

Marginal Cost of Emergency Department Outpatient Visits:
An Update Using California Data

Objective: To clarify the importance of time frame in the measurement of marginal cost, and to provide marginal cost estimates for outpatient emergency department (ED) visits that better reflect current economic conditions.

Data sources: Analyses are based upon data that California hospitals report to the Office of Statewide Health Planning and Development (OSHPD). The time period covered is 1990 through 1998. Hospitals without EDs, or hospitals designated as trauma centers, are excluded from the analysis.

Study design: Nine years of panel data are used to estimate hospital cost functions, which are then used to test for economies of scale and to derive estimates of both short- and long-run marginal costs (excluding the physician expense component).

Principal findings: We find only weak evidence in favor of scale economies, and in that context we argue that long-run marginal costs should be the preferred metric for judging the cost of treating outpatient ED visitors. We estimate these long-run costs (in 1998 dollars) to be roughly \$348 per visit for large urban hospitals, \$288 for other urban hospitals, \$203 for rural hospitals, and \$314 overall.

Conclusions: Our results suggest that the marginal cost of an outpatient ED visit is larger than is commonly believed. A key implication of this finding is that hospital administrators need to think more carefully about their non-urgent care policies, especially as they pertain to ED operations.

Keywords: hospital, emergency department, marginal cost, California.

Introduction

Per-capita utilization of California emergency departments (EDs) has increased markedly over the past few years (Melnick et al., 2004), consistent with national trends (McCaig, 1994; McCaig and Burt, 2003) where ED visits now exceed 100 million per year.

Growing reports about ED overcrowding (Derlet and Richards, 2000), long wait times, and ambulance diversion suggest a capacity squeeze, and some have used this evidence to call for additional funds to be earmarked for ED capacity expansion. Alternatively, others have argued that re-direction of non-urgent care away from the ED may be a more appropriate way to deal with the problem. To address such policy questions it is necessary to have reliable estimates of the cost of an outpatient ED visit, but the published literature on this subject is sparse.

Despite the importance of EDs in the US health care system, little is known about their current cost structure. The published literature is limited, and generally out of date. The most recent studies (Williams, 1996a; Williams, 1996b) were published in 1996 using data from 1991-1993. The other detailed study (Grannemann et al., 1986) used data from the early 1980s. With the introduction of managed care and price competition, the economic incentives facing hospitals changed dramatically that probably has affected EDs as well (Franco et al., 1997; Hoffman, 1997; Johnson and Derlet, 1996; Johnson, 1998; Karpel, 1995; Kerr, 1989; Osborn, 1996; Tsai et al., 2003). Other recent factors also may have affected ED cost structures, such as EMTALA regulations, nursing shortages, higher malpractice insurance costs that hospitals sometimes subsidize from their administrative budgets, and possibly other physician-retention related expenses.

In this paper we contribute to the ED cost literature in two ways. First, we utilize more recent panel data to estimate an ED outpatient visit's marginal cost, which we believe better reflects current economic conditions than previously published estimates. Second, we do this for both the short and long run, clarifying what each means in the present context, including the estimation issues involved.

Conceptual Framework

Although most agree that EDs practice a resource intensive style of medicine, many remain skeptical about the cost-saving impact of better ED demand management. In the case of ED patients that are seen but not admitted, some argue that these patients add very little to total ED costs: Or, in other words, that the marginal cost for such visits is far below average costs. This notion is supported in part by a couple of previous studies (Grannemann et al., 1986; Williams, 1996a); however, the former's conclusions are based upon data that we doubt reflect current hospital cost structures, and the latter relies on a very small hospital sample, among other methodological shortcomings.

