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Contributions of case mix and intensity change to hospital cost increases

by Thomas B. Bradley and Gerald F. Kominski

The 28-percent change in average Medicare inpatient cost per case between 1984 and 1987 is decomposed into three components: input price inflation, changes in average cost within diagnosis-related groups (DRGs) (intensity), and changes in the distribution of cases across DRGs (case mix). We estimate the contributions of technology diffusion and outpatient shifts to within-DRG and across-DRG cost changes. We also use California data to estimate the contribution of changes in the quantity of services provided during a stay. The factors examined account for approximately 80 percent of the real increase in average cost per case.

Introduction

Beginning in fiscal year 1984, Medicare implemented the prospective payment system (PPS) for hospital inpatient care to replace the inflationary incentives of cost-based reimbursement with incentives to encourage efficiency. In addition to this effort by the Federal Government, several States have adopted payment policies designed to control inflation in hospital costs. Despite these attempts to change hospitals' financial incentives, Medicare cost per case has continued to rise at a rapid rate. During the first 3 years of PPS, cost per case in general hospitals rose 28.4 percent, while the price of the hospital market basket rose only 11.0 percent. The real increase in average cost, therefore, was 15.7 percent (or 5.0 percent annually).

The purpose of this study was to identify factors likely to be responsible for these increases and to provide estimates of their relative contributions. We used patient-level Medicare cost data from a panel of 4,310 hospitals to decompose the increase in real average cost into two components: changes in the cost of producing discharges within DRGs (intensity change) and changes in the distribution of cases across DRGs (case-mix change). The terms "intensity" and "case mix" are often used with ambiguous or context-specific meanings. In this article, intensity refers to the cost or quantity of services provided to treat cases within a particular DRG; case mix refers to the distribution of cases across DRGs.

Both the cost of treating cases within a DRG and the distribution of cases across DRGs may be affected by changes in the relative frequency of patients' diagnoses and conditions, changes in coding practices, changes in the settings in which care is delivered, and other changes in technology and treatment practices. For example, the diffusion of new technologies may affect the cost of treating cases within particular DRGs. It may also affect the number of cases assigned to a DRG, particularly where the DRG assignment depends on the procedures performed. We attempted to measure directly two types of factors likely to have contributed to the increase in both intensity and case mix: changes in the technology employed to provide inpatient care and changes in the settings in which services are provided (particularly the shift to outpatient delivery of services). We developed measures of the contribution of technology change to both within- and across-DRG cost changes. We also developed measures of the contribution of the outpatient shift to these cost changes.

In the case of intensity change, we expected that the diffusion of high-cost technology would raise the cost per case in some DRGs and, specifically, within certain cost centers in those DRGs. We also expected that the shift to outpatient delivery of services would raise the average cost in some DRGs (and the overall average cost per case) because cases requiring relatively more resources to treat would be more likely to be admitted to a hospital, whereas less resource-intensive cases would be treated on an outpatient basis.

For case-mix change, we expected that the diffusion of technologies would contribute to increases in the number of patients assigned to DRGs affected by technological change. Such increases would be particularly likely to occur if the DRG assignment is dependent on procedure codes or if the availability of a new technology warrants admission for conditions that previously might not have been treated on an inpatient basis. We also expected that the shift to outpatient delivery of service would be most likely to occur among low-cost DRGs. This would raise the proportion of cases in relatively high-cost DRGs, thereby increasing the average cost per case.

National Medicare data do not allow us to measure directly within-DRG changes in intensity because of greater use of services (that is, intermediate products) per patient. California hospitals do report cost center level measures of service units that can be compared across hospitals. Therefore, we used California data to examine two components of intensity change: the quantity of intermediate products provided per discharge (service intensity) and the cost of producing intermediate products.

It is important for policymakers to understand the extent to which technology and service intensity

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contributed to increases in average cost because these factors may generate different sets of policy issues and options. To the extent that cost inflation is related to changes in the technologies used to provide care, policymakers may wish to evaluate new technologies more closely and monitor their diffusion. For example, the Prospective Payment Assessment Commission (ProPAC) considers technological advancement as an explicit, discrete factor in determining its recommendation for updating PPS payments. ProPAC's recommendation for technological advancement, however, is based on projected cost increases resulting from new technologies. Little empirical work has been conducted since the implementation of PPS to assess the actual impact of changes in technology on the average cost of care provided to Medicare patients.

Cost increases related to increases in the average intensity of inputs (such as labor, laboratory tests, and pharmaceuticals) are likely to occur in DRGs where outpatient care can be substituted for hospitalization. This growth in average intensity and in per-case costs should stabilize as the transition from inpatient to ambulatory treatment for certain conditions is completed. However, policymakers may wish to monitor the costs of ambulatory treatment of conditions that formerly required hospitalization to ensure that savings in hospital expenditures are not offset by increases in outpatient expenditures. Policymakers may also wish to evaluate the effects of site substitution on quality of care.

Data

The analyses rely on three sources of data: Medicare Cost Reports, a sample of patient bills from the Medicare Provider Analysis and Review (MEDPAR) files, and California Hospital Disclosure Reports.

Medicare Cost Reports provide data on hospital characteristics, costs, and charges. The Medicare Cost Reports group data for hospitals' fiscal years that begin during the relevant Federal fiscal year. To permit comparisons of costs during comparable periods, the cost report data were converted from hospital fiscal years to calendar years. These calendar year cost reports were used to calculate per diem costs for the daily service cost centers (routine and intensive care) and to calculate cost-to-charge ratios for ancillary cost centers. We used the cost reports for the year hospitals were paid under provisions of the Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA) and PPS1 through PPS5 (that is Federal fiscal years 1983 through 1988).

MEDPAR files contain patient-level data on length of stay and on charges by cost center. We used a 16-percent sample of Medicare discharges in both 1984 and 1987. We multiplied the routine and special care per diem costs from the cost reports by patient length of stay to obtain costs for routine and intensive care daily services for an individual patient bill. For the 12 ancillary cost centers, we multiplied cost-to-charge ratios from the cost reports by total charges in each cost center to estimate ancillary service costs.

The analysis file includes records for all discharges in the MEDPAR sample from a panel of 4,310 general hospitals in the 50 States and the District of Columbia. This panel includes all hospitals that met two criteria: The MEDPAR sample contained discharges for both 1984 and 1987, and we were able to construct calendar year cost reports for both years.

