The Effect of Hospital Characteristics and Organizational Factors on Pre- and Postoperative Lengths of Hospital Stay

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To determine reasons for variations in length of stay (LOS) for surgical patients, a comprehensive statistical model was specified and estimated using 1978 discharge abstract data from New Jersey. The model distinguished preoperative LOS from postoperative LOS, and analyzed differences in the impacts of each determining factor on each segment of a hospital stay. The model included a large set of control variables, but the focus of discussion in this article is on factors which reflect the preferences, policies, and organizational routines of hospitals. The empirical findings suggest strategies that hospital managers and regulators can use for reducing average LOS. For example, afternoon admissions often result in extra preoperative days of care even after adjusting for severity of illness. Apparent scarcity of posthospital care in New Jersey also seems to translate into longer hospital stays. Using a comprehensive model and a large, reliable data set, the analysis confirms many hypotheses concerning reasons for LOS variation that have been suggested by earlier research. However, the analysis also raises questions concerning the interpretation of other earlier findings.

INTRODUCTION

Hospital managers and policymakers continue to be interested in shortening hospital stays. Policymakers stress the importance of keep-

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ing lengths of stay down as a major element in the strategy to maintain hospital costs and overall health care expenditures.[1] For the same reason, third-party payers increasingly incorporate incentives into reimbursement systems for reducing LOS or they impose financial penalties for "excessive" stays.[2] The emphasis on LOS reduction as a major policy to contain hospital costs is further demonstrated by the current efforts in some states and at the federal level to implement per case reimbursement systems for hospital services.

Hospital managers' interest in shortening stays can be seen partly as a response to these financial and regulatory pressures. In addition, hospital management is becoming increasingly aware that shorter stays can enhance the efficient use of the institutional resources (e.g., the use of ancillary services and equipment). To achieve these goals, it is of vital importance that more become known about what factors play a significant role in determining the length of a surgical patient's hospital stay.

This article reports on a study of determinants of surgical lengths of stay [2]. An important feature of the analysis is the division of LOS into a preoperative component and a postoperative component. The analysis is built on the premise that the determinants of variation in preoperative stays differ in part from the determinants of postoperative stays. This approach builds on the idea of patient staging, which emphasizes the importance of the different activities that occur during the course of an illness [3]. When the two portions of the stay are combined, it is possible that factors important in only one segment of the stay become blurred in the analysis, and are not properly identified as causal factors. By separately analyzing the two components of a patient's stay, we can better pinpoint how each factor affects the length of the stay. This results in better and more useful information for both managers and policymakers.

Over 60 independent variables were included in the analysis in an effort to control for as many determining factors as possible. This article focuses on those factors which are primarily administrative rather than medical in nature. Consequently, only the findings related to variables presumably reflecting hospital preferences, policies, and organizational routines are discussed. However, the empirical findings concerning all of the variables in the model are presented in an appendix table.[3]

Many studies concerning LOS patterns have been criticized for not sufficiently controlling for all relevant factors. The comprehensiveness of the analysis presented here allows for a more nearly accurate assessment of the direct effects of each factor considered. Therefore, this study represents a major effort to retest some of the important hypotheses concerning determinants of lengths of stay with an appropriate empirical specification.

THEORETICAL FRAMEWORK

There have been many theoretical contributions concerning the determinants of hospital costs and utilization patterns in general, and length of stay variation in particular.[4] One class of models treats the hospital as a goal-oriented entity or organism, and attempts to predict hospital behavior in terms of rational choices that will maximize goal attainment [5–11]. Another class of models suggests that hospital behavior can better be explained by the behavior of individuals who use the hospital as an institution to maximize their utility. Pauly and Redisch [12], for example, assume that hospital behavior is characterized by the maximization of joint earnings by the physician staff acting as a cooperative.

Several authors have proposed behavioral models which explain hospital utilization as a complicated interactive process involving the patient, the hospital, and the physician [1, 2, 13, 14]. These models usually focus on the factors influencing hospital stays. Along these lines, Hornbrook and Goldfarb [15] have proposed a model of obstetrical care in hospitals. Their model assumes that the patient's physician maximizes an objective function that is defined over his or her income and leisure, and the probability of a successful outcome to the pregnancy episode. However, the physician's choice of treatments is seen to be subject to several constraints.

In this analysis, we also use a model that considers physician utility maximization to be the major force behind LOS determination. It includes both quantity and quality considerations and is subject to four sets of constraints: patient (or family) preferences, peer pressure, supply factors, and hospital preferences or organizational dynamics. This model recognizes the role of the physician as the primary decision maker regarding day-to-day decisions on patient lengths of stay; it incorporates the multiple objectives of the participants in the decision-making process; and it allows for differences in physician characteristics as factors explaining LOS variation.[5]

The model used here also demonstrates the appropriateness of analyzing separate LOS segments. Total LOS results from a series of decisions made by the physician, such as when to admit, when to perform the surgery, and when to discharge. As explained in our theoretical framework, these decisions are subject to constraints. Some of the constraints influence decision making across the board; other constraints are relevant only to specific types of decisions. For example, a shortage of acute beds may well result in cutting down both pre- and postoperative stays, while a shortage of nursing home beds should primarily affect the postoperative lengths of stay of those patients in need of long-term care.

