather than true differences in the price of the physician input.

The prices of three types of inputs employed by CHCs are taken from surveys conducted by the Health Care Financing Administration (HCFA) and by the American Hospital Association (AHA). The former is used for the wages of primary care physicians, while the latter is used for the wages of physician aids and medical support and ancillary personnel (other personnel). Ideally, these wages should be specific to the county in which a given center is located. A significant number of centers, however, are located in small counties (see Table 1). Especially in the HCFA survey, county-level mean wage rates would be based on a small number of observations. Moreover, there are no physicians from some counties in the HCFA survey. For these reasons, mean wages are estimated by region and size of county. The ten

Federal regions and the four county sizes defined in Table 1 are employed in these computations, so that wages are obtained for forty region-county size cells.[31] A given center then is assigned wage rates that correspond to the cell in which it is located.

The wage of primary care physicians is proxied by annual net medical practice income of primary care physicians (PCPNI) from the HCFA Physician Practice Cost Surveys of 1977 and 1978. Both surveys are used to maximize the number of observations on which a given region-county size mean is based. Net income in the 1977 survey pertains to 1976, while net income in the 1978 survey pertains to 1977. Income in each year is expressed in 1978 dollars based on the all commodities component of the CPI.[32]

The wage of physician aids is measured by annual full-time earnings of nurses employed in hospitals (NE). The wage of medical support and ancillary personnel is measured by annual full-time earnings of hospital personnel other than nurses, staff physicians, interns, residents, and other trainees (OHPE). Both measures come from the AHA annual survey of hospitals, pertain to 1979, and are converted into 1978 dollars. Nurses include registered nurses, licensed practical nurses, and licensed vocational nurses. Full-time earnings of nurses in one of the forty region-county size cells equal the total nurse payroll of all hospitals in that cell divided by the total number of full-time equivalent nurses employed. In the computation of the number of full-time equivalent nurses, one part-time nurse is counted as one-half of a full-time nurse. Similar comments apply to the computation of full-time earnings of other hospital personnel.

Conceptually, input prices should include fringe benefits as well as wages. Thus, the relevant price of input y_i in location c (region-county size cell c) is

$$w_{ic} = \hat{w}_{ic} \, (1 + k_{ic}) \quad , \qquad (15)$$

where $\hat{w}_{ic}$ is the wage per employee and k_{ic} is the ratio of the wage per employee to the fringe benefit cost per employee. Suppose that k_{ic} is independent of c, and suppose that the $\hat{w}_{ic}$ $(i = 1, 2, 3)$ rather than the w_{ic} are employed as independent variables in the cost function. Then regression coefficients and their standard errors are multiplied by $1 + k_i$, leaving statistical tests of significance unaffected. In addition, if k_i is the same for all inputs, the relative price of input y_i can be measured either by w_i/w_j or by $\hat{w}_i/\hat{w}_j$.[33]

Fringe benefits definitely are excluded from the AHA earnings data and from the net practice income of salaried physicians. Whether or not amounts that self-employed physicians spend on pensions, health insurance, and life insurance are excluded from their net practice income is problematic. These outlays should be excluded if the physician is incorporated since they can be almost fully deducted from income in computing income tax liabilities. Tax deductions are much more limited for unincorporated physicians. Hence, the measured price of a physician aid relative to that of a physician may understate the true price. In the inefficiency analysis in Section V, we comment on the sensitivity of the results to such an understatement.

Nurses and midlevel practitioners are aggregated into a single physician aid input in the production function partly because location-specific data on earnings of midlevel practitioners are extremely limited. This aggregation is less arbitrary than it may appear. Brown and Lapan (13) report that hourly wage rates of registered nurses and physician assistants are almost identical. To be sure, licensed practical and vocational nurses are less skilled than either registered nurses or physician assistants. But since CHCs focus to a large extent on fairly routine primary and preventive care, the potential exists to exploit substitution possibilities between less skilled and more skilled assistants.

IV. Empirical Results: Production and Cost Functions

Empirical estimates of production and cost functions are presented in this section. All empirical results pertaining to the efficient choice of inputs are presented in Section V. Therefore, the average cost functions presented in this section are those in which direct measures of inefficiency are excluded.

A. Production Functions

Four alternative estimates of ambulatory medical care production functions are shown in Table 3. In each regression the dependent variable is the natural logarithm of weighted onsite medical encounters (LNWOME). In regression (3-1) the set of independent variables is limited to the four input measures: the natural logarithm of primary care physicians (LNPCP) and the arithmetic values and squares of physician aids (PA, PASQ), medical or surgical specialists (MS, MSSQ), and other personnel (O, OSQ). In regression (3-2) the measures of the age distribution of medical users (FM04, FM59, FM1019, FM65) are included, while in regression (3-3) the center's age (AGE) and the dichotomous variable that distinguishes NHCs from other CHCs (OCH) are added. Finally, in regression (3-4) the arithmetic value of primary care physicians (PCP) is included.

The regression coefficients of the four input measures have the "correct signs" in the sense that an isoquant between any two inputs has a

TABLE 3

Estimates of Medical Care Production Functions,
Dependent Variable: LNWOME[a]

Variable	Regression Number 3-1	3-2	3-3	3-4
LNPCP	.543 (10.95)	.534 (10.42)	.528 (10.59)	.598 (7.91)
PA	.053 (6.37)	.053 (6.04)	.053 (6.21)	.053 (6.29)
PASQ	-.004D-1 (-3.12)	-.004D-1 (-2.95)	-.004D-1 (-3.00)	-.004D-1 (-2.69)
O	.034 (5.82)	0.035 (5.85)	0.026 (4.19)	0.025 (4.05)
OSQ	-.003D-1 (-5.02)	-.003D-1 (-5.08)	-.003D-1 (-4.08)	-.002D-1 (-2.69)
MS	.269 (2.56)	.259 (2.45)	.206 (1.99)	.208 (2.01)
MSSQ	-.041 (-1.57)	-.036 (-1.39)	-.021 (-.82)	-.018 (-.72)
FM04		-.109 (-.30)	-.161 (-.46)	-.158 (-.45)
FM59		1.065 (.98)	.604 (.57)	.720 (.67)
FM1019		-.666 (-.90)	-.530 (-.73)	-.593 (-.82)
FM65		-.614 (-1.06)	-.489 (-.87)	-.484 (-.86)

(continued on next page)

TABLE 3 (concluded)

Variable	3-1	3-2	3-3	3-4
	Regression Number			
AGE			.038 (4.29)	.038 (4.28)
OCH			-.012 (-.16)	-.004 (-.05)
PCP				-.027 (-1.24)
CONSTANT	11.577 (284.73)	11.699 (60.98)	11.635 (55.44)	11.645 (55.50)
R^2	.791	.793	.806	.806
F	171.24	108.78	99.11	92.30

[a]t-ratios in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratio associated with each regression is statistically significant at the 1 percent level of significance.

downward sloping segment and is convex to the origin in that segment.[34] Moreover, these coefficients are very stable across alternative specifications. All coefficients except those pertaining to MSSQ and PCP are statistically significant.[35] According to regression (3-3)--the preferred specification for reasons indicated below--the output elasticity of primary care physicians is .528. Evaluated at sample means, the output elasticities of the other inputs are .218 for physician aids, .044 for medical-surgical specialists, and .204 for other personnel.[36] Hence, the returns to scale parameter at the point of means is .994, indicating constant returns to scale at that point.

Variations in the age distribution of medical users among centers have little impact on the amount of output obtained from a given set of inputs. On the other hand, technical efficiency is sensitive to the number of years that a given center has been in operation. In particular, older centers get more output from their inputs. The regression coefficients of LNPCP, O, and MS are reduced slightly when age of the center is held constant. These reductions are not dramatic because older centers use more of all inputs. Apparently, the age effect is divided equally among three of the four inputs when the age variable is omitted. The original status of a CHC as an NHC has no independent effect on output, although it should be noted that NHCs are approximately five years older on average than non-NHCs. When age is deleted, the coefficient of OCH becomes significant.