The Medicare Cost Reports provide information on costs at the cost center level, but they did not provide any measure of the volume of services (or intermediate products) provided per cost center. For example, the data include total laboratory costs but no information on the number or type of laboratory tests produced. Therefore, to study changes in service intensity (that is, in the number of intermediate products per case), we used Hospital Disclosure Reports from the California Office of Statewide Health Planning and Development. These data contain measures of intermediate products reported in standard units of measurement (for example, American College of Pathology workload units for laboratory services). Thus, for Medicare discharges from California hospitals, we were able to disaggregate changes in real cost per case into changes in the average number of intermediate products per case and the cost of producing intermediate products.

The California Disclosure Report analytic file included data on 442 general acute care hospitals in 1984 and 420 of these hospitals in 1987. The file does not include hospitals owned by health maintenance organizations (HMOs) (notably Kaiser), because HMO-owned hospitals are not required to submit the financial components of the Disclosure Report. We used hospital names and cities to match the California and Medicare provider numbers of 398 hospitals. We merged these files with Medicare patient bill files for discharges from California hospitals in 1984 and 1987. The resulting file had discharges from 331 hospitals in each year. The panel of California hospitals accounted for approximately 8 percent of the national sample of Medicare discharges in both 1984 and 1987.

Changes in utilization and costs

The number of Medicare discharges in the national panel of hospitals fell 11.65 percent between 1984 and 1987. During the same period, the average cost of a hospital stay by Medicare patients rose 28.4 percent, from $2,957 to $3,798. However, the price of hospital inputs rose by 11.0 percent between 1984 and 1987 (*Federal Register*, 1990). Therefore, the real average cost per case was 15.7 percent higher in 1987 than in 1984. Henceforth, all references to 1987 costs and rates of change in costs will be real—using the market basket to deflate 1987 costs to 1984 levels. We recognize, however, that the market basket may not be the ideal index for deflating costs at the cost center level.

Costs did not rise uniformly across cost centers (Table 1). The average cost per case of routine daily services fell 2.6 percent. By contrast, the average cost per case for intensive care daily services rose more than 30 percent. The combined cost per case of routine and intensive care increased 4.2 percent—from

Table 1

Changes in real cost per case between 1984 and 1987, by cost center

Cost center	Real cost per case		Percent change
	1984	1987	
Total cost per case	$2,956.79	$3,421.60	15.7
All daily services	1,300.56	1,355.09	4.2
Routine daily care	1,034.14	1,007.31	-2.6
Intensive daily care	266.42	347.78	30.5
All ancillary services	1,656.23	2,066.51	24.8
Anesthesia	32.11	36.72	14.3
Blood	28.96	39.03	34.8
Inhalation therapy	129.74	177.10	36.5
Laboratory	306.74	349.97	14.1
Medical supplies	231.42	296.10	27.9
Occupational therapy	7.76	13.62	75.6
Operating room	213.60	263.68	23.4
Pharmacy	282.70	407.85	44.3
Physical therapy	43.56	53.11	21.9
Radiology	149.36	208.24	39.4
Speech therapy	3.21	4.80	49.3
Other ancillary	227.05	216.30	-4.7

NOTE: Totals and percent changes calculated before rounding.

SOURCES: Medicare Cost Reports for the year preceeding the prospective payment system through year 5 of the prospective payment system. Medicare provider analysis and review (MEDPAR) for 1984 and 1987.

approximately $1,301 to $1,355. This increase in average cost for daily care services accounted for almost 12 percent of the total $465 increase. Daily care services declined from a 44.0-percent share of total costs in 1984 to a 39.6-percent share in 1987.

The average cost per case of ancillary services rose 24.8 percent, from $1,656 to $2,067. Most of the dollar increase in ancillary cost per case was concentrated in six high-volume cost centers: pharmacy, medical supplies, radiology, laboratory, operating room, and inhalation therapy. Although the laboratory cost center experienced a large rise in dollar terms, the rate of increase was lower than the average for all ancillary service cost centers. Low-volume cost centers that experienced particularly large percent increases in cost per case included occupational therapy, speech therapy, and blood products. In general, these appear to be relatively labor-intensive cost centers that often involve several interventions per stay. By contrast, more capital- or supply-intensive cost centers, including anesthesia, laboratory, medical supplies, and operating room, experienced near- or below-average rates of increase.

Intensity and case-mix decomposition

The $465 total change in real cost per case can be disaggregated into an intensity (within-DRG) effect and a case-mix (across-DRG) effect:

$$\Delta C = \underset{i}{\Sigma} p_{87i} * \Delta C_i + \underset{i}{\Sigma} (C_{84i} - \bar{C}_{84}) * \Delta p_i$$

intensity effect — case-mix effect

Here p_{87i} is the proportion of discharges in DRG_i in 1987, C_{84} is the overall average cost per case in 1984, C_{84i} is the average cost of DRG_i in 1984, and is the value of the variable in 1987 minus the value in 1984.[1] The first factor on the right-hand side shows the changes in average intensity, holding case mix constant at 1987 levels. The second factor shows the effect of changes in case mix on average cost, holding costs per case constant at their 1984 levels.

At the DRG level, the intensity effect shows the contribution of each DRG's change in average cost per case to the overall change. Likewise, the case-mix effect indicates how much the change in the proportion of cases in a DRG contributed to the overall increase. Case-mix change reflects changes in both the proportion of cases in a DRG and the relative costliness of the DRG. A positive case-mix effect will result from either an increase in the proportion of cases in a DRG that costs more than the overall average or a decrease in the proportion of cases in a less costly DRG.

This analysis focuses on changes in case mix between 1984 and 1987 that were due to changes in the relative frequency of the conditions treated in hospitals. Case-mix measures are also affected by the computer program (DRG grouper) that assigns cases to DRGs and by the coding practices that determine which conditions and procedures are recorded for use by the DRG grouper. This analysis controlled for DRG grouper effects by applying the 1987 version of the DRG grouper to discharges in both years. It was not possible, however, to control for changes in coding practices (Carter, Newhouse, and Relles, 1990).

Intensity changes accounted for about $134 of the $465 increase in average cost (Table 2). Case-mix changes accounted for the other $330. More than 90 percent of the overall increase is attributable to 179 DRGs in which both the intensity and case-mix effects

[1] A technical appendix describing the derivation of the decompositions of cost per case by DRG used in the analyses of both the national and the California samples is available upon request from the authors.

