Renewed Growth in Hospital Inpatient Cost Since 1998: Variation Across Metropolitan Areas and Leading Clinical Conditions

Bernard S. Friedman, PhD; Herbert S. Wong, PhD; and Claudia A. Steiner, MD, MPH

Objective: To use disaggregated data about metropolitan statistical areas (MSAs) and clinical conditions to better describe the variation in cost increases and explore some of the hypothesized influences.

Study Design: The study uses the state inpatient databases from the Healthcare Cost and Utilization Project, containing all discharges from hospitals in 172 MSAs in 1998 and 2001. The discharge summary information was combined with standardized hospital accounting files, surveys of managed care plans, MSA demographics, and state data pertaining to caps on medical malpractice awards.

Methods: The analysis used descriptive comparisons and multivariate regressions of admission rate and cost per case in 9 leading disease categories across the MSAs. The increase in hospital input prices and changes in severity of illness were controlled.

Results and Conclusion: Metropolitan statistical areas with higher HMO market penetration continued to show lower admission rates, no less so in 2001 than in 1998. A cap on malpractice awards appeared to restrain admissions, but the net effect on hospital cost per adult eroded for those states with the most experience with award caps. Higher admission rates and increase in cost were found in several disease categories.

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The nationwide trend in hospital inpatient costs since 1990 shows a pronounced acceleration in both admission rates and cost per case starting about 1997-1998. According to the 2002 edition of American Hospital Annual Survey Trends, the annual increase of total cost of hospital inpatient care had fallen to nearly 0 by 1996. Cost per admission continued to decline until 1998. However, costs accelerated each year thereafter. The Medicare Payment Advisory Commission reported similar results for standardized Medicare accounting costs in their reports to Congress every March.

By 2001, inpatient costs were rising nearly 5% per year, against a backdrop of declining general inflation. The acceleration was noted by a number of analysts who had been expecting hospital inpatient care to continue to offset or cushion increases in other components of healthcare spending.[1]

In interview studies, many influences on hospital cost have been suggested, notably an easing of restrictions on choice of treatments, physicians, and hospitals in managed care plans.[2,3] According to these authors, the weakened restrictions in managed care were not due to legislation or regulatory action but to competition among plans for insured persons seeking choice in healthcare services, and competition among employers in some industries to satisfy employees seeking choice of healthcare plans and services.

A number of other influences that may underlie hospital inpatient cost trends have been suggested in recent studies: beneficial technological advances, increased hospital bargaining power with health plans, and defensive practices to avoid large malpractice liability. First, when a consumer is well insured, it may be difficult to deny services and costly new technologies, regardless of whether they are cost effective, even in managed care plans. It may not be profitable either for hospitals or health plans to limit some questionable uses of new technology.[4-6] Second, the number of community general hospitals continued a gradual decline via closures and mergers during the period, and the potential bargaining power of hospitals in a number of geographic areas may have increased along with the number of health plans and the declining use of exclusive networks. (See the article by Devers et al for interview evidence in a number of communities.[7]) Finally, denial of new (or existing) services with any potential benefit can result in malpractice lawsuits. There is evidence that tighter liability laws and limits on awards can reduce the costs caused by "defensive practice" in treatment for heart attacks.[8-10]

From the Center for Delivery, Organization and Markets, Agency for Healthcare Research and Quality, Rockville, Md.

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Address correspondence to: Bernard S. Friedman, PhD, Agency for Healthcare Research and Quality, 540 Gaither Rd, Rockville, MD 20850. E-mail: bfriedma@ahrq.gov.

The purpose of this study was to use disaggregated data for metropolitan statistical areas (MSAs) for 1998 and 2001 to further explore some of these possible contributors to the increase in hospital inpatient costs. The study was restricted to adults with nonmaternity admissions. At the MSA level, variation in managed care penetration and hospital market competition, as well as years of experience with malpractice award caps, can be measured. Some factors that were not clear determinants of the overall national acceleration of cost since the mid-1990s may have effects that vary by geographic region. For example, hospital salaries, wages, and other input prices, as measured in the Centers for Medicare and Medicaid Services (CMS) "market basket update" did not accelerate in the mid-1990s, nor did the severity of illness of hospital patients increase significantly in the leading diagnostic groups.[11] Nevertheless, these 2 factors and the age distribution may have been important in the growth of cost in some geographic areas but not in others.

The study further disaggregates hospitalized patients in each MSA to focus on 9 leading groups of conditions that were found to have led the growth in inpatient cost since 1993. Starting with those conditions that accounted for more than 50% of the increase in hospital cost, maternity-related and rehabilitation cases were dropped, leaving 9 condition groups that accounted for more than 22% of all adult admissions and more than 40% of the growth of cost. We started with the top 11 categories contributing about half of the growth in inpatient cost from 1993-2001 (contribution to growth was measured by the initial share of total cost multiplied by the percent increase). Maternity-related cases were dropped due to demographic trends and cycles in births unrelated to any of factors under discussion in this article. Rehabilitation cases were dropped because of suspected changes in the reporting of cases in distinct, specialized units. An apparently large increase in the rate of admission for rehabilitation cases was offset by a decline in average cost per case. The 9 remaining categories contributed 42% of the total growth of costs. A literature search found that only some of these condition groups were subject to recent and documented technology changes believed to be beneficial to patients by improving outcomes.

