

# Home health care cost-function analysis

by Joel W. Hay and George Mandes

*An exploratory home health care (HHC) cost-function model is estimated using State rate-setting data for the 74 traditional (nonprofit) Connecticut agencies. The analysis demonstrates U-shaped average costs curves for agencies' provision of skilled nursing visits, with substantial diseconomies of scale in the observable range. It is determined from the estimated*

*cost function that the sample representative agency is providing fewer visits than optimal, and its marginal cost is significantly below average cost.*

*The finding that an agency's costs are predominantly related to output levels, with little systematic variation due to other agency or patient characteristics, suggests that the economic inefficiency in a cost-based HHC reimbursement policy may be substantial.*

## Introduction

Home health care (HHC) services represent a large and rapidly growing segment of the U.S. health care market. Federal HHC expenditures alone have risen at an annual rate of 30-50 percent over the past decade, and currently exceed \$1 billion annually (HCFR, 1980). The HHC industry is now comprised of over 6,500 agencies providing close to \$5 billion of HHC services (Mandes, 1982; Kleinfield, 1983). Despite the rapid expansion of HHC programs in both public and private sectors, little research has been carried out concerning market structure, production function, or cost-function analysis for HHC agencies. HHC is increasingly presented as a cost-effective alternative to expensive institutional care. Careful consideration of HHC's potential to augment or substitute for institutional care will require an understanding of the micro-economic characteristics of HHC agencies.

The HHC industry has been traditionally characterized by nonprofit agencies, both private (for example, Visiting Nurse Associations) and public (for example, city Public Health Nursing Departments), which have tended to divide the market into distinct geographic territories. As in the nursing home industry, however, the rapid expansion of HHC demand in the past 20 years has led to a substantial degree of market restructuring. Proprietary and hospital-based agencies have captured significant shares of both the public and private markets<sup>1</sup> (Monier et al., 1981). Territorial delineation of the market has thus been somewhat eroded.

## Literature review

The economic literature has focused almost exclusively on determination of the cost savings potential of HHC services compared with institutional care. No studies of HHC agency production or cost functions have been made. Market structure analysis has been limited to descriptive statistics concerning the number of agencies in each provider class<sup>2</sup> (Monier et al., 1981).

<sup>1</sup>This is more correct in some regions of the country (for example, the South and West) than in others.

<sup>2</sup>For example, proprietary/nonprofit, free-standing/hospital-based, and so forth.

Reprint requests: Joel W. Hay, Project Hope Health Sciences Education Center, Millwood, VA 22646.

Kurowski et al. (1979) provide a detailed analysis of Medicare cost per episode data from four Massachusetts and four Pennsylvania HHC agencies. They find a considerable variation across diagnosis code in charges per HHC episode. Although they do not compare HHC with institutional care directly, they suggest that institutional care may not be more expensive than HHC for some types of elderly patients currently receiving HHC services. Kurowski et al. (1979) present evidence of economies of scale in the provision of HHC services. However, their sample is limited to only eight HHC agencies and is not therefore well-suited to studying agency-level production or cost variation.

Day (1980) examines the utilization of HHC services provided by the San Francisco Home Health Services Agency to 7,420 clients between 1957 and 1975. Since only one HHC agency was involved, Day is unable to analyze issues relating to market structure or provider cost variation. She has information on private insurance and self-pay patients, as well as Medicare patients, and is thus able to compare the relative importance of patient demographic and diagnostic characteristics with the economic and financial incentives they face in consuming HHC services. Day finds the economic and financial factors to be more influential than demographic and diagnostic characteristics in explaining HHC utilization patterns.

## Analytic approach

The selection of an appropriate economic model of behavior for nonprofit HHC agencies is not an easy task. Profit maximization would not, at first glance, appear to be an adequate behavioral description, and yet, as with the hospital sector, it may be an appropriate approximation in certain contexts. Revenue, output, or utility maximization (all subject to a zero-profit constraint) may better represent the motivation of nonprofit HHC agencies. Since the focus of this analysis is on the determination of costs, the underlying behavioral assumption is crucial only if it implies an agency utilization of inputs that is not cost minimizing for the chosen price and output combination.

Cost minimization will occur, however, as long as the agency objective function can be represented in the form

$$B(q(x)) - \lambda xr, \quad (1)$$

where  $B(\cdot)$  is a benefits function evaluated in monetary terms,  $q(\cdot)$  is a production function,  $x$  is a vector of inputs,  $r$  is a vector of input prices, and  $\lambda$  is a scalar normalization parameter. Eq. (1) includes as special cases competitive and monopolistic profit maximization, as well as output and revenue maximization subject to profit constraints. It is thus not limited to the traditional economic behavioral models.