Table 2

Summary of contribution of intensity and case-mix changes between 1984 and 1987 to real increases in aggregate average cost per case, by direction of change

Number of diagnosis-related groups[1]	Total	Direction of change		Amount of change	
		Case mix	Intensity	Case mix	Intensity
Total 457	$464.81			$330.44	$134.36
12[1]	-0.03	-	0	-0.03	0.00
12[1]	0.16	+	0	0.16	0.00
51	-57.91	-	-	-32.22	-25.68
77	26.43	-	+	-51.15	77.58
126	69.16	+	-	107.67	-38.51
179	427.00	+	+	306.02	120.98

[1]These diagnosis-related groups had no Medicare discharges in 1984 or 1987.

NOTE: Totals calculated before rounding.

SOURCES: Medicare Cost Reports for the year preceeding the prospective payment system through year 5 of the prospective payment system. Medicare provider analysis and review (MEDPAR) for 1984 and 1987.

were positive. By contrast, the intensity and case-mix effects were both negative in only 51 DRGs. In DRGs that had a positive intensity effect and a negative case-mix effect (or vice versa), the magnitude of the positive effect was generally larger.

We expected that the diffusion of technology and the shift of services to outpatient settings would contribute to the higher costs attributed to the intensity and case-mix effects. In the following sections, we develop estimates of the contributions of these factors to the intensity and case-mix effects.[2]

Effects of technological diffusion

We suspected that much of the increase in average cost was due to changes in the technology employed to treat certain conditions. In the following sections, we identify DRGs affected by technological diffusion, and we develop measures of the contribution of technological diffusion to within- and across-DRG changes in costs. Despite using the technology label, we were unable to verify that cost changes were due to technological developments.

Effects on within-diagnosis-related group intensity

Cost-increasing changes in intensity occurred in 256 DRGs. In this section, we identify DRGs that experienced cost-increasing technology changes and measure the contribution of technology to the overall increase. We define technology broadly, as the way in which resources are combined to produce an output. We do not measure the effect on cost per case of a few specific diagnostic or therapeutic innovations. We measure output by the number of discharges in a given DRG and the consumption of resources by changes in cost at the DRG/cost-center level.

To identity DRGs that experienced real cost increases because of a technology change, we selected DRGs for which the rate of growth in costs exceeded the overall rise. We eliminated DRGs with fewer than about 1,000 discharges in the Medicare population in either 1984 or 1987. We then looked for changes in cost per case at the DRG/cost-center level. We applied two screens to control for variations in inflation in inputs among cost centers: We eliminated DRG/cost-center combinations that did not experience a real cost increase or did not show a larger percent increase in cost per case that the overall increase for the cost center. Finally, we selected all DRGs in which a single cost center accounted for at least 30 percent of the DRG's cost increase. This procedure identified 84 DRGs as having experienced cost-increasing technological change in particular cost centers. None of these DRGs accounted for more than 4 percent of total costs or cases in 1987, and many accounted for less than one-tenth of 1 percent of either costs or cases. As a group, these DRGs accounted for 18.9 percent of total 1987 costs and 20.1 percent of 1987 cases.

We estimated the contribution of technological change in the DRG/cost center to the overall increase by multiplying the percent of cases in each DRG in 1987 by the DRG/cost center(s) increase in cost per case, using the following formula:

$$\Delta C(\text{within-DRG technology})_{ij} = p_{87i} * \Delta C_{ij}$$

Here p_{87i} is the proportion of cases in DRG_i in 1987 and C_{ij} is the1987 cost per case for DRG_i in technology-change cost center $_j$ minus the 1984 cost per case in the same DRG/cost-center combination. This allowed us to calculate the portion of the total within-DRG effect attributable to the technology-change DRG/cost center(s), controlling for case-mix change.

Changes in the technology cost centers of most of these DRGs contributed less than one-tenth of 1 percent of the overall increase in cost per case. Only three DRGs accounted for more than 1 percent of the increase. In aggregate, the higher cost in the technology cost centers in these 84 DRGS accounted for almost $45 (9.6 percent) of the overall increase (Table 3).

More than one cost center met the selection criteria in nine DRGs. In 10 DRGs, the increase in cost per case in the technology cost centers was partially offset by decreases in other cost centers.

[2]An appendix listing these DRG-level estimates and the decomposition of intensity and case-mix effects is available upon request from the authors.

Technology changes occurred in the routine or intensive care daily service categories of nine DRGs. These DRGs would not be considered technology-change DRGs if the definition of technology change were limited to diagnostic or therapeutic innovations. These DRGs do qualify when technology is defined broadly as the way in which resources are combined to produce a discharge. In these DRGs, the cost of daily service inputs (presumably nursing labor) required to produce a discharge rose substantially. The greater daily service requirements reflect an increased length of stay in some DRGs (for example, DRGs 57 and 424) because of an increase in average severity of illness within the DRG or a change in treatment methods. Average length of stay declined in the other DRGs with technology-related increases in daily service costs. In either case, the change in daily service requirements represented both an absolute and relative increase in the portion of daily service inputs required to produce a discharge.

The DRG/cost-center combinations listed in Table 3 indicate that our selection criteria for identifying technology-change DRGs had a degree of face validity. For example, medical DRGs have increases in pharmacy charges, surgical DRGs have increases in operating room charges, the pacemaker DRG has an increase in supply charges, and several medical DRGs have increases in radiology charges probably a result of magnetic resonance imaging (MRI). Furthermore, this list includes most of the DRGs involving new high-cost technologies that were examined by ProPAC (1987) during the first 3 years of PPS.

Effects on across-diagnosis-related group case mix

In this section we identify DRGs with utilization growth related to the diffusion of technology. We then develop a measure of the contribution of the change in the proportion of cases in these DRGs to the overall $330 increase attributable to case-mix changes.

We expected that technological change would contribute to the case-mix effect in two ways. First, technological developments might enable the admission of patients whose conditions previously might not have warranted treatment on an inpatient basis. Second, the diffusion of technology might alter the distribution of cases across those DRGs for which classification is dependent on procedure codes. The effect on case mix of a third type of technological change—the diffusion of technology to outpatient settings and the resulting treatment on an outpatient basis of conditions that previously required an inpatient stay—will be addressed in the following section. Thus, we expected that the number of cases might increase in DRGs that experienced technological change.

There are other reasons, however, to expect the number of cases to increase in some DRGs. Many conditions are classified into one of a pair of DRGs, depending on whether complications or comorbidities (CCs) are present. Payment for the with-CC DRG is higher than that for the non-CC DRG. As hospitals gained experience with PPS, it is likely that they became more thorough in their search for, and more accurate in the coding of, the CCs that produce assignment to the higher paying DRG. Thus, even in the absence of technological change, the number of cases in a with-CC DRG might rise as the result of coding changes that shift cases from the non-CC counterpart.