Production functions in which the dependent variable is the natural logarithm of onsite medical encounters (LNOME) are shown in Table 4. The parameter estimates of these functions are very sensitive to the inclusion of the two encounter-mix proportions (FPAE, FMSSE). In particular, when

TABLE 4

Estimates of Medical Care Production Functions, Dependent Variable: LNOME[a]

Variable	Regression Number 4-1	4-2	4-3	4-4	4-5
LNPCP	.508 (10.08)	.499 (9.60)	.493 (9.72)	.649 (12.40)	.678 (9.12)
PA	.062 (7.37)	.062 (6.96)	.062 (7.13)	.030 (3.23)	.031 (3.26)
PASQ	-.005D-1 (-3.89)	-.005D-1 (-3.66)	-.005D-1 (-3.72)	-.002D-1 (-1.27)	-.002D-1 (-1.15)
O	.034 (5.72)	.035 (5.75)	.027 (4.18)	.024 (4.10)	.024 (4.02)
OSQ	-.003D-1 (-4.76)	-.003D-1 (-4.83)	-.002D-1 (-3.89)	-.002D-1 (-3.50)	-.002D-1 (-2.64)
MS	.147 (1.38)	.138 (1.29)	.088 (.84)	-.028 (-.22)	-.021 (-.17)
MSSQ	-.023 (-.89)	-.019 (-.73)	-.005 (-.19)	.007 (.27)	.008 (.28)
FM04		-.015 (-.04)	-.070 (-.20)	-.132 (-.39)	-.133 (-.40)
FM59		1.114 (1.01)	.676 (.62)	.703 (.70)	.749 (.74)
FM1019		-.623 (-.82)	-.486 (-.66)	-.491 (-.71)	-.518 (-.75)
FM65		-.581 (-.99)	-.456 (-.79)	-.120 (-.22)	-.123 (-.23)

(continued on next page)

TABLE 4 (concluded)

Variable	Regression Number 4-1	4-2	4-3	4-4	4-5
AGE			.037 (4.12)	.037 (4.32)	.037 (4.32)
OCH			.008D-1 (.01)	.033 (.45)	.035 (.48)
FPAE				.909 (6.78)	.904 (6.71)
FMSSE				1.492 (2.17)	1.443 (2.08)
PCP					-.011 (-.54)
CONSTANT	8.494 (205.70)	8.587 (44.10)	8.510 (39.83)	8.172 (39.63)	8.180 (39.52)
R^2	.779	.781	.793	.822	.822
F	159.38	101.44	91.81	95.04	88.91

[a]t-ratios in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratio associated with each regression is statistically significant at the 1 percent level of significance.

FPAE and FMSSE are held constant, the coefficient of LNPCP rises by slightly more than 30 percent, the coefficient of PA is cut in half, and the coefficient of MS becomes negative. Note, however, that the fraction of onsite physician aid encounters and the fraction of onsite medical-surgical specialist encounters have positive and statistically significant effects on output. Note also that the number of medical-surgical specialists is positively correlated with the fraction of onsite medical-surgical specialist encounters (r = .665), and the number of physician aids is positively correlated with the fraction of onsite physician aid encounters (r = .242). Therefore, it is questionable whether FPAE, for example, should be held constant when the marginal product of PA is evaluated.

For the above reasons, the encounter-mix adjustment technique reflected by the weighted output variable is superior to the adjustment technique reflected by the inclusion of the encounter-mix proportions in the production function. Consequently, one of the production functions contained in Table 3 is employed in the inefficiency analysis in Section V. Since the coefficient of PCP is not significant in regression (3-4), the preferred specification is regression (3-3). This is the case because we want to evaluate marginal rates of substitution in production between physician aids and primary care physicians and between medical support and ancillary personnel (other personnel) and primary care physicians. Clearly, it is preferable to use significant coefficients only in these computations.

In Section III it was pointed out that the existence of BCHS performance standards may give centers an incentive to report inaccurate data. To the extent that centers act on these incentives, one would expect those that receive relatively large proportions of their receipts from government grants to be more likely to overstate their output. This is because reimbursement from Medicaid and other third parties requires proof that services were in fact delivered. To check the accuracy of the data, the set of variables indicating the proportions of receipts obtained from Medicaid (MEDICAID), Medicare (MEDICARE), private health insurance companies (PVTINS), and patients (PATIENT) was included in the production function specification given by regression (3-3). The test of the hypothesis that no member of this set of four variables has a nonzero effect resulted in an F-statistic of 2.74, which is not significant at the one percent level. This result strengthens our confidence in the reliability of the basic data.

B. Average Cost Functions

Average direct medical care cost (ADMC) regressions are presented in Table 5, and average total medical care cost (ATMC) regressions are presented in Table 6. Four specifications are shown in each table because of intercorrelations among output, average cost, age of the center, and sources of receipts. These correlations are highlighted in Table 7 which shows that NHCs are older, produce more output, have higher average costs, and derive a larger percentage of revenue from Medicaid than non-NHCs. The regressions in Tables 5 and 6 demonstrate that it is important to control for center characteristics (AGE, OCH) and revenue sources (MEDICAID, MEDICARE, PVTINS, PATIENT), especially the former, in assessing the impact of onsite medical encounters (OME) on average cost.

Linear, rather than quadratic, average cost functions are shown in the tables because the square of onsite medical encounters (OMESQ) is omitted from the set of independent variables. When OMESQ was included in the

TABLE 5

Estimates of Average Direct Medical Care Cost Functions[a]

	Regression Number			
Variable	5-1	5-2	5-3	5-4
OME	.007 (.53)	-.022 (-1.68)	-.007 (-.56)	-.035 (-2.64)
PCPNI	.106 (1.79)	.054 (1.23)	.069 (1.96)	.114 (1.54)
NE	1.738 (3.80)	1.137 (2.52)	1.288 (2.76)	.740 (1.61)
OHPE	.706 (1.55)	.784 (1.80)	.423 (.94)	.502 (1.17)
FPAE	-5.886 (-3.16)	-5.875 (-3.31)	-5.016 (-2.75)	-4.975 (-2.86)
FMSSE	12.444 (1.64)	.946 (.126)	6.013 (.80)	-4.641 (-.63)
FOE	-3.952 (-1.00)	-3.536 (-.93)	-4.287 (-1.10)	-4.164 (-1.11)
FM04	-.068 (-.01)	-.062 (-.01)	-4.666 (-.83)	-3.257 (-.60)
FM59	-10.796 (-.65)	-22.579 (-1.42)	-20.555 (-1.25)	-32.301 (-2.04)
FM1019	5.910 (.52)	3.923 (.36)	1.488 (.13)	3.154 (.30)
FM65	-11.355 (-1.22)	-15.133 (-1.70)	-11.396 (-1.21)	-11.323 (-1.26)
AGE		.423 (3.19)		.434 (3.31)

(continued on next page)

TABLE 5 (concluded)

Variable	5-1	5-2	5-3	5-4
	Regression Number			
OCH		-3.805 (-3.29)		-3.694 (-3.21)
MEDICAID			13.838 (3.24)	12.728 (3.12)
MEDICARE			-5.518 (-.45)	-17.259 (-1.45)
PVTINS			6.316 (1.75)	9.777 (2.80)
PATIENT			-9.715 (-3.52)	-6.951 (-2.60)
CONSTANT	-8.170 (-1.14)	3.893 (.53)	1.435 (.20)	10.791 (1.46)
R^2	.180	.263	.237	.313
F	6.25	8.55	6.40	8.22

[a]t-ratios in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratio associated with each regression is statistically significant at the 1 percent level of significance.

TABLE 6

Estimates of Average Total Medical Care Cost Functions[a]

Variable	Regression Number 6-1	6-2	6-3	6-4
OME	.005 (.32)	-.027 (-1.59)	-.012 (-.70)	-.042 (-2.43)
PCPNI	.142 (1.88)	.101 (1.38)	.153 (2.05)	.121 (1.68)
NE	2.014 (3.44)	1.354 (2.32)	1.365 (2.29)	.781 (1.31)
OHPE	1.113 (1.90)	1.200 (2.13)	.784 (1.37)	.871 (1.57)
FPAE	-8.369 (-3.51)	-8.347 (-3.63)	-7.282 (-3.12)	-7.229 (-3.21)
FMSSE	13.839 (1.42)	1.024 (.11)	6.116 (.64)	-5.401 (-.56)
FOE	-8.879 (-1.75)	-8.536 (-1.73)	-9.055 (-1.82)	-9.009 (-1.85)
FM04	1.481 (.20)	1.354 (.19)	-5.118 (-.71)	-3.687 (-.52)
FM59	-9.995 (-.47)	-23.243 (-1.12)	-20.841 (-.99)	-33.646 (-1.64)
FM1019	6.362 (.44)	4.307 (.31)	-.812 (-.06)	1.114 (.08)
FM65	-7.698 (-.64)	-11.678 (-1.01)	-7.912 (-.66)	-7.679 (-.66)
AGE		.497 (2.89)		.486 (2.86)

(continued on next page)

TABLE 6 (concluded)

	Regression Number			
Variable	6-1	6-2	6-3	6-4
OCH		-4.042 (-2.69)		-3.847 (-2.58)
MEDICAID			17.575 (3.22)	16.407 (3.10)
MEDICARE			-12.130 (-.78)	-24.705 (-1.60)
PVTINS			5.787 (1.26)	9.550 (2.11)
PATIENT			-13.206 (-3.74)	-10.213 (-2.95)
CONSTANT	-9.317 (-1.02)	3.742 (.39)	4.128 (.44)	13.948 (1.45)
R^2	.179	.243	.239	.294
F	6.21	7.66	6.48	7.50

[a]t-ratios in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratio associated with each regression is statistically significant at the 1 percent level of significance.