Several implications arise from the notion that per-ED visit marginal costs are far below average costs. First, it implies that EDs exhibit significant economies of scale. If marginal costs are below average costs, then average cost per visit ought to decline across EDs with larger and larger visit volumes. A recently completed analysis of the relationship between direct ED costs and ED volume does not find such a relationship (Bamezai et al., 2005). The key intuition offered by the authors as to why this may be the case is that capital expenses comprise only roughly 10% of total expenses—both for EDs

and for hospitals as a whole. The bulk of hospital expenses appear to be fungible and scalable according to output, making the theoretical case for scale economies very weak. Empirical evidence supporting the existence of hospital scale economies has generally been weak in the past (Lave and Lave, 1970; Feldstein, 1988). More recently, MedPac (2001) in making the case for higher reimbursement rates for rural hospitals, demonstrates that costs per discharge do not drop significantly once hospitals exceed an output rate of roughly 500 discharges per year, a threshold so low that almost ninety percent of all acute-care hospitals in the US lie above it. In other words, while there may be diseconomies to being very small, there do not appear to be persistent economies of scale. If persistent economies of scale were a reality, one would expect to see the market dominated by few, very large hospitals, at least in urban areas, where adequate access could still be maintained with a concentrated market structure. But hospital size shows a wide distribution in most urban areas.

Second, the definition of marginal cost used in the ED economics literature is ambiguous in important ways. For example, previously reported estimates make no clear distinction between the short and long run, although it is well known that altering the time frame can greatly affect estimates of economic parameters such as marginal costs and elasticities (Houthakker, 1965). The importance of differentiating between the short and long run is illustrated by the following statement that one often encounters in discussions about ED costs—since on any given day the ED is already fully staffed, the marginal cost of treating an extra visitor is quite close to zero. This sort of thinking, which belies a view of ED costs that is short run in the extreme, leads to erroneous policy conclusions.

Should we measure short- or long-run marginal costs?

The choice between short and long run marginal costs depends upon the intended policy application, which, in turn, drives the selection of an appropriate estimation method. A fairly extensive literature suggests that cross-sectional data are better suited for capturing economic behavior over the long run; time-series data, over the short run (Baltagi and Griffin, 1984; Grunfeld, 1961; Kuh, 1959; Simon and Aigner, 1970). The underlying behavioral story about why this is so depends upon the context. For example, the relationship between demand for energy and its price may appear quite weak within a country over the span of a few years, but quite strong when the comparison is made across countries with historically very different price levels, since the stock of energy-using appliances in the historically high-price country would have gradually become much more efficient. These dynamic adjustments over time—when they remain unaccounted for due to data and modeling deficiencies, as is often the case—can accumulate and manifest themselves as cross-sectional differences.

An alternative behavioral story—adjustment to future expectations—is perhaps more relevant for hospitals. In the case of hospitals, output fluctuates little from year to year, especially on the inpatient side. Since staffing decisions are made prospectively on the basis of projected demand, the year-over-year variation in costs and output may appear small, and only weakly correlated. Thus, time-series analyses may yield artificially low estimates of marginal cost. Friedman and Pauly (1981) discuss this point in greater detail, and try to solve the problem by including forecasted output in their cost model.

But forecasted output is generally unavailable, an exception being Pauly and Wilson (1986).

We take a slightly different approach to these issues. We estimate both short and long run marginal costs, and then ask which between the two is more useful for assessing the cost of ED outpatient care. In part, this requires testing for the existence of hospital scale economies. We take our cue from Baltagi and Griffin (1984), who show that in the context of panel data, removing cross-sectional differences (fixed-effects model) yields short run estimates (being conditioned only by variation over time), while retaining these cross-sectional differences yields estimates that come closest to capturing behavior over the long run. Not accounting for hospital fixed effects of course increases the risk of omitted variables bias, which we try to minimize by including additional hospital characteristics in the model, such as, ownership, location, payer mix, competition, and so on. But for reasons stated above, inclusion of hospital fixed effects as a cure all for unobserved hospital characteristics, can make matters worse.

This study uses annual data. As a result, our estimates of short-run marginal cost are conditioned by the year-over-year variation in hospital costs relative to output. Given the previous discussion about the importance of time frame, in terms of studying the scalability of ED costs relative to output, a year strikes us as a more meaningful planning horizon than a few days or weeks. But what length of time does the long run represent? This question does not have a clear-cut econometric answer; some amount of judgment is necessary for drawing reasonable conclusions as discussed later.

Methods and Data

We rely on a (nine year) panel-data approach for estimating the marginal cost of an outpatient ED visit. Our estimate accounts for ancillary services used by ED outpatients and perhaps other ED-related costs that remain hidden across other cost centers, but does not account for ED physician compensation. Total hospital-expense data, upon which our analyses are based, exclude physician compensation.