CONCEPTUAL FRAMEWORK

A number of studies on the demand and cost for hospital services have illuminated the major influences on the behavior of patients, physicians, and hospitals. Demand for hospital services from the consumer point of view, once an injury or illness has occurred or is suspected, is assumed to depend on expected benefit and out-of-pocket cost, which itself depends on the features of the patient's insurance coverage. Physicians may act as imperfect agents (ie, their incentives may not be completely aligned with the best interest of the patient). This type of model was developed theoretically in the widely known 1991 study by McGuire and Pauly.[12] Competition among hospitals could affect the combinations of service, service quality, and cost available to consumers and physicians in local hospitals. In recent reviews of research on competition among hospitals, it was shown that the details of definition of market areas and the exact measure of competition did not have a big or qualitative effect on inferences about the effects on hospital expenses or quality.[13-15] One problem that has not been overcome in most past research, or in this study, is to distinguish hospitals that are effectively under the same ownership in a single market area due to a relationship with a multihospital system or joint venture.

A full model taking patient, physician, and hospital objectives into account can be quite complex and difficult to fit empirically (see, eg, a rigorous attempt with a number of limiting assumptions by Gaynor and Vogt[16]). Nevertheless, several key working hypotheses can be plausibly offered. (1) Because alternatives to inpatient care are usually cheaper, and managed care plans have a financial incentive to substitute cheaper services, areas with a higher market penetration of managed care plans are hypothesized to have lower admission rates and cost. (2) Admission rates and cost would likely be higher for patients with diseases for which there is published evidence of beneficial changes in technology. (3) In areas with a higher proportion of uninsured patients, willingness and ability to pay for inpatient care are reduced; therefore, lower admission rates and costs are expected. (4) A cap on awards for medical malpractice is hypothesized to reduce inpatient costs, but this reduction would likely vary with the number of years since enactment, as found in earlier research by Kessler and McClellan.[8,9]

The effect of hospital market consolidation and increased bargaining power with health plans does not yield a straightforward hypothesis for hospital cost. The main prediction is that prices and potential profitability would rise. For not-for-profit hospitals, this potential gain might be "spent" on a variety of the organizations' objectives in ways that increase the observed cost. On the other hand, hospitals could potentially reduce cost due to greater volume per hospital, or reduced quality, without having to lower prices. Therefore, no directional hypothesis about cost can be offered without a lot of detailed assumptions about the ownership structure of local hospitals, motives of the hospitals, and consumer preferences.

DATA AND METHODS

Major Data Source

We assembled a database of hospitals and inpatient stays for adults in 172 metropolitan areas from 22 states for 1998 and 2001. A total of 1706 hospitals were included in the ultimate dataset. The discharge summaries were part of the state inpatient databases maintained by the Agency for Healthcare Research and Quality (AHRQ). This data source, along with terms of availability to analysts, is described at http://www.hcup-us.ahrq.gov/home.jsp. The Clinical Classification System (also defined at the AHRQ Web site) is based on principal diagnosis, does not depend on choice of treatment, and defines mutually exclusive condition groupings (see http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp). The study was narrowed to 9 top clinical categories of patients that contributed more than 40% of the national increase in total hospital cost since 1993. The clinical categories are acute myocardial infarction; coronary atherosclerosis; complication of device, implant, or graft; spondylosis, intervertebral disc disorders; cardiac dysrhythmias; osteoarthritis; respiratory failure, insufficiency; congestive heart failure, nonhypertensive; and nonspecific chest pain.

Aggregation to MSA

Individual discharge and hospital data were aggregated or averaged, as appropriate, to the level of MSA, clinical condition, and year. These were denoted respectively by the variables m, c, and t for each observation. For a single year, the hypothesized forms of 2 key relationships can be viewed as linear functional relationships:

$$\text{Admission Rate}_{m,c} = f \text{ (proportion of adults in an MSA more than 75 years old, proportion of uninsured adults, proportion of population enrolled in HMOs, hospital competition index, characteristics of hospitals in the MSA, experience with a cap on malpractice liability, dummy variable for each condition group).}$$

$$\text{Log(average cost}_{m,c}) = g \text{ (area wage index, severity index for patients, proportion of uninsured adults, proportion of population enrolled in HMOs, hospital competition index, characteristics of hospitals in the MSA, experience with a cap on malpractice liability, dummy variable for each condition group).}$$