TABLE 7

Means of Selected Variables by Type of Center

Variable	Neighborhood Health Centers (n = 68)	Other Community Health Centers (n = 257)
AGE	7.809	3.268
MEDICAID	.143	.062
MEDICARE	.034	.025
PVTINS	.047	.063
PATIENT	.077	.150
OME	43.893	15.301
ADMC	26.624	20.016
ATMC	34.687	27.074

regressions, its coefficients never were significant. Moreover, in those cases in which the coefficient of OME was negative and that of OMESQ was positive, the output that minimized average cost either was beyond the range of all observations or beyond the range of all but 1.8 percent of the observations. Instrumental variable estimates are not presented because the use of this technique raised the coefficient of output in absolute value and lowered the coefficient of the square of output. These results suggest that the average cost functions in Tables 5 and 6 are not marred by the regression fallacy.[37]

According to the results in Tables 5 and 6, output has negative and significant impacts on average direct medical care cost and on average total medical care cost once all other variables in the cost functions are held constant [see regressions (5-4) and (6-4)]. Note that the output effect is positive and not significant if the center characteristics and the revenue sources are omitted [see regressions (5-1) and (6-1)]. Regressions (5-2) and (5-3) or (6-2) and (6-3) show that more bias is introduced by the omission of the center characteristics than by the omission of the revenue sources.

Although average direct cost and average total cost fall as output rises, the elasticities of average cost with respect to output are very modest. At the point of means, the elasticity of average direct medical cost with respect to the number of onsite medical encounters equals -.035. Evaluated at an output one standard deviation above the mean output, the elasticity equals -.091. At two standard deviations above the mean output, the elasticity is -.153. The corresponding elasticities of average total medical care cost with respect to the number of onsite medical encounters are -.031 at the point of means, -.081 at an output one standard deviation above the mean, and -.135 at an output two standard deviations above the mean.[38] Thus, the average cost functions slope downward in a statistical sense, but in a practical sense they are very flat. Put differently, the departure from constant average cost is very small.

Centers that obtain relatively larger percentages of their revenues from Medicaid and private insurance companies have higher average costs, while centers that obtain relatively large percentages of their revenues from patients and Medicare have lower average costs. All effects except for that associated with Medicare are statistically significant. Of the significant effects, that pertaining to Medicaid is the most dramatic. Consider two hypothetical centers that are the same in all respects except that one obtains 100 percent of its revenue from Medicaid, while the other obtains 100 percent of its revenue from grants. The first center's average direct medical cost would exceed the second center's average direct medical cost by $12.73. The corresponding average total cost differential would be $16.41. The impacts of Medicaid reimbursement, private health insurance reimbursement, and patient reimbursement on average cost are consistent with a priori notions about the effects of alternative revenue sources on the efficient choice of inputs. The impact of Medicare reimbursement is not consistent with these notions, but Medicare is the least important source of the centers' revenues. On average, it accounts for only 2.7 percent of all revenues.[39] In any case definitive conclusions with respect to these issues must await the analysis of the determinants and effects of allocative inefficiency in Section V.

A standard prediction from the theory of production is that an increase in the price of an input used in the production process increases the average cost of output. In line with this prediction the three input price proxies (PCPNI, NE, OHPE) have positive coefficients in the eight regressions in Tables 5 and 6. In the most complete specifications of the cost functions [regressions (5-4) and (6-4)], five of the six input price effects are significant at the 10 percent level. Only the coefficient of physician net income (PCPNI) on average direct medical cost is, however, significant at the 5 percent level. Note that the simple correlation coefficient between the annual full-time earnings of nurses employed in hospitals (NE) and the annual full-time earnings of other hospital personnel (OHPE) is positive and fairly large ($r = .534$). When one of these two variables is omitted from the cost equations, the coefficients of the other are significant at the 1 percent level.[40] Given the multicollinearity problem, the finding that the three input price measures have positive impacts on average cost and t-ratios greater than one is an important and impressive one. It underscores that these measures are very good proxies for the prices of the inputs actually used by CHCs.

With respect to the empirical roles of the other variables, average cost is not in general related to differences in the age distribution of medical users among CHCs. Older centers have significantly larger costs that newer centers, and NHCs have significantly larger costs than non-NHCs. In part these results may be traced to aspects of allocative inefficiency. They also may be due to variations in casemix and scope of services that are not captured by other variables. As shown by the coefficient of the fraction of offsite encounters (FOE), onsite encounters are more expensive than offsite encounters, although the differentials are not significant at the 5 percent level on a two-tailed test.[41] The average direct cost differential between a primary care physician encounter and a physician aid encounter of $4.98 is similar to the one estimated from a regression of ADMC on FPAE, FMSSE, and FOE in Section III. The average cost of a medical-surgical specialist encounter relative to a primary care physician encounter is very different from the one obtained in Section III. This is partly because FMSSE is correlated with the center characteristics and the revenue variables [compare regression (5-1) with regression (5-4)] and partly because net income of specialists is excluded from the regressions.

V. Empirical Results: Allocative Efficiency

In this section the performance of the CHC system with respect to the efficient or cost-minimizing selection of inputs is examined. Both the efficient choice of physician aids relative to primary care physicians and the efficient choice of medical support and ancillary personnel (other personnel) relative to primary care physicians are treated. In Section V.A the extent of departures from efficient utilization of these inputs is quantified. In Section V.B the determinants of inefficiency are studied, and in Section V.C the effects of inefficiency on the total cost of ambulatory medical care are estimated.

A. Evaluation of Efficient Use of Inputs

To evaluate whether CHCs select the combinations of primary care physicians and physician aids that minimize the cost of a given output, we compute the marginal rate of substitution in production between aids and physicians (MRSPAP) for each center, divide it by the location-specific relative price of aids [WPAP = $(PCPNI)\,(NE)^{-1}$], and average the resulting ratio [RPAP = $(MRSPAP)\,(WPAP)^{-1}$] over all centers. At the same time, we compute an index of inefficiency in the use of aids relative to physicians (EPA = |RPAP-1|). Similarly, to study the efficient choice of other personnel relative to physicians, we compute the marginal rate of substitution in production between these personnel and physicians (MRSOP), divide it by the location-specific relative price of other personnel [WOP = (OHPE) $(PCPNI)^{-1}$], and average the resulting ratio [ROP = (MRSOP) $(WOP)^{-1}$] over all centers. At the same time, we obtain an index of inefficiency in the use of other personnel relative to physicians (EO = |ROP-1|). In making these computations, we employ the formula for the marginal rate of substitution given by equation (7) and the production function given by regression (3-3) in Table 3.

Summary measures pertaining to these computations are shown in Panel A (aids relative to physicians) and Panel B (other personnel relative to physicians) of Table 8. The ratio of the marginal rate of substitution between physician aids and physicians to the relative price of aids equals 1.644 and is significantly greater than one [t = 8.59 based on equation (8)]. The ratio of the marginal rate of substitution between other personnel and physicians to the relative price of other personnel equals .554 and is significantly less than one (t = -5.65). It follows that CHCs underutilize physician aids relative to physicians and overutilize other personnel relative to physicians. Put differently, the same output could be produced at a lower cost by raising the ratio of physician aids to physicians and by lowering the ratio of other personnel to physicians.

