

Hospital Cost Drivers: An Evaluation of 1998–2001 State-Level Data

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Objective: To evaluate the determinants of increased hospital inpatient expenditure growth since 1998.

Data Sources and Methods: Multivariate regression analyses were estimated for 1998-2001 utilizing state-level information from nationally representative population sources, US government agencies, and aggregate expenditures estimated from a nationally representative large health insurance plan (LHIP).

Results: During 1998-2001, LHIP inpatient expenditures per member increased by an average of 5.9% annually, twice the 2.9% annual rate of inflation. Overall level of economic activity, price-level variation, hospital technology, hospital market, and healthcare labor force are the most important drivers of recent trends in inpatient expenditures. Inpatient costs were responsive to hospital market characteristics. Each 1% increase in for-profit and medical system (chain ownership) hospital percentage was associated with approximately a 2% increase in inpatient expenditures. Each 1% increase in network (shared purchasing or other arrangement, but not ownership) hospital percentage was associated with a 1% decrease in inpatient expenditures. Each 1% increase in the gap between registered nurse demand and supply led to a 0.5% to 1% increase in hospital inpatient expenditures per capita.

Conclusions: Many characteristics contribute to inpatient expenditure growth, such as local area wages and incomes per capita, and physician market characteristics, but are not directly influenced by hospital market policies. Hospital technology and market structure are the 2 factors that are most directly amenable to healthcare policy intervention. Hospital occupancy and case-mix severity also have substantial effects on inpatient expenditure growth. With the nurse supply shortage projected to increase by 40% between 2000 and 2005, upward pressures on inpatient costs will remain.

(*Am J Manag Care* 2003;9:SP13-SP24)

growth have not been as high as those for pharmaceuticals and outpatient services during this time, hospital inpatient care represents the largest single component of healthcare expenditures, and thus even relatively small rates of growth can have large absolute effects on total healthcare expenditures.

Forrest and colleagues¹ reviewed the hospital cost literature and identified several categories of factors as contributing to hospital cost increases during the recent time period. This study builds on that literature review by estimating econometric models of hospital inpatient costs to evaluate formally which characteristics identified in the literature have substantial and significant contributions to recent trends in inpatient expenditure growth.

The analysis focuses on recent trends in expenditure data from a large health insurance plan (LHIP) for the period 1998-2001. Because this time period is too short to establish reliable relationships between inpatient expenditures and all of the potential explanatory factors identified in the literature review, variation in state-level hospital markets was used to establish the relative strength of explanatory factors. Each state experiences substantial variation and lagged adjustments in population, morbidity, income and wages, healthcare labor markets, technology, etc. Multivariate regression analysis can take advantage of this variation across state-level hospital markets to evaluate the relative

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This study was supported by a grant from Blue Cross and Blue Shield Association, Chicago, Ill.

Additional results and research details are available to interested readers at: <http://bcbshealthissues.com/costpressconf/materials.vtml>.

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After nearly a decade of historically low rates of hospital cost increases, the United States has been experiencing substantially increased hospital inpatient expenditure growth since 1998. Although the rates of inpatient expenditure

importance of different characteristics as potential drivers of hospital inpatient expenditure growth.

Healthcare expenditure growth can be factored into 2 components: price increases and increases in utilization. With rapidly evolving technology, it is difficult to partition medical expenditure increases neatly into these 2 components. New drugs, surgical techniques, and diagnostic interventions reflect higher cost treatment options that were previously unavailable. How much expenditure increases for new technologies should be attributed to increased prices and how much should be attributed to increased utilization remains controversial.² For this reason, this analysis evaluates overall inpatient expenditure growth, rather than trying to decompose expenditures into price and utilization sub-components.

An additional theoretical distinction must be made between hospital expenditures (costs to payers) and hospital costs (actual costs of providing hospital care). This difference reflects the net profit (net revenue minus costs) from provision of hospital services. For the purposes of this analysis we are interested in hospital costs to payers such as insurance companies or managed care plans. State-level hospital profit margins are difficult to estimate and in any case are not a major source of hospital expenditure growth during the recent time period.

METHODS

Data Sources

Because healthcare payers and providers are not linked into any formal data collection system, there are no straightforward ways to obtain timely information on healthcare expenditure and finance trends. Public use data are available for the Medicare and Medicaid programs, but these program beneficiaries represent special population subgroups, primarily the elderly and the poor, respectively.

In order to look at hospital cost drivers using data relevant to current trends, this analysis utilized 2 different primary sources. The first database includes state-level information from nationally representative population sources (primarily published statistics from US government agencies). These data will be referred to as the Nationally Representative State Data (NRSD). Hundreds of variables are available in this dataset (see <http://bcbshealthissues.com/costpressconf/materials.vtml>), including information on population demographics, income and socioeconomic characteristics, morbidity and disease risk

characteristics, hospital and medical technology, healthcare employment, health insurance, physician characteristics, and many other factors.