The number of Medicare beneficiaries rose 5.5 percent between 1984 and 1987 (Prospective Payment Assessment Commission, 1992). This growth in the size of the Medicare population provides an approximation of the increase in Medicare admissions that would have been expected in the absence of changes in medical practice. Therefore, we designated DRGs with a rise in the number of cases of at least 5.5 percent as DRGs with utilization increases attributable to technology-related changes in medical practice.

To control for coding-related shifts of cases from a non-CC DRG to the with-CC counterpart, we applied the 5.5-percent criterion after adjusting the number of 1987 cases in with-CC DRGs. We subtracted from the 1987 cases any decrease from 1984 to 1987 in the number of cases in the non-CC counterpart DRG. If the with-CC DRG met the 5.5-percent criterion after this adjustment, then we combined the costs and cases in the CC pair and considered them as a single condition that experienced technology-related increases in utilization.

This process identified 109 DRGs, including 25 pairs of with-CC and non-CC DRGs. The list included 25 of the 84 DRGs that were identified as having increases in within-DRG intensity related to technological change. We did not conduct further analyses to determine whether these DRGs experienced identifiable changes in technology, and we cannot verify that volume increases in these DRGs were actually the result of the diffusion of technology. For example, although we attempted to control for the effect of population growth on utilization, some DRGs may have experienced volume increases resulting from a rise in the incidence or prevalence of certain conditions.

We estimated the effect of technology-related changes in the distribution of cases across DRGs by applying the following formula to the technology/case-mix DRGs:

$$\Delta C(\text{across-DRG technology})_j = \frac{\sum_j ((C_{84j} - \bar{C}_{84}) * (Q_{87j} - (1.055 * Q_{84j}))}{\sum_i (C_{84i} * Q_{84i})) * \bar{C}_{84}}$$

Here j indicates technology/case-mix DRGs, and i includes all DRGs. $\bar{C}_{84}$ is the overall average cost per case in 1984, C_{84i} is the average cost of DRG_i in 1984, and Q_{84i} is the number of discharges in DRG_i in 1984. This formula attributes to technological change only the portion of the case-mix effect resulting from utilization increases that exceeded the 5.5-percent rise in the number of Medicare enrollees. The result of this calculation is the dollar value of the change in average cost per case that is attributable to the technology-related rise in utilization. We believe this is a

Table 3

Cost center and diagnosis-related group (DRG) combinations experiencing cost-increasing technological change between 1984 and 1987

Cost center and DRGs	Contribution to overall increase in average cost
Total	$44.62
Routine daily care	1.60
57 Tonsillectomy and adenoidectomy procedure	—
383 Other antepartum diagnoses with complications	—
424 Operating room procedures with mental illness	—
427 Neuroses except depressive	—
429 Organic disturbances plus mental retardation	—
431 Childhood mental disorders	—
461[1] Operating room procedures with other health services	—
Intensive daily care	0.08
178 Uncomplicated peptic ulcer	—
196 Total cholecystectomy	—
466 Aftercare without history of malignancy	—
Anesthesia	0.01
260[1] Subtotal mastectomy	—
Blood	0.05
392 Splenectomy	—
Laboratory	
None	0.00
Medical supplies	11.11
36[1] Retinal procedures	—
117 Pacemaker replacement	—
209 Major joint procedures	—
228 Ganglion procedures	—
291 Thyroglossal procedures	—
311[1] Transurethral procedures	—
312[1] Transurethral procedures	—
341 Penis procedures	—
Occupational therapy	0.18
461[1] Operating room procedures with other health services	—
Physical therapy	0.19
461[1] Operating room procedures with other health services	—
Respiratory therapy	0.03
285[1] Amputations	—
Speech therapy	0.00
None	—
Operating room	3.95
36[1] Retinal procedures	—
42 Intraocular procedures	—
49 Major head and neck procedures	—
50 Sialodenectomy	—
51 Salivary gland procedures	—
53 Sinus and mastoid procedures	—
219 Lower extremity and humerus procedures	—
224 Upper extremity procedures	—
259 Subtotal mastectomy	—
260[1] Subtotal mastectomy	—
267[1] Perianal and pilonidal procedures	—
285[1] Amputations	—
286[1] Adrenal and pituitary procedures	—
290 Thyroid procedures	—
310 Transurethral procedures	—
311[1] Transurethral procedures	—
312[1] Urethral procedures	—
313 Urethral procedures	—
323 Urinary stones	—
334 Major male pelvic procedures	—
335 Major male pelvic procedures	—
344 Male reproductive procedures for malignancy	—
361 Laparoscopy and endoscopy	—

See footnotes at end of table.

Table 3—Continued

Cost center and diagnosis-related group (DRG) combinations experiencing cost-increasing technological change between 1984 and 1987

Cost center and DRGs		Contribution to overall increase in average cost
373	Vaginal delivery with sterilization	—
407	Myeloproliferative disorders	—
441	Hand procedures for injuries	—
Other ancillary		8.68
43[1]	Hyphema	—
112	Vascular procedures	—
Pharmacy		6.42
21	Viral meningitis	—
119	Vein ligation and stripping	—
179	Inflammatory bowel disease	—
192	Minor pancreas, liver, and shunt procedures	—
202	Cirrhosis and alcoholic hepatitis	—
205	Disorders of liver	—
267[1]	Perianal and pilonidal procedures	—
272	Major skin disorders	—
286[1]	Adrenal and pituitary disorders	—
294	Diabetes	—
320	Kidney and urinary tract infections	—
321	Kidney and urinary tract procedures	—
345	Male reproductive system procedure	—
350	Inflammation of male reproductive system	—
368	Infection of female reproductive system	—
397	Coagulation Disorders	—
398	Reticuloendothelial and immunity disorders	—
421	Viral illness	—
423	Other infectious and parasitical diseases	—
452	Complications of treatment	—
460	Non-extensive burns	—
Radiology		12.13
10	Nervous system neoplasms	—
14	Cerebrovascular disorders	—
15	Transient ischemic attacks	—
22	Hypertensive encephalopathy	—
25	Seizure and headache	—
27	Traumatic stupor or coma	—
28	Traumatic stupor or coma	—
31	Concussion	—
43[1]	Hyphema	—
65	Dysequilibrium	—
78	Pulmonary embolism	—
81	Respiratory infections	—
141	Syncope and collapse	—
203	Malignancy of hepatobiliary system or pancreas	—
216	Biopsies of musculoskeletal system	—
239	Pathological fractures	—
285[1]	Amputations	—
408	Myeloproliferative disorders	—
409	Radiotherapy	—
419	Fever of unknown origin	—
463	Signs and symptoms without complications or comorbidities	—

[1]Indicates DRG that experienced technological change in multiple cost centers.

