

Cost As a Study Outcome

Sensitivity of Study Conclusions to the Method of Estimating Cost

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OBJECTIVES. The analyses presented here are intended to provide empirical guidance to two questions faced by researchers performing clinical trials which include a cost component: Which health care services should we track? Should we use facility specific costs or national average costs for individual services in estimating total costs?

METHODS. We reanalyzed cost data from the Department of Veterans Affairs (VA) multisite clinical trial which compared Adult Day Health Care (ADHC) to Customary Care for patients at high risk for nursing home care. The data presented here compares the original analysis (a combination of local and national costs) to an analysis based on purely facility-specific costs and to an analysis based upon purely VA national costs. Costs for hospital, clinic, nursing home, ADHC, hospital based home care, rehabilitation, pharmacy, and laboratory were included.

RESULTS. Hospital, nursing home, clinic, and ADHC in combination account for 98% of the variation in total cost per patient. Including only hospital, clinic, nursing home, ADHC, and hospital-based home care in total cost per

patient closely replicated the findings for total cost when all services were included. The originally reported analysis and the 2 new analyses, using respectively facility specific costs and national average costs, did differ substantially in the magnitude of the difference between the total cost per patient of ADHC and Customary Care. They did differ with regard to statistical significance as the *P* values were either slightly above or below 0.05.

CONCLUSIONS. Ideally all health care costs should be included in the analysis. When this is not feasible, one should determine utilization and cost for the intervention itself, costly services (usually hospital, nursing home, and clinic care), and lower cost services that are likely to be affected by the intervention. Sensitivity analysis should be performed to determine if different methods of costing (eg, facility specific versus national costs) materially affect the conclusions of the study.

Key words: hospital cost; long-term care cost; ambulatory care cost; Department of Veterans Affairs. (Med Care 1999;37:AS37-AS44)

Clinical trials to assess the impact of a variety of health service interventions on health care and cost have been conducted both within¹⁻¹⁰ and outside of^{11,12} the Department of Veterans Affairs (VA). Within VA, for example, the interventions assessed include the following: a geriatric evaluation unit;^{1,2} hospital based home care;³⁻⁵ tele-

phone care;⁶ inpatient alcohol treatment;⁷ adult day health care;^{8,9} and primary care.¹⁰ For such studies, investigators must track the utilization of health services and assign a cost to each unit of utilization to calculate the cost for each service and the total cost of care. The investigators must select the services to be included and the manner in

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which to estimate the cost of those services. Guidelines are available for addressing those issues in general^{11,13,14} and in VA.^{15,16} Despite the guidelines, there is considerable variation between the studies noted above in the services for which utilization was assessed and in the methods used to estimate costs for those services.

The variation between studies in the specific services included is probably the result of the investigators trying to balance two factors: the study resources needed to track the utilization of the individual services for study patients versus the likelihood of the interventions having an impact on the service or the services making a meaningful difference in the total cost of care.

Several methods of determining the cost of a specific service in VA and in other organizations which do not charge for care have been outlined in some detail by Chapko et al¹⁵ and Barnett.¹⁶ Those methods include measuring input costs using the VA cost accounting system, the VA reimbursement system, and charges from surrogate health care facilities. The cost method selected for a particular study is probably based upon the investigator weighing the ease of obtaining cost data versus the presumed accuracy of the resulting estimate.

The data presented here are intended to provide empirical guidance to two questions faced by researchers inside and outside the VA doing cost analyses:

- Which services should we track?
- Should we use facility specific costs or national average costs for individual services in estimating total costs?