## Data and estimation methodology

The data were taken primarily from HHC agencies' 1981 cost reports submitted to the Connecticut Commission on Hospitals and Health Care. The study consists of all 74 traditional (nonprofit, noninstitutionally-based) HHC agencies. Nontraditional agencies were excluded because their cost reports were not directly comparable.<sup>3</sup> The data are based on costs incurred in the October 1980 to October 1981 period—\$29.5 million in total costs (approximately 60 percent of the total State HHC market); these 74 agencies constitute the majority of the 117 State-licensed HHC agencies.

HHC agencies are multiproduct firms, producing services such as home health aide, skilled nursing visits, and, often, physical, speech, and occupational therapy visits. Moreover, nonprofit HHC agencies frequently produce a variety of nonHHC services, ranging from school health education programs to well-baby examinations. Instead of analyzing the entire range of services, skilled nursing visits was focused on as the output measure because it is the only service that all agencies provide, and it constitutes 45 percent of business for the study agencies. The agencies must report the portion of their costs that are allocable to skilled nursing visits for Connecticut Medicaid's rate setting.

Cost functions were estimated in this form,

$$C_i = a + b_1 Q_i + b_2 Q_i^2 + X_i d + \epsilon_i, \quad (2)$$

where  $C_i$  represents total skilled nursing costs for agency  $i$ ;  $Q_i$  represents this agency's skilled nursing visits;  $X_i$  represents a vector of factors assumed to influence agency costs, and  $\epsilon_i$  is a random error term. The primary hypothesis of the analysis is examined through tests on the estimated parameters  $b_1$ ,  $b_2$ . If  $b_1$  is positive and  $b_2$  is not significantly different from zero, the HHC agencies can be said to approach constant returns to scale as output increases. If  $b_2$  is sufficiently positive, then the agencies demonstrate decreasing economies of scale and vice versa.<sup>4</sup>

<sup>3</sup>Starting in 1982, all HHC agencies in Connecticut were required to submit uniform cost-accounting reports.

<sup>4</sup>Technically, the agency demonstrates decreasing (increasing) economies of scale if  $b_2 > (<) C/Q_i^2$ , where  $C = a + X_i d$ .

Since the analysis is limited to publicly available data sources, many of the potentially important factors—that is, patient demographic, socioeconomic, diagnostic, and case mix measures, and so forth—were not obtainable. However, agencies' budget item cost shares were used as proxies to capture cost variation due to complexity and intensity of services provided. The justification for this approach is as follows: If certain patient characteristics systematically lead to higher costs for an agency (with quantity and factor prices constant), this will be reflected in a relatively greater percentage of resources being devoted to indirect inputs (that is administration, clerical, space, transportation, and office expenses) and a relatively smaller percentage of an agency's resources being devoted to direct medical care (that is, nursing and medical supply expenditures). Conversely, if patient characteristics do not affect the allocation of an agency's resources between direct and indirect inputs to HHC production (with output and factor prices constant), it is difficult to maintain that patient characteristics have a systematic impact on an agency's cost variation.

In line with this view, costs are hypothesized to increase as greater percentages of an agency's expenses are devoted to indirect inputs, reflecting a higher complexity of services, a relatively more difficult service population, or possible managerial inefficiency. Costs are expected to decrease as the direct care cost rises, reflecting a less complex service pattern, absorbing relatively less paperwork, record-keeping, analysis, or other back-up services, and more actual HHC services.

An additional variable representing the percentage of an agency's business devoted to skilled nursing visits is also included in the analysis. It is expected that if increasing economies of scale are found, the estimated coefficient of this variable will be negative, reflecting the advantages of specializing in skilled nursing services delivery for any given level of an agency's costs; the opposite will be true if decreasing economies of scale are found.

A set of regional dummy variables is included to pick up geographic variation in factor prices, regional income, demographic characteristics, and so forth. Agencies were grouped into the five Health Systems Agency (HSA) regions of Connecticut. A dummy variable indicating if an agency was an urban core provider is also included. It is expected that inner city agencies will be more expensive, reflecting the lack of private patients (given the lower socioeconomic status of their patient populations) and the higher urban wages and prices. Finally, a dummy variable, indicating whether an agency belongs to the Visiting Nurse Association or the Public Health Nursing Department provider is included. No *a priori* hypothesis concerning the sign of this variable's coefficient is posited.