NOTE: Totals calculated before rounding.

SOURCES: Medicare Cost Reports for the year preceeding the prospective payment system through year 5 of the prospective payment system. Medicare provider analysis and review (MEDPAR) for 1984 and 1987.

conservative estimate of the effect of technology-related changes in the distribution of cases across DRGs.

Cost-increasing across-DRG technology changes affected 55 conditions represented by 72 DRGs. The rise in the proportion of cases in these DRGs contributed to the increase in the overall average cost, because they had higher than average costs in 1984. The case-mix effect attributed to technology changes in these DRGs produced a 4.8-percent increase in the overall average cost.

By contrast, 24 conditions, represented by 37 DRGs, had cost-decreasing across-DRG technology effects, because they had lower than average costs in 1984. In these DRGs, the case-mix effect attributed to technology changes produced a 0.7-percent decrease in cost per case. The net effect of technology-related changes in the distribution of cases across DRGs was to

raise average cost by $122. This was 26.4 percent of the 15.7 percent real increase in average cost—or 4.1 percentage points.

Effects of the outpatient shift

We suspect that much of the aggregate 11.65 percent drop in Medicare utilization between 1984 and 1987 was due to changes in medical practice that permitted the treatment on an outpatient basis of conditions that previously received care in inpatient settings. Changes in medical practice probably contributed to the outpatient shift in two ways. The first effect is an increase in the number of conditions that could be treated on an outpatient basis because of the diffusion of technology across outpatient settings. The second effect is a decrease in the number of admissions of patients with conditions for which inpatient care is not medically justified. For example, the sharp drop in the number of cases assigned to DRG 243 (medical treatment of back problems) may have been the result, in part, of scrutiny of these cases by peer review organizations.

In the following sections, we identify DRGs affected by the outpatient shift, and we measure the contribution of the outpatient shift to both within- and across-DRG changes in costs. Despite our use of the outpatient-shift label, we were not able to verify that volume declines in these DRGs were actually the result of outpatient shifts. For example, some volume declines may have been the result of a real reduction in treatment for certain conditions. For DRGs in which classification depends on procedure codes, changes in the distribution of cases across DRGs may also have occurred because of changes in the relative prevalence of alternative treatments.

Effects on within-diagnosis-related group intensity

In this section, we attempt to identify DRGs that experienced increases in average cost because of a shift to outpatient delivery of services. We also develop a measure of the contribution of higher average costs in these DRGs to the overall increase in average cost. We hypothesized that average intensity within some DRGs may have increased because low-cost cases that previously would have been admitted to hospitals are being treated increasingly on an outpatient basis. In DRGs with this type of intensity change, we would expect to see a decline in the number of discharges and an increase in average cost for the DRG. Furthermore, we expected that outpatient shifts would produce a larger percent increase in cost per case in the lower percentiles of the cost distributions of specific DRGs than in the higher percentiles. This effect of outpatient shift—the truncation of low-cost cases—would produce large increases in average cost in the affected DRGs.

We did not look for cost-decreasing changes in average within-DRG intensity. We thought high-cost cases within a DRG would be more likely to be shifted to a higher weighted DRG because of changes in coding practices than to be moved to an outpatient setting. Although such DRG creep would affect the average cost of specific DRGs, it would not directly affect the overall average cost per case.

We used patient bill data to identify DRGs that had real increases in average cost and large decreases in volume. We limited our search to DRGs with at least 1,000 discharges in the Medicare population. We selected DRGs that had a larger percent volume decline than the overall decline for all DRGs (that is, a decline of more than 11.65 percent). This produced a list of 75 candidate DRGs in which the truncation of low-cost cases contributed to increases in the average cost of these DRGs and to the overall increase in average cost. We did not conduct additional analyses to evaluate whether patients in the outpatient-shift DRGs had severity changes according to clinically defined measures of severity.

We created a file containing the cost percentiles for each candidate outpatient-shift DRG in each year. We calculated the percent change in cost per case at each cost percentile and the average of the percent changes for each decile. We selected DRGs in which the percent increase in cost per case in the first or second decile was significantly greater than the overall rates of increase within the DRG ($p < .05$), and neither the first nor second decile was below the mean. Note that the criterion is the mean percent change with equal weight on each percentile-based observation. This mean rate of increase will vary from the dollar-weighted mean percent change used elsewhere.

We identified 39 DRGs that appeared to have experienced increases in average cost because of truncation of low-cost cases. We compared this list with 15 DRGs that included procedures identified in a recent study (Witsberger and Kominski, 1990) as increasingly performed on an outpatient basis.[3] Only three of these DRGs (154, 269, and 270) were identified by our criteria as having experienced truncation of low-cost cases. Three DRGs (228, 259, 260) did not meet the selection criteria but were previously identified as having experienced technology-related increases in average cost.