Those questions will be answered using data from the VA Adult Day Health Care Evaluation (ADHC) Study.^{8,9} In the original ADHC analysis, a mixture of facility-specific and national average costs at the four study sites were used. In the analysis presented here, we will examine the impact of using only facility-specific costs and only national average VA costs. Originally, we decided to primarily use facility-specific costs because we felt that they more accurately reflected the manner in which care was delivered and in which utilization was reported. For example, one site had higher reported utilization of clinic services (clinic stops) compared with the other sites because they divided care into smaller units. Therefore, they also had a lower cost per clinic stop. Using a national average cost per clinic stop would have overesti-

mated the cost of clinic care for that site. However, other researchers have argued that national averages should be used because they reduce the error inherent in any facility specific estimate of cost¹⁷ or because they help to enhance the ability to generalize the findings.¹⁶

Methods

To answer the two questions, we conducted a sensitivity analysis based upon the utilization and cost data from the Adult Day Health Care Evaluation Study.⁹ The phase of the ADHC Study of interest here was a prospective clinical trial in which VA patients at risk for nursing home placement were randomized at four VA Medical Centers to receive either adult day health care (n = 381) or customary care (n = 378). Health care utilization and costs were followed for a period of one year.

Table 1 summarizes the cost for each of the VA services included in the study as originally reported. A mixture of local and national costs were used. Those costs were obtained for 1989 from the detailed measurement of local input costs for ADHC itself, a Diagnosis Related Groups (DRG) based national VA reimbursement schedule for hospital care, a Resource Utilization Group (RUG) based national VA reimbursement schedule for VA nursing home care, and the local VA cost accounting system for the other services listed. The VA cost accounting system or Cost Distribution Report provides information about the cost of inpatient, ambulatory, and long-term care. That report is available from the fiscal service at each VA medical center. We used the Cost Distribution Report to determine, for example, the cost per clinic stop for ambulatory care and indirect costs (eg, administration, utilities, and building maintenance) for each category of care.

VA medical centers were reimbursed by the VA for hospital and nursing home care in 1989 using models based upon Diagnosis Related Groups (DRG)¹⁸ for hospital care and Resource Utilization Group (RUG)¹⁹ for nursing home care. We used those models to estimate the cost of these two forms of care. For the hospital care model, the VA calculated for each DRG a VA specific weighted workload unit (WWU) and average length of stay (LOS). The WWU is a measure of the relative intensity of resources

TABLE 1. Comparison of Costs Based Upon the Original ADHC Analysis, Facility Specific Costs, and National Average Costs per Unit of Care

Service	Original Analysis			Based Upon Facility Costs			Based Upon National Costs		
	ADHC	Control	Difference	ADHC	Control	Difference	ADHC	Control	Difference
Hospital	\$ 8,112	\$ 7,860	(\$ 252)	\$ 8,964	\$ 8,691	(\$ 273)	\$ 8,271	\$ 8,013	(\$ 258)
Clinic visits	854	1,170	316	854	1,170	316	991	1,189	198
Nursing home	2,507	3,240	733	2,936	3,659	723	2,353	3,041	688
Adult day health care	3,271	0	(3,271)†	3,271	0	(3,271)‡	3,009	0	(3,009)‡
Hospital based home care	128	438	310‡	128	438	310‡	117	383	266‡
Rehabilitation	127	156	29	127	156	29	132	157	25
Pharmacy	565	579	14	565	579	14	556	572	16
Laboratory	298	250	(48)	298	250	(48)	298	250	(48)
Other	130	148	18	130	148	18	130	148	18
Total costs	\$15,993	\$13,841	(\$ 2,152)†	\$17,273	\$15,092	(\$ 2,181)*	\$15,857	\$13,753	(\$ 2,104)*

* 0.05 < P < 0.10.

† P ≤ 0.05.

‡ P ≤ 0.001.

required to care for the patient. VA assigned a DRG to each admission and then multiplied the WWU for that admission by an allocation rate per WWU to obtain the reimbursement for that admission. Hospitals were grouped into six categories (eg, Small General, Medium University Affiliated, Psychiatric), and each category had its own allocation rate. Because the study hospitals were all in the same category (Metropolitan Affiliated) the same average allocation rate per WWU (\$2692.53) was used for all four hospitals. The original cost analysis for the ADHC study used the same method to assign a cost to each hospital admission, with the exception that admissions with a LOS greater than the mean were assigned a cost equal to the reimbursement for that DRG multiplied by the ratio of the actual LOS to the average LOS. Although somewhat crude, that latter procedure was intended to reflect the higher costs associated with longer LOS. The DRG classification for each patient was obtained from the Decentralized Hospital Computer Program (DHCP) at each VA medical center. The WWU for each DRG and the allocation rate per WWU were obtained from the fiscal service at each VA medical center. The model for nursing home care was somewhat similar. Patients were periodically assessed and assigned to one of sixteen RUGs. Each RUG had an associated VA specific WWU and each category of hospitals had a allocation rate per WWU. The