There is a considerable amount of variability in the marginal rate of substitution-relative price ratios in Table 8. The coefficient of variation of RPAP equals 82.5 percent and that of ROP equals 257.0 percent. This

TABLE 8

Definition of Variables in Inefficiency Analysis

Variable	Mean	Standard Deviation	Definition
Panel A: Physician Aids versus Primary Care Physicians			
1. MRSPAP	.305	.291	Marginal rate of substitution in production between physician aids and primary care physicians in absolute value; ratio of marginal product of aids to marginal product of primary care physicians
2. WPAP	.185	.030	Wage of a physician aids relative to wage of primary care physicians; PCPNI divided by NE
3. RPAP	1.644	1.356	Marginal rate of substitution between physician aids and primary care physicians divided by relative wage of aids; RPAP = (MRSPAP) $(WPAP)^{-1}$
4. EPA	.906	1.229	Index of inefficiency in the use of aids relative to physicians; EPA = $\lvert RPAP-1 \rvert$
Panel B: Other Medical Personnel versus Primary Care Physicians			
1. MRSOP	.075	.229	Marginal rate of substitution in production between other medical personnel and primary care physicians in absolute value; ratio of marginal product of other personnel to marginal product of primary care physicians
2. WOP	.144	.027	Wage of other personnel divided by wage of primary care physicians; OHPE divided by PCPNI

(continued on next page)

TABLE 8 (continued)

Variable	Mean	Standard Deviation	Definition
Panel B: Other Medical Personnel versus Primary Care Physicians (continued)			
3. ROP	.554	1.424	Marginal rate of substitution between other personnel and primary care physicians divided by relative wage of other personnel; ROP = (MRSOP) $(WOP)^{-1}$
4. EO	.539	.821	Index of inefficiency in the use of other personnel relative to physicians; EO = $\lvert ROP-1 \rvert$
Panel C: Determinants of Inefficiency[a]			
1. POV	19.375	12.048	Percentage of population in poverty in county in which a given center is located
2. SOURCE	.147	.400	Number of sources of medical care for poor people per thousand poor people in county in which a given center is located in 1978. Number of poor people equals population of the county in 1978 multiplied by the percentage of the population in poverty in 1969. Sources include number of hospitals with outpatient departments, number of maternal and infant care projects, number of children and youth projects, and number of community health centers other than the one in question. All sources pertain to 1978

(continued on next page)

TABLE 8 (concluded)

Variable	Mean	Standard Deviation	Definition
Panel C: Determinants of Inefficiency[a] (continued)			
3. SIZE1	.271	.445	Dichotomous variables that indicate size of county in which a given center is located. SIZE1 equals one for greater metropolitan counties (counties in SMSAs with population of one million or more in 1970); SIZE2 equals one for lesser metropolitan counties (counties in SMSAs with population of less than one million in 1970); SIZE3 equals one for adjacent counties (counties adjacent to the metropolitan counties and having easy access to the central city in the metropolitan area); omitted category pertains to semirural or rural counties
4. SIZE2	.209	.407	
5. SIZE3	.286	.453	

[a]Determinants from Table 2 are not listed in this table.

variability is highlighted in Table 9, which contains frequency distributions of RPAP (Panel A) and ROP (Panel B). Note that, although CHCs employ too few physician aids on average (RPAP exceeds one on average), approximately 31 percent of all centers employ too many aids (RPAP is smaller than one for 31 percent of the centers). Similarly, although the centers employ too many other personnel on average approximately 21 percent of all centers employ too few other personnel. Given the degree of variability in these measures, it is very worthwhile to study the determinants of inefficiency in the selection of inputs.

In Section III it was indicated that the relative prices of physician aids and other personnel used here may understate the true prices because the AHA earnings data exclude fringe benefits. To examine the impact of this potential bias, it was assumed that the ratio of fringe benefits to wages equals 25 percent. Location-specific relative prices were multiplied by a factor of 1.25, and RPAP and ROP were recomputed. Clearly, this adjustment lowers RPAP and ROP, but the former remains significantly greater than one, while the latter remains significantly smaller than one. Moreover, the results of the study of the determinants and effects of inefficiency are very similar to those reported in Sections V.B and V.C.

Instead of calculating RPAP and ROP for each center and then averaging, one can compute them at the sample means [see equation (9)]. Denoting the resulting measures by $\widehat{RPAP}$ and $\widehat{ROP}$, one obtains $\widehat{RPAP} = 1.791$ and $\widehat{ROP} = .958$. These estimates are misleading in two respects. In the first place, relative input prices vary among locations and centers. In fact, the coefficients of variation of WPAP and WOP (16.2 percent and 18.8 percent, respectively) exceed the coefficients of variation of PCPNI, NE, and OHPE

TABLE 9

Frequency Distribution of Marginal Rates of Substitution Divided by Relative Wage Rates

Interval	Percent
<u>Panel A: RPAP</u> (mean = 1.644, standard deviation = 1.356)	
< 0.00	0.31
0.01 - 0.49	8.62
0.50 - 0.99	22.46
1.00	5.85
1.01 - 1.49	22.15
1.50 - 1.99	14.46
2.00 - 2.49	8.31
2.50 - 2.99	6.15
3.00 - 3.49	4.61
3.50 - 3.99	2.77
> 4.00	4.31
<u>Panel B: ROP</u> (mean = .554, standard deviation = 1.424)	
< 0.00	3.08
0.01 - 0.49	30.15
0.50 - 0.99	45.23
1.00	0.31
1.01 - 1.49	16.00
1.50 - 1.99	3.38
> 2.00	1.85

(11.3 percent, 9.7 percent, and 12.2 percent, respectively). These patterns emerge because physicians are relatively well paid in rural areas, while nurses and other hospital personnel are relatively well paid in large urban areas. Therefore, even if all centers desired to produce the same output in the least-cost manner, they would employ different combinations of inputs. In the second place, even if relative input prices do not vary, incentives for inefficient input choices may differ among CHCs.[42]

Our results with respect to the underutilization of physician aids and the overutilization of other personnel may be compared with studies of the efficient selection of inputs by private sector physicians. Using samples of physicians for 1965 and 1967 from Medical Economics, Reinhardt (8) concludes that physicians underutilize aids. The aid input in his study pertains to the sum of registered nurses, medical technicians, and office aids. Since he does not distinguish among inputs, his findings cannot be compared directly with ours. Using data from the 1976 HCFA Physician Practice Cost Survey, Brown and Lapan (13) conclude that physicians underutilize registered nurses, practical nurses, and physician assistants, overutilize secretaries, and use about the correct number of technicians. Except for the last finding, these results are very similar to ours. Moreover, Brown and Lapan exclude from their sample physicians who belong to equal cost sharing groups because they argue that such physicians may not have incentives to minimize costs. The point we wish to emphasize is that there is little evidence that profit-motivated private physicians make more efficient selections of inputs than CHCs.[43]

B. Determinants of Allocative Inefficiency

Table 10 contains regressions in which the dependent variable is the index of inefficiency in the selection of physician aids relative to physicians (EPA). This index is highly correlated (r = .675) with the index of inefficiency in the selection of other personnel relative to physicians (EO).[44] Results obtained with the latter index as the dependent variable are very similar to those obtained in Table 10. We focus on the determinants of EPA because it has a larger impact on average cost than EO (see Section V.C). Seven regressions are presented in the table because we view the analysis of the determinants of inefficiency as tentative and exploratory rather than as definitive and conclusive. In all regressions the measures pertaining to the age distribution of medical users are included. We have no specific hypotheses concerning the effects of these variables, but it is worth controlling for differences in casemix among centers. In any case, only four of the twenty-eight age distribution effects are significant at the 5 percent level--those associated with the fraction of users ages 65 and over in regressions (10-3), (10-4), (10-5), and (10-7).

We have already developed hypotheses with regard to the impacts of the fractions of receipts obtained from various sources on inefficiency (see Section III). Dramatic evidence in support of these hypotheses is revealed by the regressions. Regardless of the other variables held constant, increases in the fractions of receipts received from Medicaid and from private health insurance companies cause statistically significant increases in inefficiency, while an increase in the fraction of receipts received from patients leads to a statistically significant reduction in inefficiency. The coefficient of the Medicare variable has the "wrong sign," but it is

TABLE 10

Determinants of Inefficiency in the Selection of
Physician Aids Relative to Physicians

	Regression Number						
Variable	10-1	10-2	10-3	10-4	10-5	10-6	10-7
FM04	.426	-.449	.607	.169	.241	-.110	.301
	(.49)	(-.50)	(.95)	(.27)	(.38)	(-.12)	(.47)
FM59	3.332	2.388	4.308	3.348	2.588	4.617	2.677
	(1.27)	(.89)	(2.26)	(1.79)	(1.39)	(1.66)	(1.42)
FM1019	-2.890	-3.008	-1.890	-1.787	-1.450	-2.516	-1.403
	(-1.66)	(-1.68)	(-1.50)	(-1.43)	(-1.17)	(-1.36)	(-1.12)
FM65	.428	.933	2.019	2.548	2.778	2.018	3.211
	(.30)	(.63)	(1.98)	(2.47)	(2.72)	(1.30)	(3.02)
AGE	.105		.035		.038		.039
	(5.04)		(2.20)		(2.47)		(2.53)
OCH	-.663		-.210		-.114		-.068
	(-3.76)		(-1.61)		(-.88)		(-.49)
MEDICAID		4.339		2.092	1.941		1.789
		(7.15)		(4.75)	(4.38)		(3.83)
MEDICARE		-.774		-1.161	-1.708		-1.338
		(-.40)		(-.86)	(-1.27)		(-.96)
PVTINS		2.179		1.191	1.377		1.305
		(3.80)		(2.95)	(3.43)		(3.20)
PATIENT		-1.585		-.811	-.589		-.537
		(-3.61)		(-2.63)	(-1.88)		(-1.65)
OME			.027	.027	.025		.024
			(17.01)	(18.32)	(15.70)		(15.45)
POV						.002	-.005
						(.26)	(-1.04)