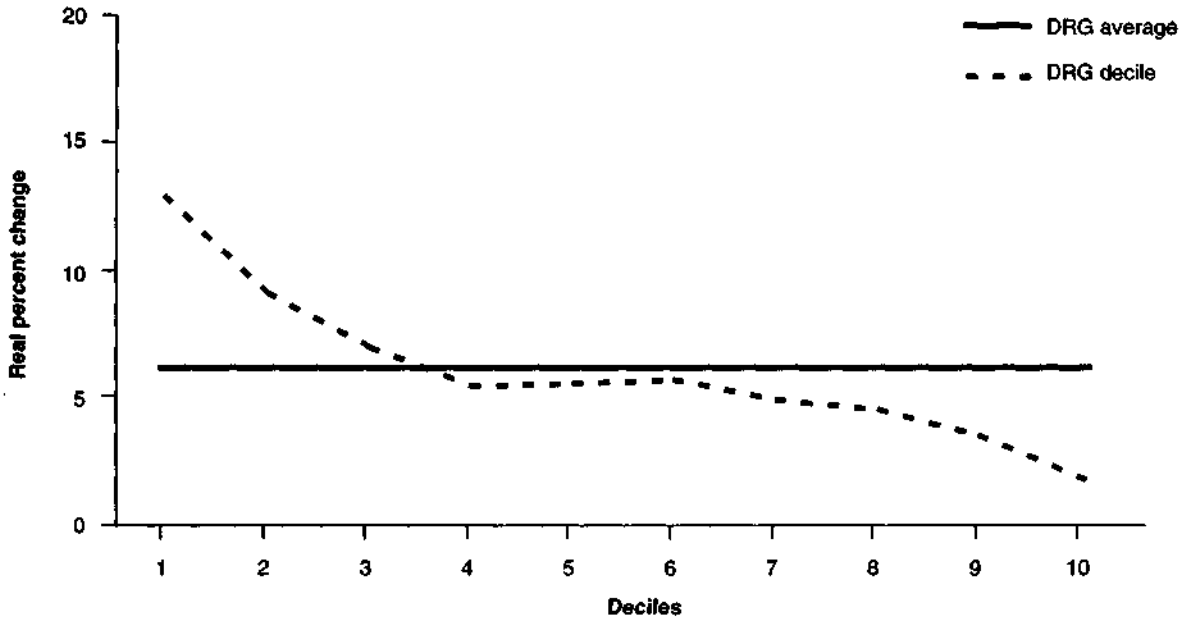
It is noteworthy that DRGs 6, 39, 262, and 364 were not identified by our selection criteria. In 1987, the number of discharges in these DRGs dropped to between 5 percent and 25 percent of the number of discharges in 1984. The selection criteria were designed to identify DRGs in which relatively low-cost cases were particularly likely to shift to outpatient settings. In these DRGs, however, it appears that the shift to outpatient settings was not limited to relatively low-cost cases. This phenomenon will be addressed in the following section.

To estimate the contribution of the candidate outpatient-shift DRGs to the increase in cost per case, we measured the area between the line showing percent

[3]DRGs 6, 228, 229 (carpal tunnel); 39 (lens extraction); 154, 155, 156 (gastroscopy or stomach biopsy); 363, 364 (dilation and curettage); 225 (bunionectomy); 259, 260, 262 (subtotal mastectomy); 269 and 270 (excision of skin lesion).

Figure 1

Real percent change between 1984 and 1987 in cost per case for diagnosis–related group (DRG) 088, by deciles



SOURCES: Medicare Cost Reports for the year proceeding the prospective payment system through year 5 of the prospective payment system. Medicare provider analysis and review for 1984 and 1987.

change in cost per case by decile and the line showing the overall change in cost up to the point at which the lines first intersect (Figure 1). This area provides an estimate of the percent increase in the DRG's average cost resulting from truncation of low-cost cases.[4] We divided this amount by the observed percent increase to determine the proportion of the total increase in the DRG's cost per case that is the result of change in average case severity. We then multiplied the observed dollar increase in the DRG's average cost by this proportion. We weighted this result by the DRG's share of total discharges in 1987 to calculate the dollar value of the overall increase in average cost attributable to the loss of low-cost cases.

Eleven of the 39 DRGs were also identified as experiencing technology-related increases in average cost. To avoid double counting the contribution of these DRGs to the intensity component of the overall increase, we had to eliminate them from either the technology-change or the outpatient-shift category. Therefore, we chose to assign these DRGs to the category in which they made the greatest contribution to the overall increase. In all of these DRGs, the increase attributable to the within-DRG effects of technology exceeded the increase attributable to the within-DRG effects of the outpatient-shift. Among these DRGs, the outpatient-shift effect raised the overall average cost about 0.1 percent, whereas the technology effect produced a 0.8-percent increase in average cost. Therefore, we assigned these DRGs to the technology category. The initial set of 39 DRGs accounted for 6.3 percent of costs and 7.3 percent of discharges in 1987. The final set of 28 DRGs experiencing a truncation of low-cost cases accounted for 4.8 percent of costs and 5.5 percent of discharges in 1987.

The overall increase in cost per case because of the truncation of low-cost cases in the final list of 28 outpatient-shift DRGs accounted for less than $2 (0.3 percent) of the $464 increase.

Effects on across-diagnosis-related group case mix

In the preceding section, we identified DRGs in which the outpatient shift is likely to have raised average cost by removing relatively low-cost cases from the DRG. In this section, we identify DRGs that experienced large declines in utilization. We then measure the contribution of changes in the distribution of cases across these DRGs to the overall increase in average cost.

We defined a large decline in utilization as a drop of at least 34.95 percent in the number of Medicare cases

[4]Note that the area between the curves is underestimated because the overall average rate of increase across percentiles would presumably be lower than the observed overall average if there had not been a shift to outpatient services. Also, we limited the maximum deviation between the percent increase in any decile and the average percent increase to 50 percent. This constraint was binding only in the first decile of DRG 183, which had an 81-percent difference between the decile and overall percent changes.

between 1984 and 1987. This is three times the overall percent decline in the number of Medicare cases in the sample. To control for changes in coding practices that might shift cases from a non-CC DRG to its with-CC counterpart, we applied the utilization change criterion to the sum of cases in each CC pair and treated each CC pair as a single condition. We limited our search to DRGs and CC pairs with at least 1,000 Medicare cases in 1984.

This process identified 100 DRGs that experienced large changes in utilization including 29 pairs of with-CC and non-CC DRGs. All of the procedures identified by Witsberger and Kominski (1990), except gastroscopy, were represented by DRGs on this list. The list also includes 14 of the 28 DRGs identified as having experienced increases in within-DRG intensity related to truncation of low-cost cases.

We estimated the effect of outpatient-shift-related changes in the distribution of cases across DRGs by applying the following formula to the outpatient-shift/case-mix DRGs:

$$\Delta C\ (\text{across-DRG outpatient})_j = \frac{\sum_j ((C_{84j} - \bar{C}_{84}) * (Q_{87j} - (0.8835 * Q_{84j}))}{\sum_i (C_{84i} * Q_{84i})) * \bar{C}_{84}}$$

Here j indicates outpatient-shift/case-mix DRGs and i includes all DRGs. $\bar{C}_{84}$ is the overall average cost per case in 1984, C_{84i} is the average cost of DRG_i in 1984, and Q_{84i} is the number of discharges in DRG_i in 1984. This formula attributes to outpatient shift only that portion of the case-mix effect resulting from utilization declines that exceeded the 11.65-percent decrease in the number of Medicare cases. The result of this calculation is the dollar value of the change in average cost per case attributable to the outpatient shift. We believe this is a conservative estimate of the effect of outpatient-shift-related changes in the distribution of cases across DRGs.