WWUs and allocation rates for the nursing home model were different from the hospital model. For the four study hospitals the nursing home allocation rate was \$47.60 per WWU per 365 days. The RUG classification for each patient was obtained from the nursing home at each VA medical center. The WWU for each RUG and the allocation rate per WWU were obtained from the fiscal service at each VA medical center.

The cost per Weighted Work Unit came from the Resource Allocation Methodology (RAM) dataset created for the VA budget allocation process. The RAM dataset has not been prepared by VA since 1990. Researchers must now make their own estimate of the average cost per DRG and RUG weights.

The patient was the unit of analysis, and the mean cost per patient is reported in the tables. Whereas the utilization and cost of health services received outside the VA were included in the original analysis reported by Ehreth et al,⁹ only health care provided by or paid for by VA are included in this paper. Non-VA care did not materially change the findings of the original study of ADHC, and it was less accurately measured. The original methods for measuring utilization and cost are described in more detail by Chapko et al.²⁰

To answer the question, "Which services should I track?" we performed the following two analyses:

Regression Predicting Total Cost from Individual Components of Cost

Stepwise ordinary least-squares regression was used to predict total cost from the cost of individual services: hospital; clinic; ADHC; etc. Both study arms were combined for this analysis and costs from the original ADHC analysis were used.^{9,20} The findings were used to determine the relative contribution of individual service costs to total cost.

Impact of Changing the Cost Components Included in Total Cost

Based upon the preceding regression, services were ordered according to their contribution to the variation in total cost. Several analyses of variance were conducted with study arm being the independent variable and total cost as the dependent variable. Total cost varied between analyses depending upon the services included. The first analysis of total cost included only hospital and ADHC costs. Nursing home costs were added to total cost for the next analysis. This process continued until all services were included, replicating the original published analysis of total cost.

To answer the question, "Should we use facility specific costs or national average costs for individual services in estimating total costs?" we conducted the following analysis:

Comparison Between the Cost of ADHC and Customary Care Using VA Facility Specific Costs Versus VA National Average Costs

The original analysis of costs for the ADHC Study⁹ used a mixture of facility-specific and national-average costs. For example, the facility-specific cost for a clinic visit was multiplied by the number of clinic visits to calculate the cost for a particular type of clinic for a particular patient. For hospital and nursing home care, however, the original analysis used an average allocation rate per WWU that was based upon a national average for each of six categories of hospitals.

To develop a more pure measure of facility costs, we developed a hospital-specific allocation rate per WWU. That was done by multiplying the average allocation rate per WWU by the ratio of

the facility-specific cost per day to the national average cost per day. Facility and national costs per day for hospital and nursing home care were obtained from the VA cost accounting system. The facility-specific cost analysis presented here used a facility cost per WWU for calculating hospital and nursing home cost. The facility-specific cost analysis used the same costs as the original published analysis for all other services.

We also conducted a national average cost analysis based upon 1989 VA national average costs for individual services. Table 2 presents a comparison of facility and national unit costs for specific services. For ADHC, a national average cost per day of care was based upon the average of the four individual ADHCs participating in the study. For hospital and nursing home care, the national average allocation rate per WWU for all VA hospitals was used instead of the hospital group allocation rate. For all other care, the VA cost accounting system's national average costs per unit of care for individual services were used.

Comparisons of the costs for ADHC versus Customary Care patients based upon national average costs and facility specific costs were conducted using an analysis of variance similar to the original analysis.