Because average cost is a nonnegative variable, the logarithm of average cost was meant to make the error distribution better approximate a normal distribution. It was advantageous to work with a first-difference model. Calculating the difference in either dependent variable for 2001 versus 1998 tended to remove a number of slow-changing unmeasured variables for each combination of MSA and clinical condition. In addition, if 1 hypothesis was that the restrictiveness of managed care plans eased, then the coefficient of HMO market share in either equation would be expected to fall over time. This hypothesis could be tested by including the initial value of that variable as well as the change in a regression. Focusing on just 1 determinant and letting 1 and 0 represent time periods, then $(Y1 - Y0) = \alpha X0 + \beta(X1 - X0)$. Gathering terms, $(\beta - \alpha)$ represents the net effect of the initial value, while β is the effect in the subsequent year. Clearly the change in effect over time is positive only if α is positive. In the case of HMO market share, a positive result for α would mean that the restrictive effect eased over time.

For 2 other key variables, the Herfindahl index of competition among hospitals and experience with malpractice award caps, the initial value and the change were included in the first-difference estimation model. The Herfindahl index (the sum of squared market shares of adult admissions for all hospitals in a market area) is an imperfect measure of concentration. Some hospitals in a market area may be under the ownership of a single system. This can't be reliably determined with the data in this study. For exploratory purposes, we included both the Herfindahl index and the proportion of local hospitals in multihospital systems. However, this variable and a number of other explanatory variables that were considered and later dropped had a relatively small change over the period for any MSA, as shown in **Table 1**; hence, they could contribute little explanatory power (see, eg, the proportion of admissions in government-owned hospitals, the proportion of admissions in teaching hospitals, and other MSA characteristics such as availability of primary care physicians).

To fit the multivariate models, ordinary least squares (OLS) estimation was used. It is possible that the variation in some of the determining variables was endogenous to the behavior of the outcome. In particular, HMO market penetration and initiation of malpractice award caps may be partly determined by business decisions and legislative action affected by prior levels of hospital cost. It would be preferable to use instrumental variables for HMO market penetration and the presence of malpractice award caps. Several variables can provide some useful independent association with these 2 characteristics of market areas. We will discuss the correlations in the Results section. However, these additional variables also may have had an effect on cost and changes in cost, in which case they would not be ideal instrumental variables.

Table 1. Descriptive Statistics for Initial Levels and Changes of Key Variables

Variable	Value in 1998*		Change: 2001-1998	
	Mean	SD	Mean	SD
Dependent†				
Inpatient cases per 1000 adults	3.198	2.11	0.1618	0.4489
Cost per case, adjusted for area wage index, $	7820	4029	1610	2700
Independent				
Severity index†			–0.600	6.200
HMO market share, %	30.406	16.715	0.077	0.749
Herfindahl index of concentration (adult admissions)	0.304	0.238	0.011	0.051
Proportion of hospitals in multihospital systems	0.654	0.314	0.021	0.215
Experience with malpractice award caps	0.312	0.374	0.100	0.059
Adult unemployment rate, %			–0.063	0.602
Population >75 years old, %			0.130	0.360
Other‡				
Area wage index	1.004	0.135		
Number of hospitals	11.500	17.836		
Population <19 years old, %	28.710	3.140		
Adults with college education, %	24.540	7.750		
Adults with high school education, %	82.390	5.810		
Proportion of Democrats in state legislature	0.560	0.111		
Presence of Certificate of Need program	0.674	0.470		
Ban on corporate contributions to political campaigns	0.360	0.482		
Population enrolled in Medicaid, 1995, %	19.560	5.750		
Malpractice premiums for general surgeons, 1995, $	26 095	8880		
Number of practicing lawyers per 1000 population, 1988	2.051	0.556		
Proportion of teaching hospitals	0.126	0.217	0.004	0.077
Proportion of hospitals owned by state and local governments	0.084	0.179	0.005	0.064

*One value per metropolitan statistical area (n = 172) unless otherwise noted.
†Measured for patients according to condition and metropolitan statistical area; 1406 observations.
‡The first group of variables was selected as possible exogenous predictors for HMO penetration in 1998. The second group was selected as possible exogenous predictors for the presence of malpractice caps in 1998. The third group was considered as determinants of cost. After testing, not all these variables were found to be suitable or convincing for truly exogenous instrumental variables.

Construction of Key Variables

Using the hospital discharge records, total charges for each case were reduced to a cost estimate, based on publicly available all-payer accounting data reported to CMS. This method has been used in a number of published studies with hospital claim files. The cost/charge ratios for hospitals in the Healthcare Cost and Utilization Project databases are documented in more detail at http://www.hcup-us.ahrq.gov, along with citations of published studies covering the method for imputing missing data and additional background studies of potential bias and refinements by condition. Hospital-wide, all-payer, inpatient cost/charge ratios were calculated from the CMS accounting reports, combining the estimated costs from distinct departments. Background studies for a few states were done with departmental cost/charge ratios overlaid on charges specific to diagnosis-related group (DRG). Diagnosis-related groups with a high proportion of routine bed unit charges, as opposed to ancillary department charges, tended to have costs underestimated. Unfortunately, many states do not report the detailed charges on discharge summaries. The condition (diagnostic) groupings used in this study were less subject to systematic bias because procedures were not a determinant of the classification, as they are for DRGs.