These state-level data have the advantage that they are official statistics. Unfortunately, most of these variables are currently available only through the year 1999.³ This relatively old time frame limited their usefulness in explaining the most recent healthcare expenditure trends. Some evidence suggests that healthcare cost trends may have shifted in the most recent time period.¹ For this reason, the NRSD was used to confirm the validity of specific variables and factors in explaining hospital cost growth, but were not used for the recent trend expenditure analysis.

These data were supplemented with an analysis of state-level aggregate expenditures estimated from a nationally representative LHIP. Whereas this LHIP, like all US healthcare payers, is not fully representative of the national population, it contains several million members from all 50 states and the District of Columbia. The primary advantage of this health insurance database is that hospital and healthcare expenditure data were captured in a more recent time period (last quarter of 1998 through the first quarter of 2002).

The primary drawback of the LHIP is that because the data are limited to a small set of demographic characteristics (essentially patient age, sex, and Medicare status), they cannot be precisely matched against the NRSD state-level information. Moreover, with only 2 years of overlap between the 2 databases, it was impossible to reliably cross-reference trend results between the NRSD and LHIP data. The NRSD database was used primarily to establish and confirm the significance of broad categories of explanatory variables.

Statistical Methods

To evaluate the relative effects of a variety of state-level characteristics on inpatient expenditures, stepwise multivariate regression was used. The LHIP database consists of 303 potential explanatory variables (see <http://bcbshealthissues.com/costpressconf/materials.vtml>) for the period 1998-2001. Two potential data reduction strategies exist in this situation—either the creation of variance components factors for each main category of explanatory variables (eg, population, insurance, providers, technology, etc)⁴ or using stepwise regression techniques to incorporate only those variables that have the highest statistical significance.⁵ Because factor analysis creates explanatory vari-

ables with little direct policy relevance, stepwise regression was chosen for the primary analysis with factor analysis used to confirm the general validity of the final stepwise specification. Because of multiple statistical comparisons, the stepwise explanatory variable coefficients' significance levels should be adjusted downwards.

A backward selection stepwise regression procedure was used to generate the regression results.⁵ Stepwise regression methods have been criticized because there is no guarantee that the final model specification is valid, and estimates may be subject to omitted variables bias.⁶ With many more explanatory variables than observation points, this criticism would potentially apply to any method for restricting regression model explanatory variables for this dataset. A major advantage of the stepwise procedure is that it is transparent, reproducible, and does not impose researcher bias on the reported findings. Stepwise regression findings should be treated as exploratory rather than definitive, and should be interpreted in the context of other findings.

The impact of any given factor on healthcare cost growth depends on the impact of that factor on costs, whether that impact changes over time, and whether the factor changes over time. Because there was little change in the explanatory variables over time in our study period, we estimate the first of these factors. Our analysis therefore highlights the potential impact of these factors on costs if they were to change over time.

Table 1. Explanatory Variables Considered in the State-level Analyses

Category	Explanatory Variable*
Demographics	Age, sex Race/ethnicity Percent of population in urban centers Percent uninsured Birth rate
Health status	Obesity (based on body mass index) Smoking High blood cholesterol levels Chronic alcohol drinking Sedentary lifestyle Cardiovascular disease, cancer, and diabetes mortality rates Traffic fatalities 3-Year average influenza deaths 5-Year average infant mortality rates
Health insurance product and benefit design	Percent of population enrolled in an HMO Medicaid enrollees as a percent of the population Medicare enrollees as a percent of the population
Provider supply and organization	Number of free-standing outpatient surgical centers Number of diagnostic imaging centers Percent of beds in hospitals operating on a for-profit basis Percent of hospital beds part of a medical system Percent of hospital beds part of a hospital "network" Hospital case-mix index Number of hospital beds, average occupancy rate, average daily census Outpatient visits per capita Total number of physicians per capita Number of specialists as a percent of total physicians Nurses per capita
Provider payment	Medicare payment-to-cost ratio Medicaid payment-to-cost ratio Private payer payment-to-cost ratio Uncompensated care
Provider operating costs	Wages in hospitals Wages in physician offices
Healthcare regulation	Cervical cancer screening Clinical trials Colorectal screening Diabetic supplies and education In vitro fertilization Other infertility services Mammography screening Mental health (general) and parity mandates Presence of Certificate of Need programs
Medical technology	Percent of total surgeries performed on an outpatient basis Percent of hospitals with CT scanner, MRI, PET scanner, SPECT scanner, and diagnostic radioisotope services Percent of hospitals offering burn care and cardiac catheterization Percent of hospitals with organ transplant capabilities Number of academic health centers
Economic variables	Disposable real income Percent of population in poverty

*Variable sources are described in reference 13.

CT indicates computerized tomography; MRI, magnetic resonance imaging; PET, Positron Emission Tomography; SPECT, Single Photon Emission Computerized Tomography.