Results

Regression Predicting Total Cost From Individual Components of Cost

Table 3 presents the results of the stepwise regression predicting total cost per patient from the cost of individual services which make up total cost. The table also presents the mean and standard deviation of cost per patient for each service. Hospital costs, alone, account for 70% of the variance in total cost. Hospital, nursing home, clinic, and ADHC in combination account for 98% of the variation in total costs. The remaining services individually account for less than 1% of the variation in total costs. An individual service's contribution to the variation in total cost is related to its variance, which is in most cases related to its mean.

Impact of Changing the Cost Components Included in Total Cost

Figure 1 presents a sensitivity analysis of the effect of varying the specific services included in total

TABLE 2. Comparison of Original, Facility Specific, and National Unit Costs for Specific Services*

Utilization Variable	Original [†]	Facility Specific				National
		Site 1	Site 2	Site 3	Site 4	
Hospital WWU [‡]	2692.53	2296.30	3295.39	2722.80	2833.12	2640.99
Nursing Home WWU [‡]	47.60	42.24	52.22	52.77	66.59	44.68
Clinic Visits [§]	Facility [¶]	42.21	29.86	48.92	41.82	39.30
ADHC Days	Facility [¶]	47.51	96.29	103.04	54.26	66.48
Pharmacy	Facility [¶]	1.70	1.71	1.79	1.87	1.74
Rehabilitation Visits	Facility [¶]	214.37	184.91	216.12	201.90	204.33
Home Care Visits	Facility [¶]	93.49	149.21	64.37	107.60	105.89

* National average costs were used for laboratory tests and varied by test.

[†] This column represents the costs used in the original ADHC analysis.

[‡] This row presents the 1989 allocation rates per weighted workload unit (WWU).

[§] The facility specific and national costs vary depending upon the specific clinic. The figures given here are for medicine, the highest volume clinic.

[¶] The facility specific rate was used in the original analysis for those services.

^{||} The actual VA purchase price for specific medications was used to calculate pharmacy costs. The figures presented in this table are the multipliers used to add on the cost of dispensing the medications at the facility specific medical center. For example, a medication that the VA purchased for \$10.00 at Site 1 would contribute a total of \$17 (\$10 × 1.70) to the cost of care for a patient (\$10 for the medication and \$7 for dispensing).

cost per patient. The primary outcome of interest in this sensitivity analysis was the difference between the cost of care for patients in the two study arms (ADHC minus Customary Care). Cost assigned to individual services were the same as those used in the ADHC study analysis.^{9,20} For that analysis, the services were entered according to their order of entry in the regression presented in Table 3. As indicated in Fig. 1, the cost difference between the two arms starts out quite high when

only hospital care and ADHC are included in total costs. As nursing home, clinic, and home care services are added, the difference decreases and the *P* value for the difference increases. That reduction is the result of the fact that the costs for nursing home, clinic, and home care in the Customary Care arm are higher than are their costs in the ADHC arm of the study (Table 1). Figure 1 indicates that the remaining services have little impact on the differences in total cost per patient between the two study arms.

TABLE 3. Descriptive Statistics and Results of the Stepwise Regression Predicting Total Cost per Patient From Individual Components of Cost

Cost Category	Mean Cost	SD	r ²	Change in r ²
Hospital	\$ 7,986	10,550	.700	.700
Nursing home	2,872	7,188	.889	.188
Clinic visits	1,012	3,599	.949	.060
Adult day health care	1,642	2,793	.981	.033
Hospital based home care	283	1,341	.991	.009
Rehabilitation	141	1,026	.995	.005
Pharmacy	572	733	.998	.003
Laboratory	274	467	.999	.001
Other	139	409	1.000	.001
Total costs	\$14,921	\$14,974		

Comparison Between Cost of ADHC and Customary Care Using Facility Specific Costs Versus VA National Average Costs

Table 1 compares the costs for the ADHC and Customary Care (Control) arms of the study using the following three methods of assigning costs to individual services: the original analysis; using only facility costs; and using national average costs. For individual service, the magnitude and *P* value of the differences between costs in the Customary Care and ADHC Care arms do not change substantially when switching from the original analysis to an analysis based upon facility specific costs or to an analysis based upon national costs. Likewise, the magnitude of the difference between total costs does not change substantially