Model specification

Our statistical model is drawn from the hospital cost literature (Breyer, 1987) and follows a fairly standard structure, where total hospital costs are modeled as follows: total hospital costs are regressed on measures of inpatient and outpatient outputs (casemix adjusted inpatient discharges, ED outpatient visits, other outpatient visits), input prices (Medicare wage index), demand (county per-capita income), teaching intensity (intern-to-bed ratio), ownership (for-profit, not-for-profit, public), and cost-containment pressures exerted by private and public payers. We capture the pressure exerted by private payers through a measure of hospital competition (Hirschman-Herfindahl index), and that by public payers through measures that capture the fiscal burden Medicare and Medicaid reimbursement policies impose upon various hospitals.

We focus primarily on outpatient ED visits since that is where savings can potentially be realized through better triage, or better ED-demand management policies. The cost of inpatients from all sources (that is, direct admits, ED admits, clinic admits, in-hospital deaths) is captured separately by including casemix-adjusted discharges in the model.

The statistical model uses a translog specification, which the present authors and others have successfully employed in previous research (Gaynor and Anderson, 1995; Zwanziger and Melnick, 1988; Zwanziger et al., 2000). One problem with such models is that cases with one or more zero outputs cannot be included—as a result, our model excludes hospitals with zero ED visits. No hospital with an ED had either zero inpatient or zero other outpatient utilization. Since this model includes quadratic and interaction terms, the estimated coefficients do not have a straightforward interpretation. We perform the necessary transformations to convert these coefficients into dollar marginal cost estimates.

Sensitivity analyses

Sensitivity analyses and specification tests suggested that pooling of data across (level 1 and 2) trauma centers and other hospitals with EDs was not producing a good model fit. For the purposes of this paper, we have chosen to exclude trauma hospitals. Bamezai et al. (2005) present some indicative results for trauma centers, but the small sample size permits very little of the detailed exploration attempted here. Our final analysis sample includes 246 non-trauma hospitals that were operational, with non-zero inpatient and outpatient outputs, throughout the analysis period (1990-1998). Our models also correct for heteroskedasticity because error variance exhibited a small but significant inverse correlation with hospital size (measured using number of staffed beds).

Data collection and processing

Our primary source of data is the State of California's Office of Statewide Health Planning and Development (OSHPD). We draw information from two key reports that each hospital submits to OSHPD: the Annual Financial Report (which includes detailed financial and utilization statistics), and the Discharge Abstract File (which includes information about patient demographics, patient zip code, primary procedure and diagnosis, payer source, and so on). Each year's Annual Disclosure Report corresponds to the hospital's fiscal year, unless an interruption occurs due to a merger, or due to a temporary (say, for renovation), or permanent closure. The Discharge Abstracts are reported on a calendar year basis. In order to place all these data elements on a comparable footing in terms of time, we combined several years of the Annual Disclosure Report, then "calendarized" them using linear interpolation, so that each year implies a standardized period (January 1st through December 31st). These data were supplemented with other variables, such as the Medicare wage index, intern-to-bed ratio, urban/rural location, and county per-capita income.

Variable construction

Dependent variable. The logarithm of total hospital expenditures (excluding physician compensation) is used as the dependent variable.

Hospital output. Three measures are used to capture hospital outputs; (1) casemix adjusted inpatient discharges; (2) ED outpatient visits; (3) other outpatient visits. An all-payer casemix index was derived from scratch to avoid biases inherent in the Medicare casemix index—the latter only represents the Medicare population. Derivation of the all-

payer casemix index involved several steps. First, charge data from the discharge abstracts were converted into costs using a hospital-specific, cost-to-charge ratio. DRG weights were constructed as the ratio of average costs of treating patients in a particular DRG relative to the average cost of a discharge overall. Finally, a hospital-level casemix index was constructed by taking a weighted average of DRG weights, with discharges from each DRG in that hospital serving as the weight. Apart from an overall casemix index we also derived one just for Medicare discharges for validation purposes (correlation between ours and the official casemix index published by Medicare turned out to be 0.84).