RESULTS

Analysis of LHIP State-Level Data: 1998-2001

Table 1 provides a listing of the explanatory variables considered for the hospital inpatient expenditure state-level regression analyses for both the factor analysis and the stepwise regressions. The LHIP data used in the analysis were taken from consistently identifiable continuously enrolled members from the last quarter of 1998 to the end of 2001. No personal identifier information was provided in the data files. The data sample consisted of 3.2 million to 3.5 million plan members each year. Approximately 30% of these plan members were dually enrolled in Medicare. Women constituted 52% of the non-Medicare members and 59% of the Medicare dually eligible members. According to the US Census in 2000, women constituted 51% of the population and 59% of the age 65+ population.⁷ While the geographic distribution of plan members was not nationally representative, at least 2500 plan members were from every state plus the District of Columbia. The LHIP population median age was nearly a decade older than the US population. This finding implies that healthcare expenditures per LHIP member will be higher than US healthcare expenditures per capita.³

Analysis of the LHIP data focused on member expenditure for hospital inpatient, non-Medicare outpatient, and prescription drugs. The LHIP claims data include amounts submitted by the provider, amounts allowed by the health insurer, and amounts paid by the health insurer. Of these 3, the claims amounts allowed are the most representative of true healthcare expenditure amounts. Submitted claim amounts are often substantially higher than the legally contracted amount per service and do not represent real transactions.⁸ The amounts paid

leave out the deductibles and coinsurance for which the patients are contractually obligated. Although the amounts allowed include some billing that is never fully recovered from patients by providers, they are the closest estimate of the true medical care expenditures. All of the final continuously enrolled sample insurance plan members had outpatient drug coverage.

The claims data analyzed were limited to inpatient, outpatient, and prescription drug expenditures. Other healthcare services (home care, nursing home care, rehabilitation care, etc) were not available for the study. We found that 56% of the estimated expenditures per member were for inpatient care, 25% for prescription medications, and 19% for outpatient services. Average amount allowed per inpatient admission was \$14 671 in 2000. This number is consistent with Organization for Economic Cooperation and Development findings on hospital costs per admission for the United States in 1999.⁹ During the 1998-2001 time period, inpatient expenditures per member increased by an average of 5.9% annually (**Table 2**). This increase was twice the 2.9% overall rate of inflation during this time period. Prescription drug expenditures increased by 11.1% and outpatient expenditures increased by 15.0% annually for the same period (**Figure 1** and **Table 2**). Inpatient expenditure increased at the slowest pace of these 3 categories, but was the largest initial component. This finding means that inpatient expenditures accounted for 34.2% of the healthcare expenditure increase in these healthcare categories for the 1998-2001 time period, prescription drugs accounted for 33.2%, and outpatient expenditures accounted for 32.6%. Results are similar whether unweighted or weighted by state population size.

Table 2. Expenditure per Member Growth Rates: 1998-2001

Expenditure Category	Growth Rate (%)*			
	Minimum	Maximum	Mean	SD
Inpatient services	0.23	12.90	5.88	2.73
Prescriptions	7.30	14.80	11.08	1.28
Outpatient services	7.18	23.14	14.96	3.53

n = 51 for each category.

*Total expenditures per member per day include all members, including those who were not hospitalized. The average annual consumer price index inflation rate during this period was 2.9% (<http://www.bls.gov>).

SD indicates standard deviation.

Figure 1. Health Expenditure Growth Rates per Member by State and Payment Category: 1998-2001