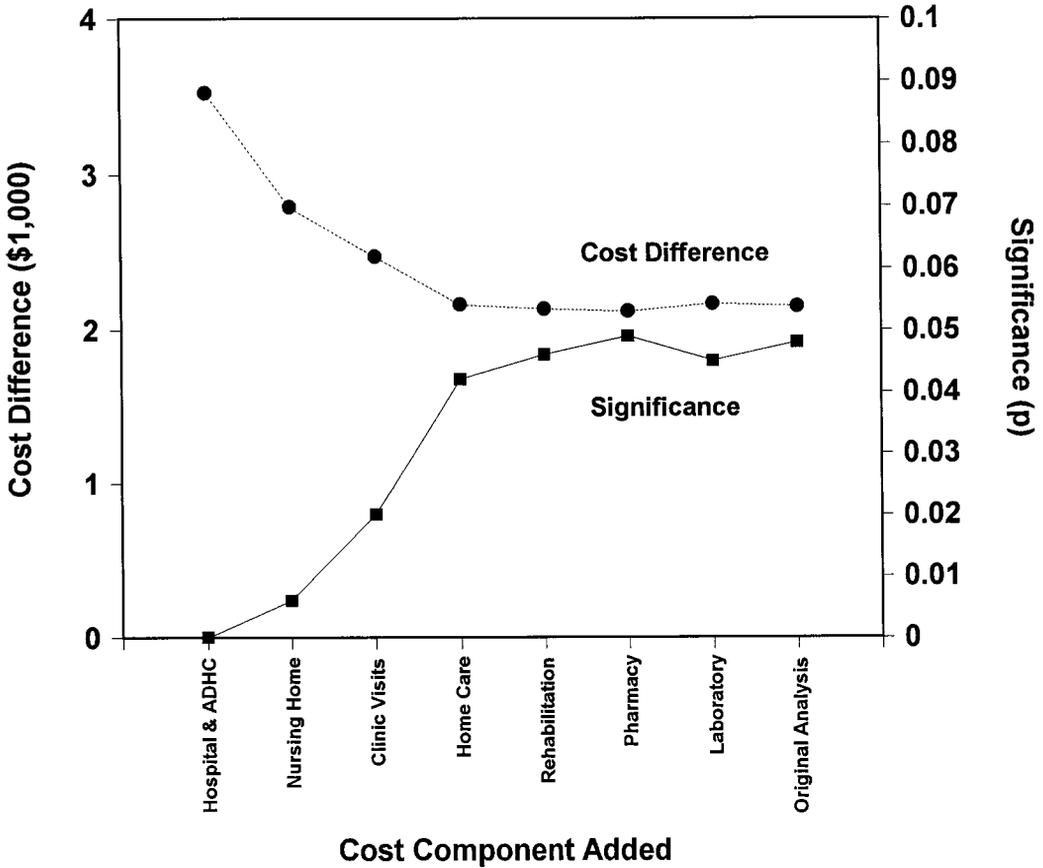


FIG. 1. Sensitivity of total cost difference (ADH4c- Customary Care) to changes in the services included in total cost. The method of calculating cost of individual services for the analysis presented in this figure are the same as in the original ADHC analysis which used a combination of national and local costs (Table 2).

but the significance of the difference between total costs changes from being significant ($P = 0.048$) in the original analysis to being marginally significant in the analysis using facility costs ($P = 0.073$) and in the analysis using national average costs ($P = 0.052$).

Discussion

We will now address the two questions posed in the introduction.

Which Services Should We Track?

One should include some measure of the utilization and cost of the intervention itself, the services

which account for a good deal of the variance in total cost, and specific lower-cost services which are likely to be impacted by the intervention.

The cost of the intervention should be included because it is usually an added cost which will hopefully be offset by lowering the costs of other services.

The cost of other services which account for a good deal of the variance in total cost should also be included. In the ADHC study, those services included the following: hospital (70%); nursing home (19%); and clinic care (6%). The large contributors to total variance can usually be quickly identified by determining the services that have the largest mean cost per patient.