The across-DRG effects of outpatient shifts were cost increasing for 66 conditions, represented by 94 DRGs. The drop in the number of cases in these DRGs contributed in the overall rise in average cost, because these DRGs cost less than the overall average in 1984. The case-mix effect attributed to outpatient shift in these DRGs produced a 3.4-percent increase in the overall average cost.

By contrast, five conditions (six DRGs) had cost-decreasing across-DRG outpatient-shift effects, because they had higher than average costs in 1984. In these DRGs, the case-mix effect attributed to outpatient shift produced a 0.2-percent decrease in cost per case. The net effect of outpatient-shift-related changes in the distribution of cases across DRGs was to raise the average cost by $95. This was 20.4 percent of the overall increase in average cost.

Intermediate product quantities and costs

The Medicare Cost Reports and patient bill files provide information that allow us to estimate the cost of services used at the cost-center level to produce a discharge. However, these data do not permit the disaggregation of these costs into the quantity and cost of intermediate products. The California Office of Statewide Health Planning and Development's Hospital Disclosure Reports do provide such information on the quantity and cost of intermediate products. By merging disclosure report data with the Medicare patient bills for discharges from California hospitals, we were able to disaggregate changes in costs at the cost-center level into changes in the quantity and cost of intermediate products.

The disclosure reports measure the quantity of intermediate products in a standard unit of measurement (SUM) for each cost center. For example, the SUM is days for the daily service cost center and American College of Pathology workload units for the clinical laboratory cost center. The methodology for calculating the quantity and cost of intermediate products at the DRG/cost-center level is described elsewhere (Kominski and Bradley, 1993).

We used the 11.7-percent increase in the California Weighted Hospital Input Price Index (CWHIPI) to deflate 1987 costs to 1984 levels.[5] The average cost per Medicare case for discharges from California hospitals was $3,941 in1984 and $4,629 in 1987. These costs are approximately one-third higher than the average for all States.

We examined changes at the cost-center level in both the cost of producing intermediate products and the quantity of intermediate products consumed per discharge. We calculated the percent change in the real cost per unit of intermediate product by dividing real dollars per SUM in 1987 by the corresponding amount in 1984. An increase in the cost per SUM may indicate a reduction in cost efficiency at the cost-center level. However, some efficiency changes may be an artifact of differences between the mix of inputs used at the cost-center level and the mix of inputs used to calculate the CWHIPI. Some changes may also be the result of inadequacies of the SUMs as measures of resource consumption.

We also developed case-mix-adjusted and aggregate measures of changes in service intensity using the percent change in the number of intermediate products consumed per discharge. The case-mix adjusted measure shows differences in service intensity for the 1984 distribution of cases. By contrast, the aggregate measure shows the cumulative effect on the consumption of intermediate products of changes in both service intensity and the distribution of cases across DRGs.

[5]The CWHIPI uses a methodology similar to the market basket used by Medicare, but it substitutes State or regional values for many of the market basket components.

Table 4

Percent change between 1984 and 1987 in intermediate product unit cost and intermediate products per Medicare discharge from California hospitals, by cost center

Cost center	Real percent change in unit cost of intermediate products[1]	Percent change in quantity of intermediate products per discharge	
		Aggregate	Case-mix-adjusted[2]
Routine care	8.5	-9.99	-18.34
Intensive care	4.7	29.01	17.06
Anesthesiology	15.4	-0.46	-8.37
Blood	7.1	3.65	-11.45
Inhalation therapy	-3.8	47.71	35.58
Laboratories	-7.0	19.12	8.48
Medical supplies	-11.0	36.97	22.36
Occupational therapy	-12.3	77.57	-13.02
Operating room	-6.0	21.54	15.05
Other ancillary	4.7	-6.61	-17.99
Pharmacy	-14.7	77.01	58.47
Physical therapy	0.1	22.53	-3.43
Radiology	-32.3	102.85	126.30
Speech therapy	6.1	25.87	-22.08

[1]Real costs deflated using California Weighted Hospital Input Price Index.
[2]1984 distribution of cases across diagnosis-related groups (DRGs) applied to number of intermediate products per discharge in each DRG.

SOURCES: Medicare Cost Reports for the year preceeding the prospective payment system through year 5 of the prospective payment system. Medicare provider analysis and review (MEDPAR) for 1984 and 1987. California Hospital Disclosure Reports for disclosure years 9-13.

Unit costs rose in the daily service cost centers (Table 4). This may indicate an increase in average severity, such that patients require more nursing and other daily service inputs. The 17-percent increase in case-mix-adjusted intensive care days per discharge suggests that there was a rise in the average severity of illness within DRGs. However, the increase in unit costs may also indicate that fixed costs are being spread over fewer patient days or that hospitals have not adjusted their labor and other variable inputs to offset changes in utilization.

Unit costs rose in five ancillary service cost centers, whereas efficiency improved in the remaining seven cost centers. We speculate that advances in blood-screening techniques maybe responsible for some of the increase in blood bank unit costs. We also suspect that diffusion of computer-assisted tomography and MRI technologies may be responsible for the dramatic increase in radiology intermediate products per discharge.

The aggregate changes in the quantity of intermediate products per discharge are larger (more positive) than the case-mix-adjusted quantity changes in all cost centers except radiology. This suggests a shift in the distribution of cases toward DRGs with greater consumption of intermediate products. The case-mix-adjusted utilization of intermediate products declined in 6 of the 12 ancillary cost centers. These declines in occupational therapy, physical therapy,and speech therapy are probably related to the sharp drop in inpatient days.

Intermediate product quantity and cost decomposition

In the national sample, we were able to measure the contributions to the overall increase in average cost of changes in case mix and changes in intensity at the DRG level. The additional detail in the California data set permits us to decompose the DRG-level intensity effect into changes in the quantity and the cost of intermediate products:

$$\Delta\text{Cost per case} = \sum_i (C_{84i} - \bar{C}_{84}) * \Delta p_i + \sum_i \sum_j p_{87i} * P87_{ij} * \Delta S_{ij} + \sum_i \sum_j p_{87i} * S_{84ij} * \Delta P_{ij}$$

Here $\bar{C}_{84}$ is the overall average cost per case in 1984, C_{84i} is the average cost of DRG_i in 1984, p_{87i} is the proportion of discharges in DRG_i in 1987, S_{ij} is the quantity of intermediate products consumed per discharge in cost center$_j$ in DRG_i, P_{ij} is the cost per unit of intermediate product in cost center$_j$ in DRG_i, and Δ is the value of the variable in 1987 minus the value in 1984.