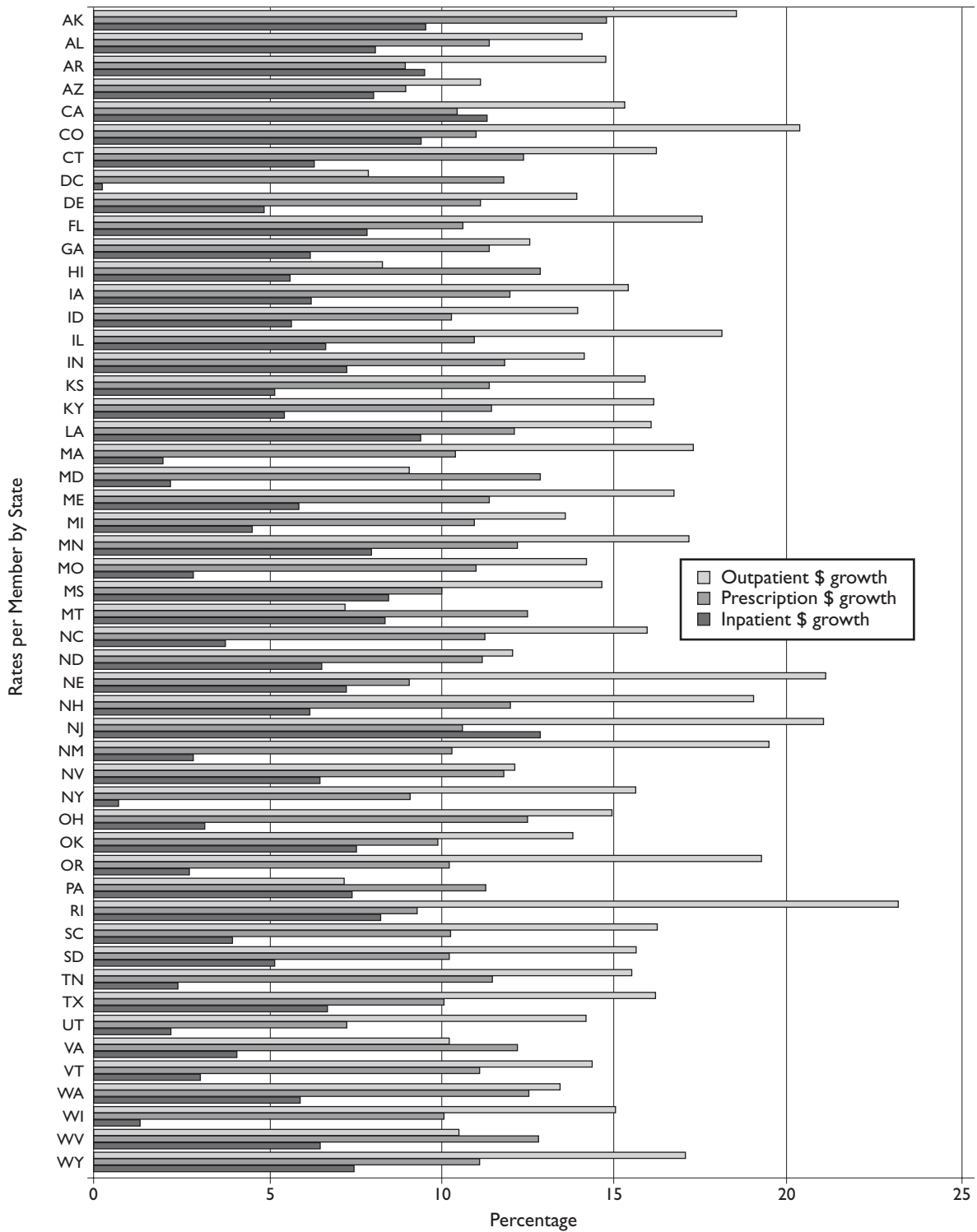


Table 3. Annual Inpatient Expenditure Growth per Member by State: 1998-2001

State	Inpatient Expenditure Growth per Member (%)	State	Inpatient Expenditure Growth per Member (%)	State	Inpatient Expenditure Growth per Member (%)
New Jersey	12.90	Nebraska	7.25	Delaware	4.89
California	11.32	Texas	6.69	Michigan	4.58
Alaska	9.55	Illinois	6.68	Virginia	4.03
Arkansas	9.51	North Dakota	6.56	South Carolina	3.98
Louisiana	9.41	Nevada	6.53	North Carolina	3.78
Colorado	9.40	West Virginia	6.48	Ohio	3.18
Mississippi	8.50	Connecticut	6.32	Vermont	3.04
Montana	8.35	Iowa	6.24	New Mexico	2.87
Rhode Island	8.25	New Hampshire	6.23	Missouri	2.87
Alabama	8.11	Georgia	6.21	Oregon	2.71
Arizona	8.03	Washington	5.89	Tennessee	2.43
Minnesota	7.96	Maine	5.88	Maryland	2.22
Florida	7.83	Idaho	5.68	Utah	2.19
Oklahoma	7.51	Hawaii	5.63	Massachusetts	1.97
Wyoming	7.48	Kentucky	5.45	Wisconsin	1.32
Pennsylvania	7.44	Kansas	5.20	New York	0.76
Indiana	7.27	South Dakota	5.18	District of Columbia	0.23

Table 3 shows the annual rates of inpatient expenditure growth per member by state. New Jersey, California, Alaska, Arkansas, Louisiana, and Colorado have the highest rates of expenditure growth per member, all exceeding 9% annually. Nationally, inpatient expenditure growth per member was 5.3% in 1999, 8.0% in 2000, and 4.9% in 2001. New Mexico, Missouri, Oregon, Tennessee, Maryland, Utah, Massachusetts, Wisconsin, New York, and the District of Columbia had the lowest rates of inpatient expenditure growth per member; all experiencing cost increases below the annual inflation rate during the 1998-2001 period. No obvious regional or demographic characteristics can explain why some states have high rates of inpatient expenditure growth while others have lower rates.

For example, New Jersey and Massachusetts are similar demographically and in many of the health policy and financing decisions to contain healthcare and hospital costs; New Jersey (+12.90% annual inpatient expenditure growth per member) is at the top of the inpatient cost increase list and Massachusetts (+1.97% annual inpatient expenditure growth per member) is 4th from the bottom. Similar contrasting comparisons can be made for Colorado and Utah and other divergent state pairs.

Table 4 shows the relative differences across states in expenditure growth per admission adjusting for differences in diagnosis-related group (DRG) discharge codes. This analysis was generated by

regressing logged individual inpatient expenditures on state and DRG discharge codes. The resulting state indicator parameters directly show the expenditure percentage increase after adjusting for patient DRG case-mix. Even after this adjustment there are substantial overlaps in state inpatient cost rankings, with many of those states exhibiting the highest cost per DRG-adjusted admission also showing the highest rates of inpatient expenditure growth per member.