Mean cost can be used to select services because between patient variation in the cost of individual

services is usually correlated with the mean cost per patient. For studies of sicker patients, hospital, nursing home, and clinic care are likely to be the major contributors. In healthier populations, hospital and nursing home care are likely to be less dominant, and the utilization pattern for similar patients should be examined to identify services that have higher average costs per patient.

If the utilization of a given high-priced service is quite variable between patients and the intervention has no impact on its utilization, then that service will only add error variance to total cost. After the study is completed, the impact of the intervention on the service is easy to determine; however, by then it is too late. One has already put in the effort to measure its utilization and cost. In addition, eliminating its cost from total cost after the data has been examined will bias the test of significance for total cost. In planning a study, the likelihood of and desire to detect an unforeseen consequence of the intervention must also be taken into consideration. Our preference tends to be toward having the ability to detect unforeseen consequences, but that usually requires larger sample sizes or more detailed data.

One should at least include the lower cost services that have a reasonable possibility of being influenced by the intervention. For lower cost services, the influence on power and sample size is not as dramatic because they contribute far less to within-group variance. In the original ADHC study, we measured the utilization and cost of pharmacy, laboratory tests, hospital based home care, and rehabilitation, but each of these accounted for less than 1% of the variation in total cost. They were selected because we thought there was a reasonable possibility that they would be affected by ADHC. In fact, we subsequently observed that the use of hospital-based home care was reduced by ADHC. In retrospect, it probably was unnecessary to include the cost of pharmacy and laboratory tests because those services take some effort to measure, they contribute little to the total cost of care, and their use can be indirectly measured by the use of hospital and clinic care.

How Sensitive Are the Conclusions of the Study to Using Facility-Specific Costs Versus National Average Costs for Each Unit of Utilization?

We would advocate doing sensitivity analyses to determine whether the method of costing makes a

difference in the conclusions. However, we suspect that using facility-specific versus national costs will not make a large difference in the magnitude of the cost differences between two treatment groups, in most cases. Different costing methods could affect conclusions if the *P* values are close to the selected cutoff for significance. It is interesting to note that each of the VA studies listed in the introduction reported only one method of estimating cost for each service. None of the studies conducted a sensitivity analysis.

We found that the absolute magnitude of the impact of ADHC on total cost per patient was not substantially impacted by using the original mixed analysis (using some local costs and some national costs), using only facility specific costs, or using only national VA costs to weigh the utilization of individual services. However, the statistical significance of the difference between the two study arms was influenced by the costing method because the original analysis of the difference between the total VA health care costs for the ADHC arm versus the Customary Care arm was significant with $P = 0.048$. The same comparison using facility specific costs yielded a $P = 0.073$ and using national average costs yielded a $P = 0.052$, which is not significant or which is at best marginally significant.

Recommendations for Future Research

The generalizability of our findings may be limited because the analysis was done on one VA study conducted at only four sites. The analysis presented here should be repeated with data from other studies inside and outside VA to determine the generalizability of our findings from the ADHC study. In addition, determining the sensitivity of study conclusions to other costing methods, such as using the Health Care Financing Administration's (HCFA) fee schedules or imputed costs from cost models,^{21,22} would be of great value. The strengths and weaknesses of the various methods of assigning costs have been discussed by several authors.^{15-17,21,22}

Summary of Recommendations for Conducting Cost Analyses

In conducting clinical trials to determine the effect of an intervention on health care costs we recommend the following:

- Ideally all health care costs should be included in the analysis. However, accuracy may need to be compromised at times because of the resources needed to collect or because of the unavailability of complete utilization and cost data. Under those circumstances, one should determine utilization and cost for the intervention itself, costly services likely to be used by the study population (usually hospital, nursing home, and clinic care), and lower cost services likely to be affected by the intervention.
- Conduct sensitivity analysis to determine if different methods of costing (institution specific costs, national average costs, and possibly other methods, such as the HCFA fee schedule or imputed costs from a cost model) materially affect the conclusions of the study.