MODEL SPECIFICATION

Guided by this theoretical framework and the findings of earlier research, we have included seven sets of variables in our analysis (see Table 1). In the case of several of these variables, different authors give varying interpretations of why or how the variables influence lengths of stay. These interpretations are discussed in the next section, a review of literature relevant to the variables considered in this article.

EMPIRICAL EVIDENCE

Several researchers have studied the effect on LOS of the day of the week of admission. Barbaro et al. [16] find that the lower the proportion of (elective) surgical patients admitted to the hospital on Saturdays and Sundays, the higher the proportion of 0- or 1-day preoperative stays. Weekend admissions are found to have longer preoperative and total stays [14, 17–20].

Emergency surgical admissions are reported to be associated with longer lengths of stay, probably because the medical condition of this type of admission is relatively more severe than the medical condition of an elective admission. But the shorter stays of elective admissions also could relate to preadmission testing and/or preadmission consultation for some of these cases. Barbaro et al. [16] find that preadmission testing has the potential to reduce preoperative LOS only if it coincides with effective operation of other aspects of the hospital organization. Others show that laboratory (or consultation) turnaround time has a positive effect on preoperative and total LOS [21–24]. Admitting patients early in the day is suggested as one way to reduce turnaround time [16].

Organizational routines can influence the physician's decision on the time of discharge as well. Some studies indicate that delays in discharge occur because of delays in transferring patients to long-term care facilities or home care agencies [25–27]. The availability of outpatient care [13] or the use of discharge planning techniques also can facilitate discharge [21,28].

Hospitals have different long-term preferences in terms of the volume and types of service activity. As a result, hospitals differ in terms of case-mix distribution, level of teaching activity, service intensity, and ambulatory care activity. Type of ownership is presumed to be an important factor determining long-term preferences. It is said that proprietary hospitals, whose explicit objective is to make a profit, tend to skim the market by admitting larger proportions of discretionary cases [29,30]. This proposition may explain the observed negative relationship between for-profit ownership and average LOS. After controlling for case mix, this negative relationship may well disappear or even reverse itself (because of revenue-generating considerations).

Municipal and religion-owned hospitals are reported to have longer lengths of stay [15,19,31]. Differences in patients' medical conditions could again be the determining factor; but differences in patient-physician relationships (e.g., relatively more ward patients in municipal hospitals) and organizational inefficiencies could also explain these findings.

The ratio of personnel to hospital beds is found to be negatively correlated with LOS [19,29]. Studnicki [32] defines intensity of services rendered as "the quantity (or volume) of services provided to the hospital patient per day" [32, p. 440]. He further cites some authors who report a negative correlation between staffing ratios, intensity of care, and length of hospital stay. Ro [13] also finds a significant effect on LOS in the "employees per bed" variable. All of these findings appear to indicate an inverse relationship between LOS and service intensity.

Conflicting evidence has been reported concerning the effect of a hospital's teaching status on LOS. Unadjusted average LOS in teaching hospitals tends to be higher than in nonteaching hospitals [33–37], partly as a result of a more complicated case load in teaching hospitals and partly due to the educational process itself [34,35]. The positive effect of teaching status on LOS is also found in some patient-specific LOS studies, which control for diagnostic categories [31,38–40]. However, more illness-specific studies show teaching status to have a negative or insignificant effect on LOS, usually combined with a greater amount of diagnostic testing in teaching hospitals [15,19,34,41,42].

Relatively more severe admissions and longer lengths of stay are associated with hospitals located in more densely populated, urban areas [11,19,35,43–45]. This may be due to the health problems of urban populations and/or it may reflect the use of large, urban medical centers equipped with sophisticated diagnostic capability by nonurban residents with severe and/or complicated medical conditions. It is fur-

Table 1: Independent Variables Included in the Analysis

1. *Medical Condition Variables*
   - Type of primary surgical procedure
   - Type of primary diagnosis
   - Presence of a secondary surgical procedure
   - Presence of a secondary diagnosis
   - Presence of multiple surgical procedures
   - Presence of multiple diagnoses
   - Patient's age
   - Patient's race
   - A socioeconomic/health status index (SEHSI)*
   - Urgent and emergency admissions
2. *Other Variables Affecting Quality/Quantity Considerations*
   - Percentage of foreign medical graduate surgeons by county
   - Percentage of board-certified surgeons by county
   - Percentage of general surgeons by county
   - The average age of surgeons by county
3. *Variables Reflecting Patient Preferences*
   - Day of the week of admission
   - Day of the week of discharge
   - Insurance coverage
4. *Variable Reflecting Peer Pressure*
   - Presence of PSRO review
5. *Supply Constraints*
   - Medical/surgical beds per 1,000 population
   - Occupancy rate
   - Long-term care beds per 1,000 population age 65 and over
   - Ambulatory care as measured by the number of general practitioners per 1,000 population and by population density

continued

ther believed that the shorter lengths of stay in rural areas have to do with less frequent use of diagnostic testing and the more readily available family support that facilitates early discharge.