Technology

One of the main factors in healthcare and inpatient cost increases is advances in expensive new medical technologies and the diffusion of newer technologies to increasingly broader segments of the patient population. There are no direct measures of these technological changes in the LHIP claims data for the most recent time period. A useful proxy is to consider the rates of use for specific drugs and drug categories that are associated with expensive technological innovation or diffusion. It is impossible to find drugs that mirror only increases in inpatient technologies. These medications were chosen because they reflect high levels of specialty medication use and should thus proxy for more intensive inpatient technologies.

For example, use of immunosuppressive medications is an indicator of organ transplantation, requiring expensive inpatient facilities. Enbrel is a relatively

Table 4. Inpatient Expenditure Growth per Admission by State Adjusting for Diagnosis-Related Groupings: 1998-2001

State	Inpatient Expenditure Growth	State	Inpatient Expenditure Growth	State	Inpatient Expenditure Growth
New Jersey	8.99	Ohio	6.20	Kentucky	5.36
California	8.57	Mississippi	6.11	Nebraska	5.35
Hawaii	8.25	Connecticut	6.09	Maine	5.32
Nevada	7.94	Massachusetts	5.99	Indiana	5.26
Florida	7.62	Michigan	5.94	Wyoming	5.20
District of Columbia	7.29	Kansas	5.92	Oregon	5.10
Arizona	7.10	New Mexico	5.90	North Carolina	5.06
Missouri	7.02	Oklahoma	5.79	Washington	5.03
Pennsylvania	6.99	Delaware	5.73	Utah	5.02
Illinois	6.83	Georgia	5.72	Iowa	4.57
South Carolina	6.66	Virginia	5.71	Vermont	4.51
Louisiana	6.64	Tennessee	5.69	South Dakota	4.33
Texas	6.63	Rhode Island	5.66	North Dakota	4.22
Alaska	6.60	Minnesota	5.59	Idaho	4.22
Colorado	6.55	New Hampshire	5.50	West Virginia	4.07
New York	6.32	Wisconsin	5.46	Montana	3.95
Alabama	6.21	Arkansas	5.42	Maryland	3.66

new arthritis medication that costs an average of \$8000 to \$16 000 per patient annually. Cardiovascular (CVD) and lipid drugs include a number of therapeutic categories (statins, angiotensin-converting enzyme inhibitors, β -blockers, antithrombotics) that have been conclusively demonstrated in the past decade to reduce the risk of CVD morbidity and mortality. Because cardiologists encourage use of these medications for secondary prevention, higher use of CVD and lipid drugs would correlate with more intensive cardiac care. Interferon beta 1-B and glatiramer acetate are recently approved treatments for multiple sclerosis that cost \$8000 to \$16 000 per patient annually. As shown in **Table 5**, with consistent double-digit annual growth rates, these treatments add directly to healthcare expenditure increases, and are also proxies for increases in expansion of organ transplantation, cardiac care units, diagnostic facilities, and other expensive inpatient hospital technological advances.

While LHIP study population membership growth has averaged 1.4% annually during 1998-2001, the numbers of new patients taking each of these categories of high-tech drugs has increased by 10% to 35% annually. New users of these medications are unlikely to alter outcomes substantially (and thus hospital costs) over such a short time frame. It is likely that similar growth rates for patients using expensive inpatient diagnostic, surgical, and other treatment technologies have also occurred during

this period. While most states show substantial annual increases for all of these high-tech drug categories, the states with the highest rates of high-tech drug adoption do not correspond consistently to states with the highest inpatient costs per admission, or with the states with high rates of inpatient expenditure growth (see <http://bcbshealthissues.com/costpressconf/materials.vtml>).

Another way to evaluate the use of inpatient technology is to examine cost outliers. Healthcare expenditures tend to be highly skewed, with small numbers of patients accounting for large total expenditures. The high-cost outliers are most likely to reflect high-intensity high-tech interventions. In the LHIP data, whereas the average cost per discharge was \$15 917 in 2001, 5% of the sample had costs per discharge exceeding \$47 424. These cases represented 28% of total inpatient expenditures in 2001. They also likely overrepresented the most technically advanced and complex treatments.

The state ranking distribution of the upper 5th percentile of costs per discharge by state was similar to those in Tables 3 and 4, implying that relatively high levels and growth rates for inpatient costs have the same pattern at the high end, where expensive and complex technology would be more likely implicated as the contributing factor as they do for inpatient costs generally (see <http://bcbshealthissues.com/costpressconf/materials.vtml>).

Health Profession Labor Shortages

As discussed in the hospital cost literature review,¹ nurses constitute 44% of the direct costs of inpatient care. Nurses are already in a shortage situation in California, New York, Massachusetts, and several other states, and these shortages are projected to substantially worsen over the next decade.¹⁰ A double-log univariate regression of the 2000 inpatient costs per member per day on the registered nurse (RN) shortage found that each 1% increase in the RN shortage leads to a 0.96% increase in hospital inpatient costs per member (see <http://bcbshealthissues.com/costpressconf/materials.vtml>). Given that the RN shortage is projected by HRSA to increase by 40% just between 2000 and 2005, the potential impact on hospital inpatient costs could be substantial.