Market structure. We estimated a Hirschman-Herfindahl index (HHI) to capture the level of competition in hospital markets, using actual zip-code level patient-flow data to define hospital markets, based upon Zwanziger's and Melnick's (1988) methodology. The HHI varies between 0 and 1, with lower levels indicating greater competition.

Medicare and Medicaid fiscal pressure. We capture Medicare fiscal pressure through an index that ranks hospitals according to how profitable their Medicare business was in 1990, the beginning of our analysis period. This index doesn't change over time, but its interaction with each year is entered into the model to capture how hospitals responded to this baseline pressure in subsequent years. If costs among hospitals subject to high or low pressure converge over time, then the coefficient on this pressure index ought to become insignificant in later years. Medicaid fiscal pressure is captured by the

proportion of total hospital days accounted for by Medicaid beneficiaries. This proportion enters the model in the form of interactions with the yearly dummies.

Results

Table 1 shows the estimated short and long run marginal cost (in 1998 dollars) of an ED outpatient visit, other outpatient visit, and inpatient discharge by hospital location (large urban, small urban, rural). The complete regression results, and variable means and standard deviations are included in Appendices 1 and 2. The marginal cost estimates presented in Table 1 are derived from the first derivative of the regression models, computed either at the overall sample mean, or means for respective subgroups, such as, large urban, other urban, and rural hospitals.

Estimates presented in Table 1 look credible on several grounds. First, the estimates display reasonable magnitudes, with other outpatient visits costing the least, followed by ED outpatient visits, and finally by inpatient discharges. Second, consistent with theory, our short-run estimates never exceed the long-run estimates. Finally, compared to the other two outputs, inpatient marginal costs show the least proportional spread across different locations. This occurs because we are able to control for inpatient casemix, but not for outpatient acuity. Almost certainly, large urban hospitals deliver more complex outpatient care, both in the ED and the clinic, than other urban or rural hospitals, a conjecture that Table 1's estimates support.

The estimated long run marginal cost of an ED visit averages \$314 across the full sample and ranges from a high of \$348 for large urban hospitals to a low of \$203 for rural hospitals. For ED visits, the short and long run estimates are very close, except in the case of rural hospitals. For the other two outputs, however, the short and long run estimates exhibit greater proportional divergence, which on the surface may appear to support the existence of hospital scale economies, but this needs to be empirically demonstrated.

In the case of multi-output cost functions, examining scale economies amounts to assessing how total costs change in the long run as all outputs are increased without changing their relative proportions (so as not to confound scale economies with scope economies). To test for this, we calculated the summation of each output's cost elasticity (Braeutigam and Daughety, 1983; Caves, Christensen, and Swanson, 1981) based on our long run regression model. We performed the above test and found that long run cost elasticities across the three outputs summed to 0.96, 0.95, and 0.90 for large urban, other urban, and rural hospitals, respectively. In other words, increasing all outputs by 10% can be expected to increase total hospital costs by 9.6%, 9.5%, and 9.0% for our three hospital groups. These results suggest that only rural hospitals would experience a measurable reduction in average costs by expanding scale, but that these gains would rapidly diminish as rural hospitals reached the size of other urban hospitals.

If economies of scale can be ruled out as a significant factor in all but the smallest of hospitals, one implication is that divergence between the short- and long-run estimates is

largely an artifact of the data. Inpatient output generally shows the greatest stability from year to year, so estimates conditioned only by variation over time show the greatest downward bias. Thus, we believe our long run estimates should be favored for planning purposes.

Discussion

This paper updates the literature on ED economics in several ways. First, we provide updated marginal cost estimates (in 1998 dollars) for ED outpatient visits on both a short and long run basis. On a long run basis these work out to \$348 for large urban hospitals, \$288 for other urban hospitals, \$203 for rural hospitals, and \$314 overall, and on a short run basis to \$346 for large urban hospitals, \$262 for other urban hospitals, \$98 for rural hospitals, and \$295 overall.

Second, we clarify the importance of time frame in how one conceptually thinks about, and estimates, marginal cost. Marginal costs can be made to appear low by compressing the time frame to a few days or weeks, since more inputs would appear unchangeable, but we contend that this is not very meaningful from a policy perspective. We suspect reliance on monthly data is a key reason why Williams's (1996a, 1996b) marginal cost estimates are the lowest in the published literature on EDs. Lave and Lave (1970) make a similar observation while comparing their results, based upon annual data, to those of studies based upon monthly data.