Severity levels (1 through 4) were determined by the established All Patient Refined Diagnosis-Related Group (APR-DRG) software package from 3M company.[17] Severity levels were based on principal and secondary diagnoses, and patient age and sex. Previous studies found that cost per case was significantly higher for severity levels 3 and 4. The proportion of cases at severity level 3 or 4 was the severity indicator used in this

study. The area wage index for hospitals, by year, came from public CMS files. The Herfindahl index already has been discussed. This measure requires that data be available for all hospitals in an area—a strength of the source data for this project. Local area demographics were from the Area Resource File (including variables such as percentage of working-age adults who were unemployed and the proportion of the population in various age and education groups). The proportion of the population enrolled in HMOs for 1998 was published in the Area Resource File, based on data from Interstudy, Inc. This information is no longer based simply on location of the health plan office, but reflects the distribution by county of members. Similar data for 2001 from Interstudy were acquired for this study.

Data on whether a state has a cap on malpractice awards (typically, a limit on awards for nonpecuniary or punitive damages), and the year enacted, were collected by Kessler and McClellan[8] and were updated by Encinosa and Hellinger in a recent study.[18] More than 40% of the states had caps in 1998. For those with caps, the number of years of experience was highly skewed because a few states have had caps for more than 20 years. For the MSAs in our regression analysis, 65 never had caps. Of the 107 with caps, the median number of years of experience was between 10 and 11, and the mode was 3 years (28 MSAs), but nearly as many had 23 years of experience. It is likely that the impact, if any, would occur gradually over time, accelerating at first and then decelerating with time. Using dummy variables for the presence and age of caps would help with descriptive comparisons of cost by MSA, but would not allow for increasing experience between 1998 and 2001. Also, a linear function of years in force would not allow for extra years to have more impact in areas with less experience at the beginning.

We assumed that the impact would be proportional to a simple S-shaped function, $1 - \exp(-\beta Y^2)$, where Y is the number of years in force. This type of nonlinear model has been used in research on technology innovation and impact. Values of β were tested from a wide range. For intuitive assessment, one end of the range implied that half the impact of malpractice caps occurred within 3 years. The other end of the range implied that half the impact did not occur until 15 years. After a number of exploratory runs, assessing the effect of experience and the mean squared error of estimation for an equation, we adopted the value of $\beta = 0.007$, which implies half of the full impact by 10 years. This is not meant to be a definitive estimate because other studies would want to assess the best value in the context of different models. In the current study with this assumed functional form and parameter value, significant associations were found by 10 years with little improvement in statistical models beyond that. Lower values of β would imply that more than half the impact of caps would occur beyond the years of experience of more than half the MSAs in the study. This did not appear to be a reasonable assumption. Future studies may choose to explore this issue more fully. The formula for experience was calculated in both 2001 and 1998 to create the change. One state with 2 MSAs dropped award caps in the middle of the period. These MSAs were assumed to gain an additional 1.5 years of experience, and the total experience was assumed to affect admissions and cost even 1.5 years after caps were dropped.

Beneficial Technology Changes

To evaluate the association of cost with particular diagnostic categories, we made a targeted literature search for medical advances. Our search used MEDLINE and other databases available at http://www.pubmed.gov. We used keyword searches for frequent principal diagnoses and procedures within each of the 9 categories from 1995 to 2003. To narrow the results, secondary key words included terms such as "new technology," "advances," "benefit," and "cost." It was not necessary that a technology be newly invented, but that statistical evidence about new or improved technologies for diagnosis or treatment be published. In some cases, effectiveness was still questioned, but perceived benefits by practicing physicians were reported. Eventually, 70 abstracts and papers were examined in detail by the project team.

We noted explicit evidence in 4 of the 9 categories that would likely lead to increasing admissions and cost per case. Highlight examples of such evidence are as follows:

- *Coronary atherosclerosis.* Insertion of a stent reduces the high rate and cost of restenosis after coronary angioplasty.[19]
- *Problem with device, implant, or graft.* More aggressive treatment of infections that can occur after implanting cardiac devices is expensive but leads to fewer deaths.[20]
- *Back and spine disorders.* Increased use of spinal fusion after simpler laminectomies or diskectomies is widely accepted by physicians, although there is still some controversy about benefit and incentives.[21]
- *Cardiac dysrhythmias.* Dual-chamber, rate-modulated pacing was demonstrated to be superior to single-chamber pacing, despite shorter life of the device and higher cost.[22]

In the other categories, changes in utilization were noted and discussed in the literature, but these changes

were not linked to evidence of beneficial advances. For example, in the category of congestive heart failure, evidence about increased use of intensive-care units, pacemakers, defibrillators, and mechanical ventilation was offered. An increase in referral to teaching hospitals was noted in some articles pertaining to cardiovascular procedures, but this increase was not explicitly linked to particular improvements in technology that might be available.