(continued on next page)

TABLE 10 (concluded)

	Regression Number						
Variable	10-1	10-2	10-3	10-4	10-5	10-6	10-7
SOURCE						-.067 (-.40)	-.052 (-.48)
SIZE1						-.531 (-2.89)	-.032 (-.24)
SIZE2						-1.164 (-5.41)	-.142 (-.86)
SIZE3						-1.106 (-5.29)	-.081 (-.50)
CONSTANT	1.175 (2.34)	1.054 (2.19)	.091 (.21)	.063 (.19)	-.012 (-.03)	1.536 (3.09)	.042 (.11)
R^2	.228	.220	.597	.622	.634	.146	.638
F	15.70	11.14	67.00	57.67	49.38	5.98	33.98

[a]t-ratios in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratio associated with each regression is statistically significant at the 1 percent level of significance.

not significant. Moreover, as already noted, CHCs receive a very small proportion of their receipts from Medicare. Of the three significant financing effects, that associated with the Medicaid variable is the largest. In the most complete specification [regression (10-7)], a hypothetical center that is fully funded by Medicaid would have an inefficiency index 1.79 points larger than a center that is fully funded by grants. To gauge the magnitude of this differential, note that the inefficiency index has a mean of .91 and a standard deviation of 1.23. Hence, the differential is very large; it amounts to 196.7 percent of the mean of the inefficiency index and to 145.5 percent of the standard deviation of the index. Put differently, an increase in the fraction of Medicaid receipts from zero to one raises the inefficiency index by almost one and one-half standard deviations.

It was indicated in Section III that non-NHCs are likely to receive a larger percentage of receipts on a prepaid basis than NHCs. This percentage also is likely to be negatively related to the number of years that a center has been in operation. These factors suggest a positive effect of AGE on inefficiency and a negative effect of OCH. Another reason for expecting these effects is that the newer non-NHCs designs emphasize small group practices which offers a somewhat limited range of services. To the extent that large scale operations promote inefficiency (see below), non-NHCs should be more efficient than NHCs, and newer centers should be more efficient than older centers. A final reason for expecting such effects is that the design and funding of newer centers and non-NHCs occurred at a time when the emphasis of U.S. health policy shifted from a concern with equity in the 1960s to a concern with efficiency in the 1970s. Support for these hypotheses is contained in the regressions in Table 10. The coefficient of AGE is positive and significant in all regressions in which it is included. The coefficient of OCH always is negative, but it is significant only when the number of onsite medical encounters is excluded from the regression. Of course, AGE and OCH are negatively correlated. When the former variable is omitted from the regressions, the coefficients of the latter are negative and significant.

Theoretically, the effect of output, measured by the number of onsite medical encounters, on inefficiency is expected to be U-shaped. That is, inefficiency first should decline as output rises, reach a minimum value at a certain output, and then begin to rise as output rises. The forces that generate this relationship are similar to those that generate a U-shaped average cost function. The principal source of declining inefficiency is randomness of demand. On any given day, the administrator of a CHC cannot predict with perfect certainty the number of patients who will require services. Hence, in order to treat a certain percentage of potential patients, some excess amount of the key physician input is required. As output rises, the variability in demand tends to decline and a more appropriate input mix can be selected. The increasing complexity of large scale operations is the basic cause of an increase in inefficiency beyond some output. If the chief administrator of a CHC is a nonphysician, he may find it difficult to select the cost-minimizing mix of a large number of highly skilled physicians relative to other inputs. Even if the administrator is a physician, the limited amount of his own time input may inhibit the selection of an appropriate combination of inputs at large output levels.

The estimated output effects, given by the coefficients of the number of onsite medical encounters (OME) in regressions (10-3), (10-4), (10-5), and (10-7), are positive and very significant; the t-ratios range from 15.45 to 18.32. Moreover, the impacts are numerically large. Based on regression (10-7), a one standard deviation increase in output causes the inefficiency index to rise by .42 of a standard deviation. Linear, rather than quadratic, output effects are shown in Table 10. If the square of output (OMESQ) is added to the set of independent variables in regression (10-7), the coefficient of OMESQ is negative and significant, while that of OME is positive and significant.[45] The output that "maximizes" inefficiency occurs, however, beyond the range of observations. These results suggest that the forces associated with the complexity of large scale operations dominate those associated with randomness of demand throughout the range of output. Although the output effect diminishes in the quadratic specification, it is larger than in the linear specification even when evaluated at an output two standard deviations above the mean output (.039 versus .024). Therefore, the coefficient of OME in regression (10-7) is a conservative lower bound estimate of the impact of output on inefficiency.

The natural logarithm of the weighted number of onsite medical encounters is the dependent variable in the production function. Therefore, the parameter estimates of output in Table 10 would be biased if the disturbance term in the production function were correlated with the disturbance term in the inefficiency equation. To examine the extent of this bias, the total number of medical users (TMU) was substituted for the number of onsite medical encounters in regression (10-7). The coefficient of TMU was

.063 (t = 12.88). This result strengthens our confidence in the importance and magnitude of the output effect.

It is possible the impact of randomness of demand on inefficiency depends on the characteristics of the county in which a given center is located rather than on output per se. For example, demand might be more unpredictable in a sparsely populated county, in a county with a small percentage of the population in poverty, and in a county with numerous alternative sources of ambulatory medical care for poor persons. To explore this notion, the following county-specific variables are included in regressions (10-6) and (10-7): the percentage of the population in poverty (POV); the number of sources of ambulatory medical care for the poor per thousand poor people (SOURCE); and dichotomous variables that identify greater metropolitan counties (SIZE1), lesser metropolitan counties (SIZE2), adjacent counties (SIZE3), and semirural or rural counties (the omitted category). These measures, which are defined precisely in Panel C of Table 8, are constructed from the BCRR tape and from the Area Resource File.[46]

There is little evidence in the regression analysis that county characteristics are important determinants of inefficiency. In regression (10-6), which omits all center characteristics except the age distribution of users, the coefficients of POV and SOURCE have the wrong signs and are not significant. County size does appear to have a U-shaped effect on inefficiency. CHCs in small rural or semirural counties are less efficient than those in other counties, and these differentials are significant. Centers in lesser metropolitan and in adjacent counties are equally efficient (compare the coefficients of SIZE2 and SIZE3), while centers in greater metropolitan counties are less efficient than those in the two preceding types of counties. The county size differentials are not, however, significant once all center characteristics are held constant [see regression (10-7)]. In the full regression the poverty variable has the correct negative sign, but it is not significant. The coefficient of SOURCE still is negative and not significant.

In summary, it is notable that our exploratory regression analysis "explains" up to 64 percent of the variation in the inefficiency index. Consistent with a priori notions, alternative mechanisms for financing CHCs affect the efficient choice of inputs in the predicted directions. Older centers are less efficient than newer centers, and larger centers are less efficient than smaller centers.

C. Effects of Inefficiency on Costs

To estimate the cost savings associated with movements toward optimal input mixes, the inefficiency indexes are included in average cost functions in Tables 11 and 12. Table 11 contains simple regressions of average direct medical care cost (ADMC) and average total medical care cost (ATMC) on the index of inefficiency in the selection of physician aids relative to physicians (EPA) or the index of inefficiency in the selection of other personnel relative to physicians (EO). Either index has a positive impact on average cost, but the effect of EPA exceeds that of EA. Moreover, the coefficients of EPA are significant at the 1 percent level, while the coefficients of EO are not. In the full average cost specifications in Table 12, the coefficients of EPA fall somewhat relative to those in Table 11 but retain their significance. In particular, the average direct cost effect is significant at the 5 percent level, while the average total cost effect is significant at the .5 percent level. On the other hand, when EO

TABLE 11

Regressions of Average Cost on Inefficiency Indexes[a]

Variable	ADMC Regressions 11-1	ADMC Regressions 11-2	ATMC Regressions 11-3	ATMC Regressions 11-4
EPA	1.579 (4.83)		2.213 (5.33)	
EO		.876 (1.74)		1.365 (2.12)
CONSTANT	19.968 (40.00)	20.927 (42.26)	26.662 (42.06)	27.932 (44.19)
R^2	.067	.009	.081	.014
F	23.31	3.01	28.37	4.49

[a]t-ratios in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratios associated with regressions (11-1) and (11-3) are significant at the 1 percent level; those associated with regressions (11-2) and (11-4) are not significant at the 1 percent level.