Finally, we ask whether short or long run estimates should be preferred for planning purposes? We argue that short run estimates being considerably below the long run estimates in our study is just an artifact of the data. Were this not so, hospital scale economies should have been evident, but our tests are unable to find significant supporting evidence for this. Thus, the short run estimates are best interpreted as a conservative lower bound, with true marginal costs being closer to the long-run estimates. To accept this conclusion, however, also requires some amount of institutional knowledge and judgment. Exactly over what time frame is a hospital able to modify its inputs, thereby its costs, to adjust to projected demand? While this question cannot be addressed purely econometrically, we have every reason to believe that hospitals are quite flexible at the margin. For example, most hospitals in California (and probably elsewhere) now utilize flexible scheduling systems that adjust staffing levels according to hospital occupancy and visit rates, varying the number of on-duty staff by time of day and day of week based upon historical trends and expected demand. Were the long run to span several years, one would expect to find stronger evidence in favor of scale economies. Given that we do not, and given the increasing practice of staffing to census, we can only surmise that hospitals are able to adjust inputs fairly easily at the margin. And, in that context, the long-run estimate becomes a better choice for gauging the per-unit cost of generating a particular output.

Another potential application of our findings concerns the relative cost of treating outpatients in EDs compared to non-emergency clinic settings. Given that our marginal cost estimate for an ED outpatient visit appears quite high, it offers support for the notion

that some portion of ED outpatients (i.e., the non-urgent) might be more cost effectively treated in alternative settings. Ideally, we would have liked to estimate the marginal cost of treating non-urgent patients in the ED, but the acuity data reported by hospitals for their ED outpatients is highly unreliable. Nonetheless, variation in our estimates across hospital types may shed some light on this issue. For example, under the assumption that rural hospitals treat only relatively simple cases in their EDs and refer all of the more acute patients, one might argue that \$203 represents a reasonably good estimate of the marginal cost of a non-urgent ED visit. Similarly, our estimates of the long-run marginal cost of other outpatient visits across all three types of hospitals (\$155, \$132, and \$100, respectively) might provide information regarding the cost of treating non-urgent ED patients in a non-ED setting. Taken together these findings suggest that treating non-urgent ED patients in alternative settings may be cost saving to some extent. Whether or not one finds this argument compelling, it is worth noting that even the low estimate of \$203 is far greater than what Williams (1996a, 1996b) reports as the marginal cost of a non-urgent ED visit (\$24), or for that matter, the marginal cost overall across all urgency levels (\$88). Considerable divergence remains between his results (which are very short run) and ours, even after accounting for inflation.

Finally our findings may have relevance for the level of ED standby capacity. EDs face variable demand, some of which administrators can plan and staff for using flexible scheduling, but undoubtedly they must also maintain spare capacity to handle demand variability. It is thus reasonable to argue that provision of non-urgent care during the non-peak periods can help improve resource utilization within the ED, and that perhaps in

the context of filling such lulls, the marginal cost of non-urgent ED visits may be low. This argument must be made with care. Investing in greater standby capacity will lower short-run marginal costs, and vice versa. But our results suggest the standby capacity is not inexpensive.

Ultimately, the issue of ED capacity must be addressed within a broader context. How much standby capacity is desirable and socially cost-effective? In the case of EDs, where the key inputs are human resources, the desired level of standby capacity is a policy choice, driven less by technical and economic imperatives of the kind that drive, to use a previously cited example, the construction of electricity transmission networks.

Increased reports of over-crowding, long wait times, and patients leaving the ED without being treated suggest that hospitals are finding it difficult to maintain a large amount of ED standby capacity in the current reimbursement environment. Our results suggest that ED care is expensive. Therefore, ED administrators must carefully define their core mission and staff the ED accordingly. While, in principle, an ED's optimum product mix could include some amount of non-urgent care (strategically delivered during the lulls), arguments that marginal costs are low rapidly lose credibility when demand for non-urgent care exceeds this optimum level, and EDs start expanding staff and other inputs in response to it. Our results suggest that over the long run EDs do increase inputs in response to volume increases. In this connection, note that our short-run estimates (conditioned only by the year-over-year variation in the data) implicitly remove the effect of differential levels of standby capacity across hospitals; yet these estimates are considerably higher than those published previously.