RESULTS

Basic descriptive statistics are provided in Table 1. For the dependent variables and the severity of illness, the variables were calculated over all the combinations of MSA and clinical condition used later to fit regressions. Clearly, there was a relatively high variance in the change of these variables over time. Most of the other variation was calculated at the MSA level only. There was considerable initial variation in the Herfindahl index, the proportion of hospitals in systems, and other measures of the mix of hospitals in an MSA. However, the changes over time were relatively small. There was relatively high variation in the experience with malpractice award caps, and the average increase was about one third of the initial average. The latter result is fairly substantial and due to nearly half the hospitals with caps being in the early upswing of the S-shaped experience curve.

Table 2 provides a selected set of breakdowns of the initial 1998 values for admission rate and cost together with the changes between 1998 and 2001, controlling for diagnostic category. In the first 2 rows, the HMO market penetration is divided at the median value. Admission rates per 1000 adults were about 10% lower already in 1998 for the areas with above-median HMO penetration (2.98 vs 3.22). Remarkably, the difference widened over time. The admission rate fell by 1.3% where the HMO penetration was relatively high, but was essentially flat when HMO penetration was below the median. Cost per case also was lower in areas with above-median HMO penetration ($7259 vs $7736). The difference shrank somewhat by the end of the period. The bivariate correlations of HMO market penetration with some variables that could affect the locational decisions of plans and self-selection by enrollees found a number of significant positive associations in 1998 with the hospital area wage index, the number of hospitals, the proportion of area population less than 19 years old, and the proportion of adults with 16+ years of education. In a multivariate regression for the HMO penetration in 1998 fitted to these variables, all had t values greater than 1.0, and the F test was significant, with an adjusted R^2 of .21. (A number of other descriptors of area demographics and supply of physicians were considered and not found to be significantly correlated with HMO penetration.) These variables were not used as instruments in the later analyses because of concerns that the instruments themselves may have an unacceptable degree of association with the change in admissions and cost.

The second set of 2 rows provides breakdowns for a median split of observations by the Herfindahl index in 1998. With above-median concentration, the MSA admission rate per 1000 adults was initially nearly 9% higher than that in the areas with below-median concentration. This difference tended to widen over time, as shown in the second column. This is consistent with the survey reports of increased bargaining power by hospitals. If each admission became more profitable, hospitals in more concentrated markets would compete with one another for more admissions. However, it also is possible to imagine a scenario in which less concentration (greater competition) led hospitals to make their services more diverse and attractive, yielding more admissions in total. Cost per case was somewhat higher with above-median concentration, but the rate of growth was slightly lower. One might expect, based on the survey studies, that cost would be higher and rising more in the more concentrated markets. However, as we noted earlier, the theoretical link between concentration and prices or profits does not immediately imply a link between concentration and cost. For example, in more concentrated areas there may be less competitive pressure to offer every new technology available for a small group of patients; hence, costs might be lower. The net effect, descriptively, appears to be that cost is higher with concentration, but the difference narrows over time.

Descriptive breakdowns in relation to the existence of malpractice award caps and the years since initiation are provided later, so only a few correlation results will be offered here. States may have enacted award caps before 1998 for a number of reasons, including high and rapidly rising healthcare costs, high malpractice premiums, or a high burden on state budgets of Medicaid spending. A number of potentially exogenous determinants of legislative action (ie, not the level or rate of increase in costs) were examined. In a regression for whether a state had an award cap in 1998, all of the following variables were significant, with an absolute t value of >2.0 and an overall adjusted R^2 of .32: the proportion of Democrats in the state legislature (1995, positive effect), the continuation of a voluntary Certification of Need program (1995, negative effect), and a ban on corporate contributions to election campaigns

Table 2. Selected Descriptive Breakdowns, 1998-2001*

Market Penetration or Herfindahl Index	Admission Rate, 1998 (per 1000 Adults)	Increase in Admission Rate (%)†	Cost per Case (Adjusted for Area Wage Index), 1998	Increase in Cost per Case (Adjusted %)‡
Above-median HMO market penetration in MSA, 1998	2.98	–1.3	$7259	0.8
Below-median HMO market penetration in MSA, 1998	3.22	0.1	$7736	–1.2
Above-median Herfindahl index for hospital concentration in MSA, 1998	3.26	1.0	$7583	–0.2
Below-median Herfindahl index for hospital concentration in MSA, 1998	3.02	–1.2	$7378	0.3

MSA indicates metropolitan statistical area.
*Each cell is a weighted mean, using the number of adults in 1998 as the weight for admission rates and the number of cases in 1998 as the weight for the cost per case, controlling for the 9 leading conditions; 1286 observations.
†Increases for each dependent variable were first regressed on the 9 condition dummy variables, with errors assumed to be correlated by MSA. The residuals from those regressions were then used for the breakdowns.
‡These are approximate. No "smearing" technique was used because the mean values of the change in log(cost) were small.