TABLE 12

Estimates of Average Cost Functions, Inefficiency Index Included[a]

Variable	ADMC Regression 12-1	ATMC Regression 12-2
EPA	.931	1.986
	(1.90)	(3.16)
OME	-.059	-.092
	(-3.24)	(-3.96)
PCPNI	.074	.097
	(1.33)	(1.36)
NE	.825	.962
	(1.80)	(1.63)
OHPE	.397	.647
	(.92)	(1.17)
FPAE	-4.243	-5.666
	(-2.39)	(-2.49)
FMSSE	-4.988	-6.143
	(-.68)	(-.65)
FOE	-4.121	-8.917
	(-1.11)	(-1.86)
FM04	-3.692	-4.615
	(-.68)	(-.67)
FM59	-34.782	-38.939
	(-2.20)	(-1.92)
FM1019	4.039	3.000
	(.38)	(.22)
FM65	-13.745	-12.845
	(-1.52)	(-1.11)

(continued on next page)

TABLE 12 (concluded)

Variable	ADMC Regression 12-1	ATMC Regression 12-2
OCH	-3.576	-3.593
	(-3.12)	(-2.44)
AGE	.401	.417
	(3.05)	(2.47)
MEDICAID	11.046	12.817
	(2.66)	(2.40)
MEDICARE	-15.510	-20.973
	(-1.31)	(-1.38)
PVTINS	8.656	7.157
	(2.46)	(1.58)
PATIENT	-6.488	-9.226
	(-2.43)	(-2.69)
CONSTANT	11.346	15.131
	(1.54)	(1.60)
R^2	.321	.316
F	8.03	7.84

[a]t-ratios in parentheses. The critical t-ratios at the 5 percent level are 1.64 for a one-tailed test and 1.96 for a two-tailed test. The F-ratio associated with each regression is statistically significant at the 1 percent level of significance.

replaces EPA in regressions similar to those in Table 12, its coefficient in the ADMC function is not significant at the 5 percent level. In addition, the coefficient of EPO in the ATMC function is not significant at the .5 percent level.

The above points are emphasized because EPA and EO are highly correlated (r = .675). When both variables are included in average cost functions with no additional regressors, the coefficients of EPA rise relative to those in Table 11, while the coefficients of EO become negative. When both are included in regressions similar to those in Table 12, the coefficients of each are positive. In some instances the coefficient of EPA alone is significant, while in other instances neither is significant.[47] In all cases the coefficient of EPA exceeds that of EO. Given the strong positive relationship between EPA and EO and given the greater precision with which the EPA effects are estimated, the cost savings computations are based on regressions that exclude EO. These computations should be interpreted as the joint impacts of movements toward the optimal mixes of physicians relative to physician aids and of physicians relative to other personnel on average cost. To the extent that EPA is positively related to the inefficient use of such additional inputs as space and capital equipment, these inefficiencies also are reflected in the computations.

The inefficiency index equals zero if the actual input mix selected corresponds to the cost-minimizing input mix. Hence, the regression coefficient of the inefficiency index multiplied by its mean value gives the cost associated with allocative inefficiency or the cost savings associated with the elimination of this phenomenon. Based on regressions (11-1) and (11-3), average direct medical care cost would fall by $1.43 in 1978 dollars and average total medical care cost would fall by $2.00

in 1978 dollars if allocative efficiency were eliminated. Since the average value of onsite medical encounters equals 21,283 encounters, these savings amount to a $30,435 reduction in total direct cost on average and a $42,556 reduction in total cost on average. Put differently, the total direct cost of the entire CHC system would fall by 6.7 percent and the total cost of the system would fall by 6.6 percent. The comparable estimates from Table 12 are a $.84 drop in average direct cost, a $1.80 drop in average total cost, a $17,878 decline in the total direct cost of a typical center, a $38,309 decline in the total cost of such a center, a 3.9 percent reduction in the total direct cost of the CHC system, and a 6.3 percent decline in the total cost of the system.[48]

The calculations based on Table 11 are upper bound estimates of cost savings because EPA is related to variables that influence average cost with inefficiency held constant. For instance, an increase in the fraction of receipts received from Medicaid raises EPA and also raises average cost. Since EPA effects in Table 12 are smaller than those in Table 11, the coefficients of EPA are biased upward by the omission of correlated regressors. The calculations based on Table 12 are lower bound estimates because intercorrelations among EPA and other variables lead to somewhat imprecise estimates of the partial effect of each variable. In any event, the system-wide cost reduction due to the elimination of allocative inefficiency appears to be rather modest; it ranges from 6.3 to 6.6 percent of total cost. In summary, the empirical results in Section V indicate that there are statistically significant departures from cost-minimizing behavior. These departures have statistically significant determinants and statistically significant positive effects on average cost. But the magnitudes of the average cost effects are not large.

The estimated parameter of a given variable in the complete average cost function in Table 5 or 6 [regression (5-4) or (6-4)] is the sum of the direct effect of that variable on average cost and the indirect effect that operates through allocative inefficiency. The inclusion of the inefficiency index in the average direct or average total cost function in Table 12 permits us to isolate the direct effects and to compare them with the corresponding total effects. These comparisons are made in Panels A and B of Table 13 for the variables that are important determinants of inefficiency: the center's age; the fractions of revenues obtained from Medicaid, private health insurance companies, and patients; and the number of onsite medical encounters. Note that, if the signs of the figures in the last column are ignored, they give the indirect effect through allocative inefficiency as a percentage of the direct effect.

The most dramatic parameter changes pertain to those associated with onsite medical encounters. The negative output effect in the average direct cost function rises by 68.6 percent when the inefficiency index is held constant. The corresponding increase in the average total cost function is a whopping 119.0 percent. These results occur because the total impact of output on average cost reflects two forces that go in opposite directions. The direct effect is negative due to the existence of economies of scale. But the indirect effect is positive because larger centers use less efficient input mixes than smaller centers. Although the effects of output on average cost rise in absolute value when inefficiency is held constant, the elasticities of average cost with respect to output remain fairly small. In the average direct cost function these elasticities are -.059 at the point of means, -.159 at an output one standard deviation

TABLE 13

Total and Direct Effects of Selected Variables in Average Cost Functions

Variable	Total Effect (absolute value)	Direct Effect (absolute value)	Percentage Increase (+) or Decrease (-)[a]
		Panel A: ADMC Regressions[b]	
AGE	.434	.401	-7.60
MEDICAID	12.728	11.046	-13.21
PVTINS	9.777	8.656	-11.47
PATIENT	6.951	6.488	-6.66
OME	.035	.059	+68.57
		Panel B: ATMC Regressions[c]	
AGE	.486	.417	-14.20
MEDICAID	16.407	12.817	-21.88
PVTINS	9.550	7.157	-25.06
PATIENT	10.213	9.226	-9.66
OME	.042	.092	+119.05

[a]Defined as the ratio of the direct effect to the total effect minus one multiplied by 100.

[b]Total effects are taken from regression (5-4) in Table 5. Direct effects are taken from regression (12-1) in Table 12.

[c]Total effects are taken from regression (6-4) in Table 6. Direct effects are taken from regression (12-2) in Table 12.

above the mean output, and -.280 at an output two standard deviations above the mean output. In the average total cost function the corresponding elasticities are -.068, -.188, and -.337. Therefore, the average cost functions in Table 12, like those in Tables 5 and 6, are fairly flat; the departures from constant average cost are not dramatic.

The direct effect of each variable in Table 13 except for output is smaller than the corresponding total effect because the indirect effect associated with that variable works in the same direction as the direct effect. In the average direct cost function the largest percentage decline caused by the inclusion of the inefficiency index is associated with the Medicaid coefficient, which falls by 13.2 percent. In the average total cost function the 21.9 percent decline in the Medicaid coefficient ranks second to the 25.1 percent decline in the private health insurance coefficient. Note that with one exception the direct effects of age and the three financing variables are statistically significant in the regressions in Table 12.[49] Therefore, the total effects of these variables are not due solely to their impacts on allocative efficiency. It cannot be ascertained whether the direct effects are attributed to differences in casemix, scope of services, technical efficiency, or other factors.

VI. Summary and Implications

The purpose of this paper has been to assess the economic performance of community health centers in delivering ambulatory medical care to poverty populations. Throughout the paper the focus has been on the extent of departures from cost minimization, the determinants of such departures, and their impacts on the cost of services. The main empirical results in the paper and their policy implications can be summarized as follows.