In summary, we present an approach for estimating the marginal cost of ED outpatient visits from aggregate hospital-level data. Our findings suggest that these costs are greater than is commonly believed, suggesting the need for further research regarding when and how best to deliver non-urgent care through the ED.

References

- Baltagi, B. H. and Griffin, J. M. Short and long run effects in pooled models. *International Economic Review*. 1984;25:631-645.
- Bamezai, A., Melnick, G. A., Nawathe, A. C., The cost of an emergency department visit and its relationship to emergency department volume. *Annals of Emergency Medicine*. 2005;45:483-490.
- Braeutigam, R. R. and Daughety, A. F. On the estimation of returns to scale using variable cost functions. *Economics Letters*. 1983;11:25-31.
- Breyer F. The specification of a hospital cost function. *Journal of Health Economics*. 1987;6:147-157.
- Caves, D. W., Christensen, L. R., Swanson, J. A. Productivity growth, scale economies, and capacity utilization in U.S. railroads, 1955-74. *The American Economic Review*. 1981;71:994-1002.
- Derlet, R. W., Richards, J.R. Overcrowding in the nation's emergency departments: Complex causes and disturbing effects. *Annals of Emergency Medicine*. 2000;35:63-67.
- Feldstein, P. *Health Care Economics* (Albany NY: Delmar Publishers, Inc., 1993)
- Franco SM, Mitchell CK, Buzon RM. Primary care physician access and gatekeeping: a key to reducing emergency department use. *Clinical Pediatrics*. 1997;36:63-68.
- Friedman, B., Pauly, M. Cost functions for a service firm with variable quality and stochastic demand: The case of hospitals. *The Review of Economics and Statistics*. 1981;63:620-624.

- Gaynor M, Anderson GF. Uncertain demand, the structure of hospital costs, and the cost of empty hospital beds. *Journal of Health Economics*. 1995;14:291-317.
- Grannemann TW, Brown RS, Pauly MV. Estimating hospital costs. A multiple-output analysis. *Journal of Health Economics*. 1986;5:107-127.
- Grunfeld, Y. The interpretation of cross section estimates in a dynamic model. *Econometrica*. 1961;29:397-404.
- Hoffman DE. Emergency care and managed care: a dangerous combination. *Washington Law Review*. 1997;71:327-340.
- Houthakker, H. S. New evidence on demand elasticities. *Econometrica*. 1965;33:277-288.
- Johnson LA. Managed care and emergency medicine: current experience in California. *Annals of Emergency Medicine*. 1998;31:414-416.
- Johnson LA, Derlet RW. Conflicts between managed care organizations and emergency departments in California. *Western Journal of Medicine*. 1996;164: 137-142.
- Karpiel M. *Managed care in Emergency Medicine, Understanding the New Economics and Opportunities*. Dallas, TX:American College of Emergency Physicians; 1995.
- Kerr HD. Access to emergency departments: a survey of HMO policies. *Annals of Emergency Medicine*. 1989;18:274-277.
- Kuh, E. The validity of cross-sectionally estimated behavior equations in time series applications. *Econometrica*. 1959;27:197-214.
- Lave, J. R., Lave, L. B. Hospital cost functions. *The American Economic Review*. 1970;60:379-395.

Melnick, G. A., Nawathe, A. C., Bamezai, A., Green, L., Emergency department capacity and access in California, 1990-2001: An economic analysis. *Health Affairs (web exclusive)*. 2004;W4:136-142.

McCaig LF, Burt CW. National hospital ambulatory medical care survey: 2001 Emergency Department Summary. Advance Data from Vital and Health Statistics. No. 335. Hyattsville, MD:US National Center for Health Statistics; 2003.

McCaig LF. National hospital ambulatory medical care survey: 1992 emergency department summary. Advance Data from Vital and Health Statistics. No. 245. Hyattsville, MD:US National Center for Health Statistics; 1994.

Medicare Payment Advisory Commission. *Report to the Congress: Medicare in rural America*. Washington, DC:MedPac; June 2001.