(1998, negative effect). These were interesting associations, but again these variables could have some relation to future costs and hence were not deemed convincing for use as instrumental variables. Other measures were considered: malpractice premium rates for surgeons (1995) and the proportion of the state budget allocated to Medicaid (1995). These 2 variables were negatively correlated with the existence and age of award caps, suggesting that these were outcomes of caps.

Regression Results

Table 3 provides results for both the change in admission rates and the change in cost per case. Consider first the admission rate. The results suggest that HMO market penetration continued to restrain admission rates after 1998. A negative effect in the initial year indicates that restrictive effects did not weaken over time. The percentage of unemployed adults, included as a proxy for the uninsured population, had a significantly positive effect, counter to expectation. This could perhaps be due to less use of ambulatory and preventive services, resulting in more preventable admissions. Longer experience with malpractice award caps as of 1998 was associated with slower growth of admission rates, but the added experience as of 2001 did not have a significant association. This is consistent with a diminished effect over time. The hospital concentration measures did not have significant independent effects.

In 3 of the 4 condition groups where evidence of beneficial technology advances was found, the increases in admission rate were significant. However, 2 other condition groups also had significantly high increases in admission rates. These coefficients are all relative to the category of acute myocardial infarction, which was a little below the average in the change of admission rate over time. The unexpected, large positive difference for nonspecific chest pain stands out as unexpected. Also, the increase in admissions with a principal diagnosis of osteoarthritis, after controlling for advanced age, was not expected.

The last two columns in Table 3 provide results for the change in log of adjusted cost per case. Because the severity scores do take age into account, no age variables were needed. The severity index had a large effect on cost, as expected, after controlling for the type of condition. In these models, neither the initial level nor the change in the HMO market penetration had a significant association with cost. The proportion of unemployed adults was associated with lower cost per case, as expected. The Herfindahl index and the proportion of system membership did not have significant associations with cost. The level of experience with award caps in 1998 was not significant, but increased experience appeared to restrain the growth of cost. Because of the S-shaped function used to calculate experience, areas with fewest years of experience had the most increase in experience. Among the specific disease groups, only 2 (spondylosis, intervertebral disc disorder, and cardiac dysrhythmias) were significantly different from the default category. Both of these differences were expected on the basis of evidence of beneficial technology change.

In view of the timeliness of the question of the effect of malpractice award caps, an effort was made to transform the results from Table 3, together with initial data in MSAs with varying numbers of years of experience with caps, to promote discussion of how the cost per adult may be associated with the experience with award caps. The results are shown in **Table 4.** In the starting year of 1998, MSAs in states with no award cap had an average cost per adult in each of the 9 categories of admissions of about $25. The technique known as "smearing" was used with the OLS regression of log(cost) in Table 3 to estimate values of cost per case in 2001.[23] The average cost per adult in the states without caps increased by about 30% in 3 years. The average cost per adult increased by a smaller 21% rate in states with 1 to 10 years of experience with caps. Reading down the columns for cost per adult, there was a substantial drop in cost per adult after 10 years of experience with caps. This was associated with lower admission rates more so than with lower costs per case. However, the final column shows that the percent increase in cost per adult was higher after more than 10 years of experience, a somewhat faster increase than that for states with no award caps. This suggests erosion of the impact of caps after many years.

Table 3. Regression Results for Change in Admission Rates and Cost per Case, by MSA and 9 Disease Categories, 1998-2001*

	Change in Admission Rate per 1000 Adults		Change in Log of Adjusted Cost per Case†	
Variable or Disease Category	**Coefficient**	***t* Statistic**	**Coefficient**	***t* Statistic**
Independent variable				
Change in percentage of unemployed adults	0.0937	3.47‡	–0.0392	–2.29§
Change in percentage of population >75 years old	8.3770	2.03§	Age included in severity index	
Change in severity index‖			0.0051	3.11‡
HMO market share, 1998, %	–0.2632	–2.90‡	–0.0506	–0.78
Change in HMO market share, %	–0.0224	–4.02‡	–0.0095	–1.66
Herfindahl index (admissions), 1998	–0.0224	–0.30	–0.023	–0.38
Change in Herfindahl index	–0.0104	–0.04	0.2446	1.30
Change in proportion of hospitals in systems	0.0499	0.98	0.0546	1.28
Experience with malpractice award caps¶	–0.0828	–2.34§	0.041	1.38
Change in experience with caps	0.1588	0.63	–0.4193	–2.01§
Disease category#				
Acute myocardial infarction (default)				
Coronary atherosclerosis	0.0188	0.35	–0.0253	–1.88
Complication of device, implant, or graft	0.3050	7.76‡	–0.0001	0.00
Spondylosis, intervertebral disc disorder	0.1888	4.06‡	0.071	3.96‡
Cardiac dysrhythmias	0.3491	8.79‡	0.0458	3.59‡
Osteoarthritis	0.3470	8.41‡	–0.0244	–1.51
Respiratory failure, insufficiency	–0.0546	–1.58	0.0194	0.76
Congestive heart failure, nonhypertensive	–0.0147	–0.32	0.023	1.88
Nonspecific chest pain	0.6490	13.92‡	0.0186	1.24
Constant	**0.0658**	**1.21**	**0.2344**	**5.94**
R^2		**0.27**		**0.11**
df		**1251**		**1251**
Clusters		**167**		**166**