The first factor on the right-hand side shows the effect of changes in case mix on average cost, holding DRG costs constant at their 1984 levels. The second factor shows the independent contribution of changes in the quantity of intermediate products consumed per discharge to the overall increase in average cost. The third factor is the increase in the cost of producing intermediate products at the DRG/cost-center level. The cost factor is a residual. It is the change in the cost of intermediate products that remains unexplained after controlling for changes in case mix and in the quantity of intermediate products consumed per discharge.

The average cost of a Medicare case in California hospitals rose $688, or 17.4 percent. About $433 (11.0 percentage points) is attributable to changes in case mix. Changes in the quantity of intermediate products per discharge accounted for $102 (2.6 percentage points) of the overall increase. The net increase in the cost of intermediate products was

Table 5

Sources of increase between 1984 and 1987 in cost per case

Source of cost increase	U.S. hospitals		California hospitals	
	Percent increase	Percent of real increase	Percent increase	Percent of real increase
Total	28.5	—	31.2	—
Input prices	11.0	—	11.7	—
Quantity	15.7	100.0	17.4	100.0
Within diagnosis-related group (DRG) intensity effect	4.5	28.9	6.4	37.0
Service intensity	NA	—	2.6	14.8
High-cost technology	1.5	9.6	NA	—
Truncation of low-cost cases	0.1	0.3	NA	—
Unexplained	3.0	19.0	3.9	22.2
Across-DRG case-mix effect	11.2	71.1	11.0	63.0
Technology-related	4.1	26.4	NA	—
Outpatient shift	3.2	20.4	NA	—
Other	3.8	24.3	NA	—

NOTES: Input prices and quantity effects are multiplicative. The components of quantity were estimated using an additive decomposition, however. Case-mix change is estimated holding costs at 1984 levels, and intensity change is estimated for 1987 case mix. Totals and percents calculated before rounding.

SOURCES: Medicare Cost Reports for the year preceeding the prospective payment system through year 5 of the prospective payment system. Medicare provider analysis and review (MEDPAR) for 1984 and 1987. California Hospital Disclosure Reports for disclosure years 9-13.

responsible for the remaining $152 (3.9 percentage points) of the rise in costs.

The decomposition of changes in cost per case for California discharges generally is consistent with the results of the analysis of national data. In both analyses, case-mix change accounted for approximately 11 percentage points of the real increase. The contribution of intensity change was almost 2 percentage points higher in the California analysis than in the national level analysis. In both analyses, however, we were able to explain 35 to 40 percent of the within-DRG effect on costs by changes in the services provided to patients. Thus, in the national sample, 1.6 percentage points of the 4.5 percent intensity increase were attributable to changes in technology and case severity. In the California analysis, 2.9 percentage points of the 6.4-percent intensity increase were attributable to changes in the quantity of intermediate products.

Discussion

The fundamental finding of this study is that hospital costs increased because the product changed—a hospital stay in 1987 was a different and more expensive product than a hospital stay in 1984. The components of the increase in costs in both the national and California analyses are summarized in Table 5.

Changes in case mix account for more than 70 percent of the 15.7 percent real increase in cost per case. Almost one-half of the aggregate real increase (7.4 percentage points) was attributed to changes in the distribution of cases across DRGs because of the technological diffusion and the outpatient shift.

Changes in within-DRG intensity accounted for the remaining real increase in average cost. The effects of the diffusion of high-cost technology in 84 DRGs accounted for approximately one-third of the total within-DRG increase in costs. By contrast, the effect on overall average cost of the truncation of low-cost cases was negligible. In retrospect, it is clear that the relatively low average cost of cases in these DRGs explains the limited contribution to increases in average cost: A small dollar increase produces a much larger percent increase in the average cost of a low-cost DRG than in the overall average cost. Two-thirds of the within-DRG effect remains unexplained.

It is reassuring that we can explain approximately 80 percent of the increase in average cost, because we can identify differences in the product that appear to justify the higher cost. It is troubling because we cannot be certain that we are getting our money's worth for the new product. For example, the California analysis indicates that, on average, a patient admitted in 1987 consumed nearly 3 percent more intermediate products than a patient with the same condition would have consumed in 1984. Did this increase in consumption of intermediate products produce better quality care? If so, was the improvement in quality sufficient to justify the additional expense? We did not attempt to measure changes in the quality of care, so these questions remain beyond the scope of our study.

The largest component of the increase in average cost is the change in case mix. Despite our use of the 1987 grouper on all discharges, some of these differences may be due to changes in coding practices. However, even though coding practices may affect revenues, they should not have much effect on costs. If cases are moved between DRGs to capture higher payments, we would expect the average intensity of treatment (measured by consumption of intermediate products at the DRG/cost-center level) to decrease in the higher-cost DRGs. We did not observe substantial declines in costs at the DRG/cost-center level. We conclude, therefore, that the change in case mix does reflect real differences in the mix of conditions and procedures for which Medicare patients are admitted to hospitals.

Between 1984 and 1987, discharges of Medicare patients fell by nearly 12 percent, and the mix of conditions and procedures for which patients were admitted has changed dramatically. Thus, it appears that patients with conditions that would have been treated on an inpatient basis in 1984 were not being admitted in 1987. Are these patients being served on an outpatient basis, and, if so, is the care they receive cost effective and of appropriate quality? Alternatively, have these patients been shifted out of hospitals into less accessible, less cost-effective, or lower quality care?

We cannot address the relative accessibility or quality of outpatient care. However, the unexplained 3-percentage-point increase in within-DRG cost per case may be relevant to comparisons of the cost effectiveness of inpatient and outpatient care. Some of this residual increase in average cost may represent the allocation of fixed costs over a declining number of patients. Because these fixed costs exist whether a patient is treated on an inpatient or outpatient basis, they should be factored into any short-to-medium term cost-effectiveness evaluation.

The unexplained increase in average cost per case merits further analysis. To the extent that it represents the allocation of fixed costs over fewer patients, it is an important factor to be considered in setting payment levels for services delivered in inpatient and outpatient settings. However, if the unexplained increase in cost per case represents a continuing failure to control costs, then it may be necessary for policymakers to develop new policies and strengthen existing policies to provide hospital managers with the incentive and ability to better control costs.

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