Osborn HH. Health maintenance organizations: managed care or mismanaged care? *Annals of Emergency Medicine*. 1996;27:225-228.

Pauly, M. V., Wilson, P. Hospital output forecasts and the cost of empty hospital beds. *Health Services Research*. 1986;21:403-428.

Simon, J. L., Aigner, D. J. Cross-section and time-series tests of the permanent-income hypothesis. *The American Economic Review*. 1970;60:341-351.

Tsai AC, Tamayo-Sarver JH, Cydulka RK, Baker DW. Declining payments for emergency department care, 1996-1998. *Annals of Emergency Medicine*. 2003;41:299-308.

Williams RM. The costs of visits to emergency departments. *The New England Journal of Medicine*. 1996a;334:642-646.

Williams RM. Distribution of emergency department costs. *Annals of Emergency Medicine*. 1996b;28:671-676.

Zwanziger J, Melnick GA. The effects of hospital competition and the Medicare PPS program on hospital cost behavior in California. *Journal of Health Economics*. 1988;7:301-320.

Zwanziger J, Melnick GA, Bamezai A. The effect of selective contracting on hospital costs and revenues. *Health Services Research*. 2000;35:849-867.

Table 1 Marginal cost estimates in 1998 dollars

Hospital type	ED outpatient visit		Other outpatient visit		Inpatient discharge*	
	Short run	Long run	Short run	Long run	Short run	Long run
Large urban	\$346	\$348	\$113	\$155	\$3102	\$6645
Other urban	\$262	\$288	\$101	\$132	\$2772	\$5972
Rural	\$98	\$203	\$90	\$100	\$2831	\$6340
Overall	\$295	\$314	\$110	\$144	\$2984	\$6417

*Casemix index set to 1 for all hospital locations.

Appendix 1 Estimated model results

Variable	Short-run model	Long-run model
	Coefficient (Std. Error)	Coefficient (Std. Error)
Ln(casemix-adj. discharges)	0.520* (0.127)	0.729* (0.101)
Ln(outpat. ED visits)	-0.294* (0.142)	-0.291 (0.192)
Ln(other outpat. visits)	0.219* (0.081)	-0.167 (0.105)
Ln(casemix-adj. Discharges) squared	0.037* (0.008)	0.073* (0.008)
Ln(outpat. ED visits) squared	0.023* (0.011)	0.039* (0.017)
Ln(other outpat. visits) squared	0.038* (0.004)	0.051* (0.006)
Ln(casemix-adj. discharges) x Ln(outpat. ED visits)	0.013* (0.013)	-0.036* (0.018)
Ln(casemix-adj. Discharges) x Ln(other outpat. visits)	-0.088* (0.008)	-0.087* (0.011)
Ln(outpat. ED visits) x Ln(other outpat. visits)	-0.018 (0.011)	-0.005 (0.015)
Year 1991 dummy	0.121* (0.020)	0.111* (0.046)
Year 1992 dummy	0.211* (0.020)	0.193* (0.047)
Year 1993 dummy	0.250* (0.021)	0.220* (0.047)
Year 1994 dummy	0.259* (0.022)	0.232* (0.047)
Year 1995 dummy	0.291* (0.022)	0.254* (0.047)
Year 1996 dummy	0.335* (0.023)	0.275* (0.047)
Year 1997 dummy	0.364* (0.025)	0.276* (0.047)
Year 1998 dummy	0.404* (0.028)	0.302* (0.048)
Ln(HHI index)	-0.158* (0.022)	-0.108* (0.026)
Ln(HHI index) x 1991 dummy	0.034* (0.015)	0.030 (0.036)
Ln(HHI index) x 1992 dummy	0.072* (0.015)	0.062** (0.036)
Ln(HHI index) x 1993 dummy	0.087* (0.015)	0.066** (0.036)
Ln(HHI index) x 1994 dummy	0.092* (0.015)	0.078* (0.036)