## Empirical results

The descriptive statistics and variable descriptions are listed in Table 1. The average cost per visit ranges from \$13.85 to \$50.88. The number of visits per agency ranges from 914 to 42,357. The percentage of business devoted to skilled nursing visits ranges from 22 to 87 percent. It is apparent that there is a broad diversity in an agency's size and manner of operations.

Table 2 presents the regression findings.<sup>5</sup> The key result is the positive and significant coefficients on VISITS and VISITS2, implying a U-shaped average cost curve with substantial diseconomies of scale within the observed range of an agency's size. For the sample representative agency, the estimated marginal cost is \$23.20, significantly less than the average cost (\$25.57), suggesting that the sample representative agency is providing less than the optimal number of visits. While this type of observed behavior is consistent with monopolistic profit maximization, it is not consistent with long-run competitive market behavior or with agency objectives, which leads to the overprovision of agency nursing services to promote social welfare. If the sample representative agency were trying to maximize revenue or output, subject to a zero profit constraint, it would be observed on the upward sloping portion of its average cost curve, not the downward sloping section.<sup>6</sup>

The representative agency's estimated average cost function, based on the Table 2 results, is

$$AC = 12044/VISITS + 20.31 + .000235 VISITS.$$

This curve reaches its minimum at 7,159 visits, about 1,000 visits per year more than the sample representative agency. If all agencies were operating at the optimal production point, the potential savings to consumers Statewide would be about 10 percent of the \$11.8 million spent for all sample agencies' skilled nursing visits.

At the margin, the agency could expand public HHC visits without losing money, since Government programs reimburse on the basis of average costs. If the sample representative agency were attempting to overprovide nursing services relative to profit maximizing behavior, as one might expect from a community service nonprofit organization, it would be observed at a point with marginal costs exceeding average costs.

Most of the other exogenous variables are not significant in the Table 2 equation, although the ones that are significant tend to conform to *a priori* hypotheses. Of the cost share variables, only MED-

SUPLY is significant, and in the expected direction.<sup>7</sup> However, this observation provides only limited support for the hypothesis that variation in patient characteristics affects agency costs since variation in indirect input cost shares is not systematically related to costs.

The Fairfield County dummy variable (HSA1) is significant, confirming the effect of the relatively high cost-of-living in southwestern Connecticut. None of the other regional dummy variables are significant despite the large urban areas in HSA2 and HSA4. Surprisingly, the URBAN dummy itself is insignificant, suggesting that the patient or diagnostic case mix characteristics of core urban HHC agencies are not sufficiently different to cause systematic variation in total agency costs. The HHCPRCNT variable is significantly positive, which is also consistent with *a priori* expectations.

Home health services are highly labor intensive (particularly skilled nursing visits), and individual HHC agencies may be presumed to be sufficiently small purchasers in the nursing labor market so as to have little impact on nurse market wages. The question of why the estimated average cost function does vary with output is thus reasonable. These data are not detailed enough to allow examination of the factors leading to curvature of the average cost function. It would seem that the small agencies (that is, less than 4,000 visits annually) may face visit scheduling inefficiencies leading to nursing staff downtime or suboptimal transportation routing. Large agencies may fall victim to excessive administrative complexities.

The  $R^2$  statistic for the regression is .96, implying that omitted variables, such as patient characteristics, can only account for an additional 4 percent of agency cost variation. This  $R^2$  value is high for a cross-sectional regression, particularly relative to most health care data. However, in comparison with hospital or physician production or cost regressions, HHC agencies provide a relatively uncomplicated set of services.

To explore the robustness of the estimated results, a number of other specifications were examined. Both logarithmic and double-log cost functions were estimated, but the results were not substantively different from those in Table 2. Moreover, the resulting average and marginal costs were not as tangibly representable in monetary terms.

To examine further whether omitted-variables biases, due to systematic differences of large urban HHC agencies, could be detected, all agencies with more than 16,000 visits were deleted from the sample. This sampling rule led to the exclusion of the seven largest Visiting Nurse Associations, representing 35 percent of the sample agency output. Estimated coefficients for the resulting subsample concurred closely with the Table 2 results in terms of signs and signifi-

<sup>5</sup>To correct for heteroskedasticity, observations were weighted by the inverse square root of VISITS.

<sup>6</sup>If agencies were constrained by demand to the downward sloping portion of their average cost curve, one would expect agency mergers to lower unit costs of production in the absence of local barriers to entry. This would follow *a fortiori* if agencies were optimizing social welfare.

<sup>7</sup>NURSE was omitted from the final specification since the sum of cost share variables is perfectly collinear with the constant term.