Input decisions by CHCs do reflect departures from cost-minimizing behavior. In particular, the centers employ too few physician aids (nurses and physician assistants) relative to primary care physicians and too many medical support and ancillary personnel relative to primary care physicians. These findings suggest that it is misleading to criticize CHCs for employing too much non-physician labor, as has been done by the General Accounting Office (14). Instead, it is important to distinguish among different types of inputs. When compared with similar studies of the efficient selection of inputs by private sector physicians, these findings also suggest that CHCs do <u>not</u> make less efficient selections of inputs than profit-motivated private physicians. To be sure, the incentives of private physicians to minimize cost are diluted somewhat by third-party reimbursement on a fee-for-service basis. Moreover, incentives exist for CHCs to minimize cost, particularly if they seek to maximize a utility function that depends on the quantity and quality of services delivered and operate on budgets whose size is determined by the number of enrollees rather than on the amount of services delivered.

Allocative inefficiency responds to alternative financing mechanisms in the expected direction. Specifically, Medicaid or private health insurance reimbursement on a fee-for-service basis increases allocative inefficiency which in turn raises average cost. This calls into question the recommendation made by the General Accounting Office (14) that centers should try to maximize their nongrant revenue. Our results indicate that centers who receive a relatively large percentage of their revenues from grants select more appropriate input mixes than other centers and therefore have lower costs. This does not mean that Medicaid financing of CHCs should be discouraged per se. For instance, the level of allocative efficiency would not fall and might even rise if the Medicaid program were used to promote the delivery of services on a prepaid capitation basis. Under one such plan, the state Medicaid programs could make the prepayments for Medicaid-eligible persons who choose to enroll in CHCs. Under a second plan, Medicaid-eligible persons could be issued vouchers directly which they could use to enroll in CHCs. Both plans have been promoted by the Reagan Administration in an attempt to promote competition and control inflation in the health care sector. Our findings imply that a CHC system financed to a large extent by Medicaid prepayment is not inconsistent with these goals and even might help to achieve them.

The average cost function of CHCs is characterized by moderate economies of scale, but smaller centers select more appropriate input mixes than larger centers. Since the average cost function is fairly flat, the costs of building a number of centers in the same area to encourage access are not substantial. Moreover, if per capita transportation costs are considered, such a policy might even lower costs. This is because per capita transportation costs are negatively related to the number of centers in an area. In turn, the fewer the number of centers the larger is the output of any one center.

Under the assumption that the centers in our study are representative of the roughly 800 centers in existence in 1980, the CHC system-wide cost reduction due to the elimination of allocative inefficiency amounts to $32 million in 1978 dollars. At a time of tight Federal and state budgets and a rapid rate of inflation in the cost of medical care, a cost reduction of this magnitude should be encouraged if it is not too difficult to achieve. But the decline in cost is modest; it equals approximately 6 percent of the CHC system-wide total cost.

The above results seriously question the conventional wisdom that services in the public sector are produced less efficiently than in the private sector. We find no evidence that allocative inefficiency is more widespread among CHCs than among private sector physicians. Moreover, although there are statistically significant departures from cost-minimizing behavior in the CHC system, their impacts on the cost of care are relatively small. Elsewhere, we have shown that the CHC program has played an important role in the decline in infant mortality, especially black infant mortality, since 1965 [Goldman and Grossman (17)]. Thus, we conclude from our two studies that the CHC program is an effective vehicle to achieve the goal of improvements in the health of the poor. Substantial improvements appear to have been accomplished, and the costs in terms of departures from the optimal utilization of inputs appear to be small.

Footnotes

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[1]For detailed descriptions of the development of CHCs, see Lave and Leinhardt (1), Hollister et al. (2), Reynolds (3), Seacat (4), Davis and Schoen (5), Plaska and Manseau (6), and Roemer (7). The CHCs studied in this paper are not limited to those that follow the Neighborhood Health Center, Rural Health Initiative, or Urban Health Initiative program designs. Also included are those that follow the Family Health Center, Community Health Network, and Hospital-Affiliated Primary Care Center designs. The first two designs, which date to the early 1970s, emphasize the delivery of services on a prepaid capitation basis, the former in rural areas and the latter in urban areas. The original intent was for the state Medicaid program to make the prepayment for Medicaid-eligible

persons. This did not meet with great success, and the family health center and network terms were dropped. Support for these centers through Medicaid fee-for-service payments has gradually increased [Roemer (7)]. The latter design is more recent and pertains to a primary care group practice operating in a hospital outpatient department with a billing and cost structure that is distinct from the rest of the hospital. For more information on these designs, see Plaska and Manseau (6).

[2] Maternal and infant care projects originated in the 1963 amendments to Title V of the Social Security Act of 1935. Children and youth projects originated in the 1965 amendments to Title V. Federal subsidization of clinics that deliver family planning services to low-income women initially can be traced to the 1967 amendments to Title V. Federal efforts in this area were expanded in 1970 with the passage of the Family Planning Services and Population Research Act (Title X of the Public Health Services Act). Note that other types of clinics within the Federal delivery system, such as Appalachian health centers, black lung clinics, and migrant health centers, are not considered either conceptually or empirically in this paper. This is because these clinics are few in number and relatively new. Moreover, unlike CHCs, black lung clinics focus on one particular disease, while migrant health centers service transitory population groups.

[3] See, for example, Reinhardt (8), Kehrer and Zaretsky (9), Smith et al. (10), Gollady et al. (11), Zeckhauser and Elliastam (12), and Brown and Lapan (13).

[4]In addition to efficiency in the production of ambulatory care, there are two other standards to evaluate the CHC system. These are the efficiency of this public health system in identifying low-income, medically underserved areas with poor initial health levels and the impact of the centers on health outcomes. We have studied these issues elsewhere [Goldman and Grossman (17)].

[5]If factor supply curves are not perfectly elastic, condition (3) still holds provided each supply curve has the same constant elasticity.

[6]We have experimented with a second measure of inefficiency given by

$$\hat{e}_{ijt} = (r_{ijt} - 1)^2 \quad .$$

Results obtained with this measure were very similar to those obtained with the measure described in the text.

[7]See, for example, Reinhardt (8), Kehrer and Zaretsky (9), Brown and Lapan (13), Feldstein (25), Boaz (26), and Pauly (27).

[8]Empirically, we examine both the efficient choice of physician aids relative to physicians and the efficient choice of other personnel relative to physicians. Sometimes the actual value of the physician input as well as the natural logarithm of this input is included in the transcendental production function. We experiment with this specification in Section IV. The properties of the production function highlighted below are not altered by the inclusion of y_{1t} in the function.

[9]This follows because

$$\frac{\partial(f_{2t}/f_{1t})}{\partial y_{2t}} = 2\alpha_1^{-1} \alpha_3 y_{1t} \quad ,$$

which is positive if α_3 exceeds zero.

[10]Boaz (26) computes a measure which is similar to r_{21t} but does not examine the determinants of inefficiency or its role in the average cost function.

[11]For detailed discussions of allocative and technical efficiency, see Leibenstein (28) and Welch (29).

[12]The above definition of economies or diseconomies of scale is more general than one based on the returns to scale parameter in the production. A production function has constant returns to scale if output doubles when all inputs double, increasing returns to scale if output more than doubles, and decreasing returns to scale if output less than doubles. If input prices are independent of the level of inputs, increasing returns to scale implies falling average cost, decreasing returns implies rising average

cost, and constant returns implies constant average cost. The definition in the text is more comprehensive because a production function could have constant returns to scale, but average cost could rise with output if some inputs could not be varied and fall with output if input prices fell as the amounts of the inputs purchased rose.

[13]Let c be the total product cost of output x, and let q be total patient and employee transportation cost associated with output x. Total cost inclusive of transportation cost is

$$c^* = c + q \quad ,$$

and average cost is

$$(c^*/x) = (c/x) + (q/x) \quad ,$$

or

$$ac^* = ac + t \quad .$$

Differentiate the last equation with respect to x to obtain

$$(dac^*/dx) = (dac/dx) + (dt/dx) \quad .$$

If dt/dx exceeds zero, dac*/dx may exceed zero even if dac/dx is less than zero.

[14]Suppose that a policy maker wants to minimize the total cost of a given output of the <u>entire</u> CHC system in the United States, and suppose that all centers have identical cost functions. To accomplish this goal,

output should be allocated among centers such that marginal cost is the same in each center and each center is producing at the minimum point on its average cost function. If the total output of the system is less than the output of each center multiplied by the number of centers, some centers should be closed down. [For proof of this proposition and modifications in the case when cost functions differ, see Patinkin (37)]. Normatively, since CHCs service all parts of the United States, minimization of the total cost of the combined output of the system is not a realistic policy goal.