MSA indicates metropolitan statistical area.
*Regression method: ordinary least squares with errors clustered by MSA. Errors are assumed to be correlated within an MSA, and the error variance differs between MSAs.
†The adjustment is log(cost per case/area wage index).
‡$P < .01$.
§$P < .05$.
‖Proportion with a severity score of 3 or 4 in the 3M All Patient Refined Diagnosis-Related Group (APR-DRG) severity scoring system.[17]
¶Depending on the number of years in force, as defined in the text.
#Categories are from the Healthcare Cost & Utilization Project clinical classification system. Complete details about the construction and rationale of the project are provided at http://www.ahrq.gov/data/hcup. Disease categories are listed in order of their respective contributions to half the growth of total hospital costs between 1993 and 2001. Maternity-related cases are excluded.

Table 4. Actual and Fitted Values of Hospital Inpatient Cost per Adult, 1998 and 2001*

Years That Malpractice Award Caps Were in Force, 1998	Weighted Averages						
	Actual Discharges per 1000 Adults, 1998	Fitted Discharges per 1000 Adults, 2001	Actual Cost per Case ($), 1998	Fitted Cost per Case ($), 2001	Actual Cost per Adult ($),† 1998	Fitted Cost per Adult ($), 2001	Increase
None	3.35	3.50	7433	9235	24.93	32.33	29.7%
1-10	3.20	3.40	7999	9117	25.60	30.97	21.0%
>10	2.67	2.76	6944	8993	18.53	24.80	33.8%

MSA indicates metropolitan statistical area.
*Selected condition categories, cost-adjusted by the areawide wage index. These are averages for MSA residents in the 9 categories of conditions contributing the most to the growth of hospital inpatient costs between 1993 and 2001. Maternity-related discharges are excluded.
†The national admission rate for adults was about 125 per 1000 adults. Therefore, an average of $24 per adult in the disease categories of this study would be consistent with nearly $900 per adult overall in 1998.

DISCUSSION

Some major factors associated with the recent increases in hospital inpatient cost, seen by comparing MSAs on 9 leading groups of conditions, are not as simple as some observers have suggested. Any easing of restrictions in managed care plans probably did not ease the restraining effect of managed care plans on hospital admission rates per adult. Areas with higher unemployment rates saw higher admission rates, which was partially offset by a lower level of increase in cost per case. Hospital market concentration within MSAs, albeit difficult to measure in this study, was suggested as important in survey studies but with ambiguous theoretical effects. The level or change in concentration was not found to have a significant association with the change in admissions and cost. Incentives to practice defensive medicine appear to affect the admission rates and the increase of costs for the leading condition groups studied, as shown in the effects of prior experience and increasing experience with malpractice caps. Defensive practice also may account for the surprisingly large increase in admissions for some conditions (eg, nonspecific chest pain), but this requires more investigation to separate defensive practice from other incentives (eg, financial incentives for the hospital to admit insured patients from the emergency department, financial incentives for physicians who bill for in-hospital services independently). However, it is not known whether those financial incentives increased over this period.

Beneficial changes in medical technology are likely to be important determinants of increases in admission rates and cost per case. Significant increases in admission rates were seen in 3 of the 4 condition groups with documented medical advances. Significant increases in cost per case were seen in 2 of the 4 condition groups with such documented advances.

The study has clear limitations. The results cover a third of the hospitals in the country, and do not include hospitals outside MSAs. The leading disease groups in this study accounted for only about 42% of the increase in hospital inpatient costs. Better measures of local income and insurance coverage at the MSA level might contribute to an explanation of cost changes. The number and size distribution of competing health plans, as well as consumer out-of-pocket share of covered expense, should be considered as underlying determinants of hospital cost. The literature on technology changes is vast, and the search methods used in this study were not exhaustive. Therefore, some costly improvements in treatment for other diseases in the leading categories may have been missed, especially if the improvements were adopted before publication of large definitive studies in the literature.