LHIP Multivariate Statistical Analysis: 1998-2000

To evaluate the relative importance of various groups of explanatory factors in accounting for hospital inpatient cost increases, a backwards-stepwise regression analysis was conducted using the LHIP state-level inpatient cost per member per day variable as the dependent variable. All variables, except indicator variables were log-transformed, so that the regression coefficients provide unit-free elasticity estimates. Additionally, many of the explanatory variables are only available for a subset of these years. Conservatively only those observations that had complete data on the dependent and independent variables were used for the estimation.

The analysis included a comprehensive set of potential explanatory variables, including population age, sex, race, and growth rates; hospital technology; health insurance and healthcare financing characteristics; health profession information; hospital market characteristics; state healthcare

regulations and mandates; population morbidity; and cost of living (see <http://bcbshealthissues.com/costpressconf/materials.vtml>).

This multivariate specification shows the independent contribution of each variable after adjustment for all other factors. As shown in **Table 6**, many of these variables are significantly associated with hospital inpatient costs per member per day. Because of high collinearity between hospital technology and case-mix characteristics when aggregated to the state level, specific coefficients are somewhat problematic. For policy purposes it is useful to focus on the aggregate effects of hospital technology, market, and utilization variables, rather than specific coefficients.

In magnitude, economic characteristics are most important; each 1% increase in per capita disposable income and hospital and physician office wage levels is associated with a 2% or more increase in inpatient costs. Next in order of responsiveness are hospital technology characteristics; states with more hospitals that belong to academic health centers or have spectral scanners or burn care facilities have substantially higher inpatient costs while states with more hospitals that have diagnostic radioisotope facilities, magnetic resonance imaging (MRI), higher bed occupancy, and higher case-mix severity have substantially lower inpatient costs. These latter 2 variables reflect hospital capacity utilization and thus imply increasing short-run returns to scale (decreasing average costs) as inpatient volume and case severity increases.

Hospital market characteristics are also important. Larger percentages of for-profit and medical system hospital beds in each state are associated with higher inpatient costs, whereas larger percentages of network hospitals and higher occupancy rates are associated with lower inpatient costs.

Medical system hospitals are hospitals that are jointly owned by a single administrative organization (for-profit, nonprofit, or religious). Hospital networks are groups of hospitals that are organized for the purposes of purchasing supplies and sharing other resources without joining into formal hospital system ownership agreements.

The hospital flow of funds indicator is significantly positive. This variable measures proportion of Medicare hospi-

Table 5. New Patient Growth Rates for Selected High-Tech Drug Categories: 1998-2001

Drug Category	Growth Rate (%)			
	Minimum	Maximum	Mean	SD
Cardiovascular	5.47	16.57	10.14	2.68
Lipid	10.49	22.79	15.37	3.01
Enbrel	0.00	100.75	35.48	23.58
Immune suppression	-7.33	42.87	16.21	9.56
Multiple sclerosis	-54.93	103.97	32.17	25.78

n = 51 for each category.
SD indicates standard deviation.

Table 6. Stepwise Regression of Inpatient Costs per Member Day on Explanatory Characteristics: 1998-2000

Dependent Variable: Log Inpatient Amount per Member per Day Explanatory Variables	β	Standard Error	Significance
(Constant)	-67.267	11.966	0.000
Certificate of need	0.135	0.039	0.002
Certificate of need (level 1)	0.219	0.040	0.000
Certificate of need (level 3)	0.152	0.086	0.086
Log_Male_Medicare85up	0.103	0.032	0.003
Log_Female_non-Medicare3039	-0.092	0.037	0.017
State cervical cancer screening mandate indicator	-0.106	0.036	0.006
State colorectal screening mandate indicator	0.218	0.100	0.037
State other infertility services mandate indicator	-0.121	0.043	0.008
State in vitro fertilization mandate indicator	-0.585	0.093	0.000
State mammography screening mandate indicator	0.326	0.056	0.000
State general mental health mandate indicator	-0.172	0.038	0.000
State mental health parity mandate indicator	0.171	0.040	0.000
Incidence of mental illness (log)	-0.197	0.071	0.009
Per capita disposable income (log)	2.265	1.078	0.043
Average wage in physician offices (log)	1.945	0.269	0.000
Average wage in hospitals (log)	2.833	0.436	0.000
Other specialist physicians per capita (log)	0.868	0.271	0.003
General practitioners per capita (log)	0.503	0.135	0.001
Medical specialists per capita (log)	-0.760	0.210	0.001
Percent of hospitals with diagnostic radioisotope labs (bed-weighted) (log)	-2.339	0.452	0.000
Percent of hospitals with spectral scanners (bed-weighted) (log)	0.947	0.257	0.001
Percent of hospitals in academic health centers (bed-weighted) (log)	2.662	0.573	0.000
Percent of hospitals with MRIs (bed-weighted) (log)	-0.687	0.319	0.039
Percent of hospitals with burn care facility (bed-weighted) (log)	1.970	0.383	0.000
Number of hospitals with catheter laboratories (log)	0.126	0.031	0.000
Percent smoking (log)	-0.534	0.124	0.000
Births per thousand population (log)	0.737	0.212	0.001
Outpatient visits per capita (log)	0.938	0.180	0.000
Hospital occupancy rate (log)	-0.799	0.182	0.000
Ratio of outpatient visits to inpatient admissions (log)	-0.416	0.192	0.038
Medicare hospital case-mix index (log)	-2.686	0.690	0.000
Percent of hospitals in medical system (bed-weighted) (log)	1.975	0.304	0.000
Percent of hospitals for-profit (bed-weighted) (log)	1.938	0.315	0.000
Percent of hospitals in network (bed-weighted) (log)	-1.031	0.183	0.000
Number of diagnostic imaging centers per 1000 population (log)	0.284	0.048	0.000
Time trend	0.827	0.282	0.006
Registered nurses per capita (log)	-0.499	0.193	0.014
Uncompensated care (log)	-0.028	0.009	0.004
Hospital flow of funds (log)	1.816	0.492	0.001