	(0.016)	(0.037)
Ln(HHI index) x 1995 dummy	0.114*	0.106*
	(0.016)	(0.037)
Ln(HHI index) x 1996 dummy	0.124*	0.111*
	(0.016)	(0.037)
Ln(HHI index) x 1997 dummy	0.101*	0.070**
	(0.017)	(0.038)
Ln(HHI index) x 1998 dummy	0.109*	0.074**
	(0.017)	(0.039)
Ln(PPS pressure index)		-0.004
		(0.027)
Ln(PPS pressure index) x 1991 dummy	0.000	-0.003
	(0.017)	(0.039)
Ln(PPS pressure index) x 1992 dummy	-0.012	-0.004
	(0.017)	(0.039)
Ln(PPS pressure index) x 1993 dummy	-0.011	0.014
	(0.017)	(0.039)
Ln(PPS pressure index) x 1994 dummy	-0.011	0.014
	(0.017)	(0.039)
Ln(PPS pressure index) x 1995 dummy	-0.024	0.004
	(0.017)	(0.038)
Ln(PPS pressure index) x 1996 dummy	-0.013	0.010
	(0.017)	(0.038)
Ln(PPS pressure index) x 1997 dummy	0.011	0.040
	(0.017)	(0.038)
Ln(PPS pressure index) x 1998 dummy	0.000	0.034
	(0.017)	(0.038)
Ln(1 + proportion MediCal days)	0.109	-0.124
	(0.060)	(0.109)
Ln(1 + proportion MediCal days) x 1991 dummy	-0.057	-0.056
	(0.064)	(0.151)
Ln(1 + proportion MediCal days) x 1992 dummy	-0.044	0.009
	(0.064)	(0.151)
Ln(1 + proportion MediCal days) x 1993 dummy	0.008	0.147
	(0.065)	(0.151)
Ln(1 + proportion MediCal days) x 1994 dummy	0.072	0.228
	(0.064)	(0.149)
Ln(1 + proportion MediCal days) x 1995 dummy	0.074	0.261**
	(0.064)	(0.148)
Ln(1 + proportion MediCal days) x 1996 dummy	0.089	0.256**
	(0.064)	(0.147)
Ln(1 + proportion MediCal days) x 1997 dummy	0.141*	0.398*
	(0.064)	(0.147)
Ln(1 + proportion MediCal days) x 1998 dummy	0.120**	0.409*
	(0.065)	(0.147)
Not-for-profit dummy	-0.007	0.026*
	(0.012)	(0.009)
For-profit dummy	-0.023	0.006

	(0.020)	(0.027)
For-profit dummy x 1991 dummy	-0.021	-0.004
	(0.016)	(0.037)
For-profit dummy x 1992 dummy	-0.019	0.000
	(0.016)	(0.037)
For-profit dummy x 1993 dummy	-0.013	-0.003
	(0.016)	(0.037)
For-profit dummy x 1994 dummy	-0.028**	-0.028
	(0.016)	(0.037)
For-profit dummy x 1995 dummy	-0.044*	-0.031
	(0.016)	(0.037)
For-profit dummy x 1996 dummy	-0.056*	-0.035
	(0.016)	(0.037)
For-profit dummy x 1997 dummy	-0.047*	-0.032
	(0.016)	(0.037)
For-profit dummy x 1998 dummy	-0.057*	-0.031
	(0.016)	(0.037)
Ln(Medicare wage index)	0.000	0.450*
	(0.064)	(0.059)
Ln(1 + inter-to-bed ratio)	-0.337*	0.677*
	(0.136)	(0.084)
Ln(county per-capita income)	0.073	0.256*
	(0.057)	(0.030)
Intercept	11.904*	9.588*
	(0.968)	(0.823)

* Significant at 5% level

** Significant at 10% level

Appendix 2 Means and standard deviations (1998)

Variable	Mean	Standard Deviation
Total hospital expenses (\$)	65,800,000	54,200,000
Casemix adjusted discharges	7,111	6,088
ED outpatient visits	17,560	10,491
Other outpatient visits	80,704	80,649
Hirschmann-Herfindahl index	0.42	0.16
Medicare pressure index	0.43	0.17
Proportion MediCal days	0.21	0.18
Medicare wage index	1.19	0.15
Resident-to-bed ratio	0.02	0.06
County per-capita income (\$)	26,767	6,671
For-profit dummy	0.25	--
Not-for-profit dummy	0.43	--
Large urban dummy	0.58	--
Other urban dummy	0.29	--
Rural	0.13	--