The possible effects of experience with malpractice award caps gave results at and above the upper end of the range (5%-9%) found by Kessler and McClellan[8,9] for heart attacks. Interestingly, the savings in cost for areas with more than 10 years of experience with award caps appeared to be weakening—the growth rate of cost during this period in those areas was slightly greater than the growth rate in all other areas. The results here cannot be considered as definitive because of the difficulty in finding convincing instrumental variables to control for possible endogeneity of the enactment and continuation of award caps. The topic is worthy of more research because policies to reduce incentives for defensive practice might yield savings in hospital inpatient

cost that could be put to more effective use within the healthcare system. Improving the safety and outcomes of services will likely require investments in information systems, training, and organizational reforms for better coordination of services.[24] However, there may be other or better ways to achieve savings in inpatient cost. These might include reducing the profitability to physicians and hospitals of costly technologies with weak supporting evidence, or varying the consumer out-of-pocket responsibility for costs, depending on evidence of effectiveness.

We plan to repeat this type of disaggregated study of admission and cost increases, with the data even more disaggregated to the level of hospital and payer group. Another avenue of exploration is to study which procedures and which payer groups within several of the condition groups account for more or less of the growth of expense, and how such trends might be related to beneficial technology advances and a variety of market forces.

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REFERENCES

1. Levit K, Smith C, Cowan C, Lazenby H, Sensenig A, Catlin A. Trends in health care spending, 2001. *Health Aff (Millwood).* 2003;22(1):154-164.

2. Lesser C, Ginsburg P, Devers K. The end of an era: what became of the managed care revolution in 2001? *Health Serv Res.* 2003;38(1 part II):337-355.

3. Mehrotra A, Dudley RA, Luft H. What's behind the health expenditure trends. *Annu Rev Public Health.* 2003;24:385-412.

4. Friedman B, Devers KJ, Steiner CA, Fox S. The use of expensive health technologies in the era of managed care: the remarkable case of neonatal intensive care. *J Health Polit Policy Law.* 2002;27(3):441-464.

5. Chernew M, Fendrick AM, Hirth RA. Managed care and medical technology: implications for cost growth. *Health Aff.* 1997;16:196-206.

6. Aaron HJ. The unsurprising emergence of renewed health care cost inflation. *Health Affairs* Web exclusive. January 23, 2002. Available at: http://content.healthaffairs.org/cgi/content/full/hlthaff.w2.85v1/DC1. Accessed January 19, 2006.

7. Devers KJ, Casalino LP, Rudell JJ, et al. Hospitals' negotiating leverage with health plans: how and why has it changed? *Health Serv Res.* 2003;38(1 part II): 419-446.

8. Kessler D, McClellan M. Do doctors practice defensive medicine? *Q J Econ.* 1996;111(2):353-390.

9. Kessler D, McClellan M. How liability law affects medical productivity. *J Health Econ.* 2002;21:931-955.

10. PriceWaterhouseCoopers. *The Factors Fueling Rising Healthcare Costs.* Prepared for the American Association of Health Plans. April 2002. Available at: http://www.ahip.org/. Accessed January 19, 2006.

11. Steiner CA, Friedman B, Wong H, Andrews R. The recent acceleration in hospital inpatient costs: a closer look. Paper presented at: Annual Research Meeting of Academy Health; June 6-8, 2004; San Diego, Calif.

12. McGuire TJ, Pauly MV. Physician responses to fee changes with multiple payers. *J Health Econ.* 1991;10:385-410.

13. Gaynor M, Haas-Wilson D. Change, consolidation, and competition in health care markets. *J Econ Perspect.* 1999;13:141-164.

14. Romano P, Mutter R. The evolving science of quality measurement for hospitals: implications for studies of competition and consolidation. *Int J Health Care Finance Econ.* 2004;4:131-157.

15. Wong HS, Zhan C, Mutter R. Do different measures of hospital competition matter in empirical investigations of hospital behavior? *Rev Ind Organ.* 2005;26: 61-87.

16. Gaynor M, Vogt WB. Competition among hospitals. *RAND J Econ.* 2003;34(4): 764-785.

17. Averill R. Development of the All Patient Refined DRGs (APR-DRGs). *3M HIS Res Rep.* 2000;8-97:1-22.

18. Encinosa W, Hellinger F. Have state caps on malpractice awards increased the supply of physicians? *Health Affairs* Web exclusive. May 31, 2005. Available at: http://content.healthaffairs.org/webexclusives/index.dtl?year=2005. Accessed January 19, 2006.

19. Moussavian M, Casterella PJ, Teirstein PS. Restenosis after angioplasty. *Curr Treat Options Cardiovasc Med.* 2001;3(2):103-113.

20. Chua JD, Wilkoff BL, Lee I, et al. Diagnosis and management of infections involving implantable electrophysiologic cardiac devices. *Ann Intern Med.* 2000;133: 604-608.

21. Abelson R, Petersen M. An operation to ease back pain bolsters the bottom line, too. Business section. *The New York Times.* December 31, 2003.

22. Flaker G, Greenspon A, Tardiff B, et al. Death in patients with permanent pacemakers for sick sinus syndrome. *Am Heart J.* 2003;146(5):887-893.

23. Duan N. Smearing estimate: a non-parametric retransformation method. *J Am Stat Assoc.* 1983;78:605-610.

24. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century.* Washington, DC: National Academy of Sciences; 2001.