$R^2 = .994$; adjusted $R^2 = .973$.

MRI indicates magnetic resonance imaging.

tal funds that flow from beneficiary state of residence to hospital state, and is thus a proxy for hospitals that attract relatively larger numbers of patients from beyond their state borders. The RN per capita variable is significantly negative, indicating that each 1% increase in state nursing supply reduces inpatient costs by 0.5%. Internal medicine (primary care) specialists per capita are significantly negatively associated with inpatient costs while general practitioners and other physician specialists per capita are significantly positively associated with inpatient costs.

Higher proportions of younger women in the population are negatively associated with inpatient costs, while higher proportions of older men and births are positively associated with inpatient costs. Although these population demographics are relevant, they are not as important as the hospital technology, workforce, and hospital market characteristics in explaining recent trends in inpatient expenditure growth.

Figure 2 summarizes the Table 6 regression results by factor groupings in terms of their potential contribution to inpatient expenditure growth. When aggregated to the state level, there was little change in many of the explanatory variable trends during the short time period under study. Most of the explained variation in the data is across states (for example variation in for-profit ownership status), not over time. It is thus more useful for policy purposes to show the potential for each factor to con-

tribute to expenditure growth, rather than its actual contributions to growth during the observation period. This Figure shows the percentage of total inpatient expenditure growth attributable to each of these groups of factors if all factors increased equally by 1%. Grouping highly correlated variables together, and reporting the net effect of groups of factors also provides a more robust assessment of factor contribution to growth.

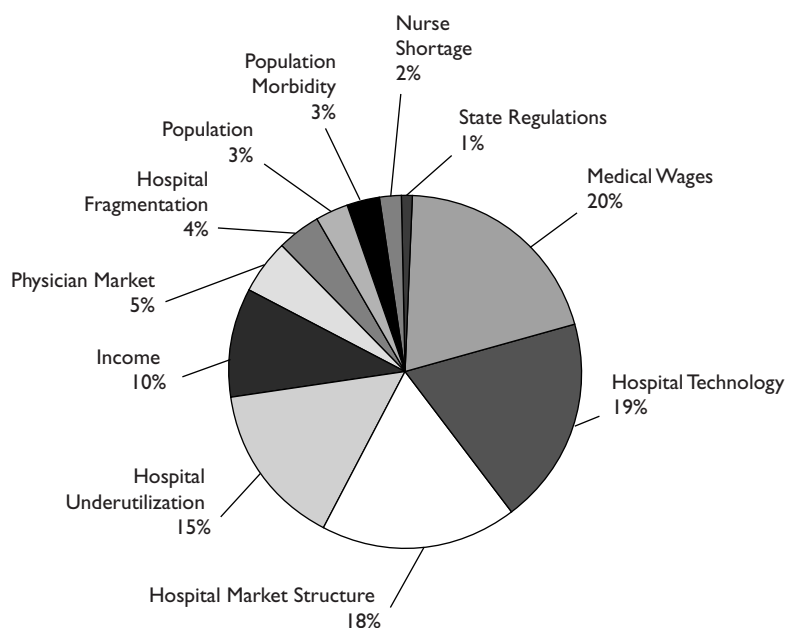
DISCUSSION

Use of state-level aggregate data to assess health-care market trends is subject to limitations due to potential aggregation, endogeneity, and omitted variables bias.¹¹ No econometric methods are conclusively validated with such aggregate data. Many hospital markets are geographically complex and are not neatly characterized within state boundaries. A more definitive assessment of structural relationships could be achieved using micro-level observations on individual patient treatment episodes within specific hospital markets. Such analyses require extensive data and were beyond the scope of this exploratory analysis of hospital cost drivers. These micro-level analyses would overcome many of the weaknesses of the aggregate data and would be a valuable follow-up research strategy.