**Table 1**  
**Variable descriptions**

Variable	Definition	Mean	Standard deviation	Sum	Minimum	Maximum
VISTCOST	Average cost per skilled nursing unit	25.575135	6.32908	1892.5600	13.8500	50.8800
ADMIN	Share of allocable costs going to agency administration	0.143188	0.06941	10.5959	0	0.4291
NURSE	Share of allocable costs going to nursing salaries and benefits	0.319206	0.12462	23.6213	0	0.7477
CLERIC	Share of allocable costs going to clerical expenses	0.093484	0.03340	6.9178	0	0.2156
TRANSPT	Share of allocable costs going to transportation expenses	0.035667	0.02902	2.6393	0.0058	0.2402
MEDSUPPLY	Share of allocable costs going to medical supplies	0.006854	0.00601	0.5072	0.0010	0.0355
SPACE	Share of allocable costs going to space occupancy expenses	0.024152	0.01842	1.7872	0	0.0996
OFFICE	Share of allocable costs going to office expenses	0.024196	0.01535	1.7905	0.0037	0.1273
HSA1	Fairfield County Health Systems Agency (dummy variable)	0.121622	0.32908	9.0000	0	1.0000
HSA2	New Haven County Health Systems Agency (dummy variable)	0.121622	0.32908	9.0000	0	1.0000
HSA3	Eastern Connecticut Health Systems Agency (dummy variable)	0.324324	0.47132	24.0000	0	1.0000
HSA4	Hartford/Tolland Counties Health Systems Agency (dummy variable)	0.243243	0.43197	18.0000	0	1.0000
HSA5	Northwestern Connecticut Health Systems Agency (dummy variable)	0.189189	0.39433	14.0000	0	1.0000
URBAN	Agency serves core urban community (dummy variable)	0.094595	0.29465	7.0000	0	1.0000
VNA	Agency is a Visiting Nurse Association (dummy variable)	0.554054	0.50046	41.0000	0	1.0000
INTEREST	Share of allocable costs going to interest payments	0.001775	0.00555	0.1313	0	0.0271
OVERHEAD	Share of allocable costs going to other expenses	0.045175	0.02865	3.3429	0.0051	0.1837
VISITS	Annual number of skilled nursing visits	6247.45	7230.89	462312.	914.	42357.
COST	Total annual agency costs allocable to skilled nursing	159742.78	206724.72	11820965.94	24987.24	1405405.26
VISITS2	VISITS × VISITS	90609979.	258148981.	6705138452.	835396.	1794115449.
HHCPRCNT	Percentage of agency business devoted to skilled nursing (subcontractual services are excluded)	0.442663	0.13101	32.7570	0.2276	0.8650

**Table 2**  
**GLS regression: Dependent variable is COST**

Parameter	Estimates	Parameter = 0	PR >   T
INTERCEPT	- 10282.9472	- 0.69	0.4935
ADMIN	- 36679.0767	- 1.07	0.2901
CLERIC	- 3938.6991	- 0.05	0.9594
TRANSPT	43958.7214	0.37	0.7109
MEDSUPPLY	- 838595.5544	- 1.96	0.0553
SPACE	130613.7147	0.99	0.3252
OFFICE	105995.6836	0.49	0.6284
HSA1	29189.3691	2.87	0.0098
HSA2	9754.4364	0.94	0.3526
HSA3	589.2250	0.08	0.9376
HSA4	2885.4332	0.36	0.7204
URBAN	- 19000.3673	- 0.80	0.4293
VNA	- 107.3178	- 0.02	0.9848
VISITS2	0.000235	3.98	0.0002
VISITS	20.3113	11.65	0.0001
HHCPRCNT	49985.0336	2.65	0.0104

N = 74

R - Square = 0.9599

cance. The implication is that the larger HHC agencies appear to fit the same cost function as the smaller ones.

## Conclusions

Any conclusions based on this research should be characterized as tentative. The primary limitation of the analysis is the lack of numerous patient and agency characteristics that might be hypothesized to influence agency costs, but are not reported to the State rate-setting commission. Further investigation of HHC agency cost and production variation would benefit from detailed collection of data on agency and patient characteristics.

The generalizability of these findings beyond Connecticut is conjectural. By focusing on intra-State cost variation, the analysis has controlled for State to State differentials in regulatory and market conditions. However, Connecticut has a relatively highly regulated HHC market. Young and Fisher (1980) report that costs per HHC episodes and utilization rates for Medicare HHC services are significantly higher on an average in New England.