References

1. **Rubenstein LZ, Josephson KR, Wieland GD, English PA, Sayre JA, Kane RL.** Effectiveness of a geriatric evaluation unit. *N Engl J Med* 1984;311:1664.
2. **Englehardt JB, Toseland RW, O'Donnell JC, Richie JT, Jue D, Banks S.** The effectiveness and efficiency of outpatient geriatric evaluation and management. *JAGS* 1996;44:847.
3. **Hughes SL, Cummings J, Weaver F, Manheim LM, Conrad KJ, Nash K.** A randomized trial of veterans administration home care for severely disabled veterans. *Med Care* 1990;28:135.
4. **Cummings JE, Hughes SL, Weaver FM, Manheim LM, Conrad KJ, Nash K, et al.** Cost effectiveness of veterans administration hospital-based home care. *Arch Intern Med* 1990;150:1274.
5. **Hughes SL, Cummings J, Weaver F, Manheim, Braun B, Conrad K.** A randomized trial of the cost effectiveness of VA hospital-based home care for the terminally ill. *Health Serv Res* 1992;26:803.
6. **Wasson J, Gaudette C, Whaley F, Sauvigne A.** Telephone care as a substitute for routine clinic follow-up. *JAMA* 1992;267:1788.
7. **Kashner TM, Rodell DE, Ogden SR, Guggenheim FG, Karson CN.** Outcomes and costs of two VA inpatient treatment programs for older alcoholic patients. *Hosp Comm Psych* 1992;43:985.
8. **Hedrick SC, Rothman ML, Chapko MK, Ehreth J, Diehr P, Inui TS, et al.** Summary and discussion of methods and results of the adult day health care evaluation study. *Med Care* 1993;31:SS94.
9. **Ehreth JL, Chapko MK, Hedrick SH, Savarino JE.** Cost of VA adult day health care programs and their effect on utilization and cost of health care. *Med Care* 1993;31:SS50.
10. **Weinberger M, Oddone EZ, Henderson WG.** Does increased access to primary care reduce hospital readmissions? *N Engl J Med* 1996;334:1441.
11. **Gold MR, Siegel JE, Russell LB, Weinstein MC.** Cost-effectiveness in health and medicine. New York: Oxford University Press, 1996.
12. **Elixhauser A, Halpern M, Schmier J, Luce BR.** Health care CBA and CEA from 1991 to 1996: An updated bibliography. *Med Care* 1998;36(suppl):MS1.
13. **Weinstein MC, Statson WB.** Foundations of cost-effectiveness analysis for health and medical practices. *N Engl J Med* 1977;296:716.
14. **Siegel JE, Weinstein MC, Russell LB, Gold MR.** Recommendations for reporting cost-effectiveness analyses. *JAMA* 1996;276:1339.
15. **Chapko MK, Ehreth JL, Hedrick S.** Methods of determining the cost of health care in the Department of Veterans Affairs medical centers and other nonpriced settings. *Eval Health Prof* 1991;14:282.
16. **Barnett PG.** Review of methods to determine VA health care costs. *Med Care* 1999;37(suppl):AS9.
17. **Swindle RW, Beattie MC, Barnett PG.** The quality of cost data: A caution from the department of veterans affairs experience. *Med Care* 1996;34:MS83.
18. **Fetter RB, Shin Y, Freeman JL, Averill RF, Thompson JD.** Case mix definition by diagnosis-related groups. *Med Care* 1980;18(suppl):1.
19. **Fries BE, Cooney LM.** Resource utilization groups: A patient classification system for long-term care. *Med Care* 1985;23:110.
20. **Chapko MK, Rothman ML, Ehreth JL, Hedrick SC, Sullivan JH, Erdly W, et al.** Data collection in the adult day health care evaluation study. *Med Care* 1993;31:SS15.
21. **Kukull WA, Koepsell TD, Conrad DA, Immanuel V, Prodzinski J, Franz C.** Rapid estimation of hospitalization charges from a brief medical record review. *Med Care* 1986;24:961.
22. **Barnett PG.** Research without billing data: Econometric estimation of patient-specific costs. *Med Care* 1997;35:553.