[15] If the average cost function is linear, the parameter estimate of β_1 still is biased away from zero. In particular, the estimated value is negative if the true value is zero.

[16] For a detailed description of the BCRR tape, see Bureau of Community Health Services (39).

[17] The BCRR tape contains data for 1977, but there is an extremely large number of missing values for that year. Neighborhood health centers are not designated as such on the tape. We identified them based on an earlier BCHS publication (40).

[18] Psychiatric encounters are reported as a separate category, but they account for less than 1 percent of all medical encounters. These encounters are excluded from the medical encounter variable used in this study.

[19] In the case of NHSC personnel, the centers must reimburse a portion of their salaries to the Federal government. The reimbursement formula is based in part on the revenues generated by these personnel.

[20]In fact the initial service date must be June 1978 or earlier. This eliminates centers who began to operate in the latter part of 1978 and thus have limited data for that year.

[21]This count excludes centers who failed to file at least one report during the period from 1977 through 1980. It also excludes centers located in Puerto Rico and the Virgin Islands.

[22]Strictly speaking, missing values cannot be distinguished from zero values on the BCRR tape. The algorithm used here is to assume that zero values for the above variables denote missing data, while zero values for other variables are "true zeros."

[23]Offsite encounters are reported separately. They pertain to encounters both between CHC users and CHC staff and between CHC users and nonstaff. These two types of offsite encounters cannot be distinguished.

[24]Other inputs, such as medical equipment, floor space, and administrative personnel, are omitted from the production function. These exclusions are due to the absence of disaggregated measures in physical units and due to the problem of allocating inputs that generate indirect costs.

[25]For a justification of the use of average cost weights, see Feldstein (25).

[26]Feldstein (25) argues that the average cost weights obtained by the above procedure can be viewed as useful approximations even when average cost depends on output and other variables.

[27]The regression also was estimated with average total medical care cost as the dependent variable. The weights obtained were almost identical in relative terms to those reported in the text. Note that little should be inferred about the wage rate of physician aids relative to primary care physicians from the regression results because an aid may spend a longer amount of time with a patient at an encounter than a primary care physician.

[28]The above measure differs from but is highly correlated with ($r = .984$) a simple two-year average of unit cost in each year. The variable used is a weighted average of annual unit cost, where the weight is the fraction of encounters in each year.

[29]It should be stressed that the assumption of constant average cost in the production context simply is used to approximate a set of weights to calculate weighted output. Moreover, our main reason for fitting production functions is to examine inefficiency in the selection of inputs rather than to examine the extent of economies of scale.

[30]All centers are small employers relative to their local market areas. Therefore, there is little reason to expect them to have significant amounts of monopsony power.

[31]The ten Federal regions and the states within each region are as follows:

Boston	(Maine, Vermont, Mass., Conn., R.I., N.H.)
New York	(N.Y., N.J.)
Philadelphia	(Penn., Del., D.C., Maryland, Va., W. Va.)
Atlanta	(Ala., Fla., Georgia, Ky., Miss., N.C., S.C., Tenn.)
Chicago	(Ill., Indiana, Minn., Michigan, Ohio, Wisconsin)
Dallas	(Arkansas, N.M., Oklahoma, Texas, Louisiana)
Kansas City	(Iowa, Kansas, Missouri, Nebraska)
Denver	(Colo., Montana, N.D., S.D., Utah, Wyoming)
San Francisco	(Ariz., Calif., Hawaii, Nev.)
Seattle	(Alaska, Idaho, Oregon, Washington).

These designations are based on the city in which each of the ten Federal regional offices is located.

[32] In the computation of mean net income by region and size of county, observations are weighted by the inverse of the probability of selection. The resulting weighted means are, however, very similar to unweighted means. Net income of medical and surgical specialists is excluded from the cost function because it is highly correlated with net income of primary care physicians (r = .652). Moreover, as mentioned above, we do not study the efficient choice of these two types of personnel.

[33] The above analysis also applies if CHCs reimburse the Federal government for k percent of the wages of NHSC personnel. In that case, the relevant price of input y_i is the net price:

$$w_i = \hat{w}_i (1 - k) \quad ,$$

where $\hat{w}_i$ is the gross price (the wage actually received by input y_i). It is clear that

$$(w_i/w_j) = (\hat{w}_i/\hat{w}_j) \quad .$$

[34]When the marginal product of an input becomes negative, the isoquant begins to slope upward.

[35]Statements concerning statistical significance in the text are based on one-tailed tests except when the direction of the effect is unclear on a priori grounds or when the estimated effect has the "wrong sign." In the latter cases two-tailed tests are used.

[36]If α_2 is the regression coefficient of PA and α_3 is the regression coefficient of PASQ, the output elasticity of PA is α_1 PA + $2\alpha_2$ PASQ. Output elasticities of O and MS are obtained in the same manner.

[37]The above comments also apply to the average cost functions that include the inefficiency index in Section V.

[38]Sometimes the elasticity of the average cost function is defined as the elasticity of output with respect to average cost. If this convention is used, the ADMC elasticities are -28.57 at the mean, -10.59 at one standard deviation above the mean, and -6.54 at two standard deviations above the mean. The corresponding ATMC elasticities are -32.26, -12.35, and -7.41.

[39]One explanation of the negative Medicare reimbursement effect is that the variable is a proxy for the percentage of elderly medical users who are eligible for Medicare, and these users have minor medical problems. Davis and Schoen (5) report that the elderly poor are under-represented in the population of patients treated in CHCs. This may be because the CHCs cannot provide adequate medical care for some of the serious medical problems associated with old age or because the elderly

are less mobile than other groups in the population. Hence, elderly medical users of CHCs probably are relatively healthy. Note that an increase in the fraction of users ages 65 and over (FM65) leads to a reduction in average cost.

[40]The omission of OHPE or NE slightly weakens the coefficients of PCPNI because as explained in Section V PCPNI is negatively correlated with these two variables. But the coefficients of PCPNI retain their significance at the 10 percent level.

[41]This is the relevant test because the direction of the effect is unclear on a priori grounds. To the extent that offsite encounters occur in hospitals, they should be more expensive. It is likely, however, that some of the costs of offsite encouners are not reported.

[42]In the computation of $\hat{RPAP}$, the mean of NE divided by the mean of PCPNI is used rather than the mean of WPAP. The mean of WPAP is, however, almost identical to $\overline{NE}/\overline{PCPNI}$. The same comment applies to the computation of $\hat{ROP}$. As shown by equations (9) and (10), $\hat{RPAP}$ exceeds $\overline{RPAP}$ and $\hat{ROP}$ exceeds $\overline{ROP}$. The difference between $\hat{ROP}$ and $\overline{ROP}$ is larger than that between $\hat{RPAP}$ and $\overline{RPAP}$ because the standard deviation of other personnel exceeds that of physician aids and because the simple correlation between other personnel and physicians ($r = .880$) exceeds that between physician aids and physicians ($r = .675$).

[43]Both Reinhardt (8) and Brown and Lapan (13) make efficiency computations at sample means rather than making them separately for each physician and then averaging. In the latter study this may not introduce much

bias because equal cost sharing groups are excluded. Note that our interpretation of Brown and Lapan's results differs somewhat from their own interpretation. They estimate a production function with six inputs and examine the efficient choice of each input relative to physicians. But they also compute a weighted (by hours worked) average of the marginal product of all five aids. From this computation, they conclude that physicians employ the appropriate number of aids. We question the value of this calculation since the composite aid input is disaggregated in the production function.

[44]The marginal product of physician aids is negative for one center and that of other personnel is negative for ten centers. Hence, RPAP has one negative value and ROP has ten negative values. When RPAP is negative, the inefficiency index is given by a simple average of EPA and a value slightly greater than the maximum value of EPA for the 324 centers for whom RPAP is positive. A similar procedure is employed when ROP is negative. This estimate is used because, if the marginal product of one input is negative, the inefficiency index may be a misleading indication of the magnitude of the departure from cost minimization. Since very few centers have negative marginal products, the results in Sections V.B and V.C are not sensitive to this procedure.

[45]Coefficients of independent variables other than OME are not affected by the inclusion of OMESQ.

[46]The Area Resource File is a county-based data service prepared by Applied Management Sciences, Inc., for the Bureau of Health Professions, Health Resources Administration, U.S. Department of Health and Human Services.

[47]In all cases EPA and EO taken as a set are significant determinants of average cost.

[48]Estimates of cost savings are not sensitive to alternative computational methods. For example, the estimates are similar to those reported in the text if the computations are made separately for regressions with EPA or EO and then averaged.

[49]The exception pertains to the coefficient of private health insurance in regression (12-2).

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