Despite these caveats, certain results deserve comment. The analysis shows a strong and robust relationship between total cost and output levels. The relationship does not appear to be substantially mediated by broad agency characteristics—that is, cost share variation, urban core location, type of provider, or HSA location. This observation raises the possibility that more detailed agency and patient characteristics will not substantially reduce residual cost variation. HHC agencies do not provide services as technically varied or complex as those provided in hospitals, thus agency cost variation is likely to be much less sensitive to provider-patient mix than would be the case for hospitals and other health care institutions.

The finding of marginal cost lower than average cost for the representative agency raises intriguing questions regarding agency objectives. It is not consis-

tent with competitive market behavior or with behavioral models that suggest a generous provision of services to maximize the agency's social welfare function. The finding is consistent with a view that agencies place the goal of institutional survival above that of maximizing patient services within a given budget. While it is possible that because of chance a period of short-run disequilibrium was observed in an otherwise competitive market, the agencies in our sample have maintained the same relative sizes for many years. Further analysis of panel cost data will shed light on whether the nonoptimality of agency costs per visit is a temporary phenomena.

A more plausible explanation of the observed non-competitive HHC market structure centers around the cost-based reimbursement methods used by Government programs (for example, Medicare and Medicaid) and health insurers to pay for HHC services. Since a large percentage of a traditional agency's skilled nursing visits is reimbursed by third parties, on an allowable cost basis, there is little incentive for an agency to produce at the minimum point on its average cost curve. Data on agency revenues as well as their costs is needed to determine (1) why agencies tend to produce at a point to the left of the minimal cost point and (2) how they price services to public and private patients. These questions are beyond the scope of this analysis.

If these empirical results are to be believed, cost-based reimbursement may not be appropriate in the HHC market. The justification for using an allowable cost-reimbursement mechanism is that market-determined prices will penalize those agencies that provide care to relatively sicker and, hence, costlier patient populations. If market mechanisms are substituted for cost-based reimbursement, agencies may compete to "cream skim" the healthiest patients so as to minimize their costs per visit. While there may be merit to this argument in the institutional health care setting, the finding that HHC agency costs are predominantly related to output levels, with little systematic variation due to agency characteristics that can be

associated with patient case mix, suggests that the cream skimming may not be a plausible HHC strategy to reduce costs per visit. Furthermore, the economic inefficiency inherent in an HHC cost-based reimbursement policy may be quite substantial.

## Acknowledgments

The authors would like to thank Neville Doherty, Terrie Wetle, Tryfon Beazoglou, Susan Reisine, and Howard Bailit for their comments on an earlier draft.

## References

- Chiswick, B.: The demand for nursing home care: an analysis of the substitution between institutional and noninstitutional care. *Journal of Human Resources*: 295-316, Vol. II; No. 3, Summer 1976
- Creese, A., and Fielden, R.: Hospital or home care for the severely disabled: A cost comparison. *British Journal of Preventive and Social Medicine* 31(2):116-121, June 1977.
- Day, S.: *Geriatric Home Care: For Whom? How Long? How Much? What Then?* Final Report. HCFA Grant #18-P-97362/5-01. Department of Health and Human Services, December 1980.
- Doherty, N., Segal, J., and Hicks, B.: Alternatives to institutionalization for the aged: Viability and cost effectiveness. *Aged Care and Services Review* 1(1):1-16, Jan./Feb. 1978.
- Health Care Financing Review*, HCFA Program Statistics. HCFA Pub. No. 03068. Office of Research, Demonstrations, and Statistics, Health Care Financing Administration. U.S. Government Printing Office, December 1980.
- Kleinfield, N. R., Home Health Care Boom, *New York Times*, 30 June 1983.
- Kurowski, B., Schlenker, R., and Tricarico, G.: *Applied Research in Home Health Services, Volume II*. Contract No. 240-77-0148. Final report prepared for the DHHS, Health Services Administration, March 1979.
- Mandes, G.: *Telecare: A Business Plan*. Unpublished master's thesis: Yale University, 1982.
- Monier, C., Matowiecki, M., and Yessian, M.: In-home services to the elderly. Office of Service Delivery Assessment, Office of the Inspector General, DHHS, September 1981.
- Weissert, W.: Costs of adult day care: a comparison to nursing homes. *Inquiry* 15(No. 1):10-19, Spring 1978.
- Widner, G., Brill, R., and Schlosser, A.: Home health care: Services and costs. *Nursing Outlook* 26(8):488-493, August 1978.
- Young, K., and Fisher, C.: Medicare episodes of illness: a study of hospital, skilled nursing facility, and home health agency care. *Health Care Financing Review*, Office of Research, Demonstration, and Statistics, Health Care Financing Administration. U.S. Government Printing Office, December 1980.