Initially, fixed- and random-effects variance components models were proposed for the state-level regression analyses. Such variance components models can allow for correction of unobserved state-level explanatory factors.¹² These approaches are less feasible for analysis of the 1998-2000 LHIP data panel, because too many degrees of freedom are required to estimate the state-level variance components. Moreover, state-level explanatory variables are highly correlated with the state-level variance components. Although this correlation violates a necessary estimation assumption for random effects models, it does not violate the requirements for fixed-effects analysis.¹² Fixed-effects models were consistent with and similar to the OLS estimates reported here.

A third variable reduction strategy would use theory or experience to

Figure 2. Drivers of Inpatient Expenditures: 1998-2000



reduce the list of explanatory variables. This strategy was not favored, because there is no theoretical or experiential basis for including or excluding highly similar variables (eg, percent of beds in hospitals with spectral scanners vs percent of beds in hospitals with MRIs) with state-level aggregate data. However, following the theory-based method for variable selection, an LHIP regression model was generated using a similar set of explanatory variables as developed by The Lewin Group.¹³ This approach had similar findings; demographics and market structure variables were significant in the inpatient expenditure regression, while other variables were not.

The stepwise regression approach chosen for this analysis has the advantage that the results are generated empirically from the observed data. The weakness of this approach is that certain important explanatory factors may be spuriously eliminated from the final specification because they are imprecisely measured or are suppressed by correlated but less important variables. For example, if forward selection stepwise procedures are used the results are somewhat different although basically consistent with the backward stepwise elimination results. While the stepwise regression results are consistent with the alternative regression approaches, the technique will require better validation. In future work, larger datasets (longer time series and smaller geographical regions) will provide direct validation of the stepwise method with bootstrap resampling and split sample estimation/prediction error assessment.

This analysis of state-level healthcare and inpatient expenditure data indicates that overall level of economic activity, price-level variation, hospital technology, hospital market, and healthcare labor force, particularly nursing labor force supply shortages, are the most important drivers of recent short-term trends in inpatient expenditures. Although insurance coverage, managed care market share, population demographics, and morbidity characteristics certainly affect hospital inpatient expenditures over the long term, they contribute relatively little to the recent upsurge in inpatient expenditure growth during the recent time period under evaluation.

The observed pace of medical and hospital technological change is dramatic. Each of the “high-tech” drug categories exhibited double-digit annual patient growth over the past 4 years. Inpatient technologies tended to be correlated with each other at the state level of analysis; thus isolating independent effects for each type of hospital technology was difficult. Nevertheless, state variation in inpatient expenditures was highly responsive to dif-

ferences in the mix of diagnostic and therapeutic hospital technology units identified in the data. As is typical with aggregate time series data, the adjusted R-square (R^2) for the regression is high (0.94). The residual expenditure growth might possibly be due to unobservable or diffuse hospital technology factors, such as medical information systems, quality control systems, medical error and safety control systems, etc.

Certainly many of the high-tech drugs and other inpatient technologies represent cost-effective and life-saving treatments unavailable just a few years ago. Whether they represent acceptable clinical value for money spent requires detailed patient-level analysis beyond the scope of this research. Nevertheless, as long as the current pace of medical technology adoption is maintained, inpatient costs will clearly escalate.

Each 1% increase in for-profit and medical system hospital percentage is associated with approximately a 2% increase in inpatient expenditure per person. However, each 1% increase in network hospital percentage is associated with a 1% decrease in inpatient expenditures. Economies of scale in network organizations may offset some of the market power associated with for-profit and medical system hospitals. Again, because of estimation collinearity at the state level, the independent effects of each of these hospital market characteristics cannot be precisely isolated with these data. Nevertheless, inpatient costs are highly responsive to variations in hospital market concentration and structural organization.

Given the strong relationship between economic activity and hospital inpatient expenditures, it is likely that the current economic slowdown will ameliorate some of the inpatient cost increase pressure. The last economic slowdown in 1991-1992 triggered a number of aggressive cost containment strategies that held the rate of healthcare expenditure growth in check for several years. However, the primary mechanism that was used at the time involved moving more consumers into managed care health insurance plans and aggressively discounting provider reimbursement levels. These options have been pushed to the limits and will not substantially alleviate future inpatient and healthcare cost trends.

Nursing payroll constitutes nearly half of hospital costs. Whether evaluated in a univariate or multivariate regression context, the state-level regression analyses show that each 1% increase in the gap between RN demand and supply leads to a 0.5% to 1% increase in hospital inpatient expenditures per

capita. Evidence also suggests that lower RN staffing ratios per hospital bed (or per patient) leads to poorer clinical outcomes.¹ With the nurse supply shortage projected to increase by 40% between 2000 and 2005, the upward pressure on inpatient costs will remain substantial, even if other cost drivers are successfully contained. Any countervailing market pressure by hospital owners are unlikely to fully offset this trend, as nurses have continually expanding career opportunities outside of the hospital environment, and these other nursing markets are also growing.

Acknowledgments

I thank Karen Fitzner, PhD, Mary Madison, Nadine Caputo, Inger Saphire-Bernstein, Maureen Sullivan, Eric Swanson, and Neepa Patel for helpful comments. I also acknowledge staff at the Lewin Group for assistance in assembling the analytic data files.

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