Finally, the relationship between LOS and hospital occupancy rate has received considerable attention in the literature. Some empirical studies indicate that average hospital stays increase with average occupancy rates [35,46]. This has been interpreted as evidence that hospitals differ in style of practice and risk-aversion. Those hospitals which prefer a higher level of excess bed capacity may keep occupancy rates lower partially by keeping LOS down [11]. Or it may suggest that hospitals with very high occupancy rates experience organizational problems (such as queuing problems in ancillary services) in the diag-

Table 1: Continued

6. *Hospital Characteristics Suggesting Hospital Preferences*
   - —Teaching status
   - —Ownership
   - —Geographic location
   - —Occupancy rate
   - —Level of ambulatory services
7. *Other Hospital Policies and Organizational Routines*
   - —Day of the week of admission
   - —Day of the week of discharge
   - —Hour of admission
   - —Admission class
   - —Discharged to long-term care facility
   - —Discharged to home care agency
   - —Ratio of RNs to other nursing personnel
   - —Ratio of nursing personnel to hospital beds
   - —Ratio of full-time to part-time nursing personnel

*The socioeconomic/health status index equally weights three ordinal variables: municipality-wide average income measured in ten intervals (10 highest, 1 lowest) municipality-wide unemployment rate measured in ten intervals (10, lowest unemployment rate; 1, highest unemployment rate); and municipality-specific ratio of infant and fetal deaths to live births measured in ten intervals (10, lowest ratio; 1, highest ratio).

nostic phase, the treatment phase, and/or the discharge phase, resulting in longer average lengths of stay [46]. What is often overlooked, however, is that the observed positive effect of occupancy rate may well be a statistical artifact. A high occupancy rate may be a consequence rather than a cause of a high average LOS—or both variables may be interrelated, with neither variable causing the other.

One indication of such a statistical artifact is that the positive effect of occupancy rate on LOS appears to be stronger in studies using more aggregate levels of analysis. Hartman and Watts [47], for example, find a very strong positive effect of statewide average occupancy rate explaining to a large extent the variation in average LOS.[6] Most empirical studies which focus on individual patient lengths of stay show that occupancy rate has a negative or insignificant effect on it [13,21,48]. Lave and Leinhardt [14] find that LOS in a large teaching hospital correlates positively with occupancy rate at admission time but does not correlate with occupancy rate at discharge time.

The analysis we present now re-evaluates several of the relationships observed in earlier studies, in the context of a comprehensive, multivariate model.

Data Collection and Methodology

The main source of data for this study was the edited file of 1978 discharge abstracts for New Jersey general hospitals. The data set was constructed by the New Jersey State Department of Health for the purpose of developing a per case prospective reimbursement system. From this database, eight common surgical procedures were selected (see Table 2).[7] Choice of selection was based on the following criteria: (1) at least 1,000 cases with that surgical procedure had to have been recorded during 1978 in the 100 general hospitals of New Jersey; (2) the coefficient of variation could not exceed 100 percent; and (3) average LOS had to be at least 5 days.

These criteria were designed to avoid the analysis of surgical procedures where the impacts of outliers would have dominated the findings. After excluding data from patients who had died in the hospital, 27,384 cases were available for analysis.[8]

Hospital-specific data were collected from the 1978 American Hospital Association's survey of hospitals [49] and from hospital profiles maintained by the New Jersey State Department of Health. Physician characteristics were available from a survey done in 1977 by the state's department of health and from a publication of the American Medical Association [50].[9] County- and municipality-specific data on health system, health status, demographic, and socioeconomic characteristics were collected from New Jersey's department of health and department of labor and industry profiles.[10]

Although the goal of the model is to explain variation in LOS across individuals, the list of independent variables includes many factors that describe the hospital where the individual is treated or the area where the hospital is located. This hybrid-type model recognizes that an individual's LOS is determined partly by factors specific to his or her particular condition and partly by factors common to all individuals undergoing treatment in a given hospital. This mixing of independent variables describing different units of analysis is common to such research. No statistical problems should occur since data from 100 different hospitals were analyzed.

The ordinary least-squares multiple regression procedure was used to estimate the effects of the independent variables on the dependent variables (preoperative and postoperative length of stay).[11] The model is comprehensive, including an unusually large number of independent variables. For this reason, we are confident that the coefficients will be measured accurately—not biased by too many omitted factors. However, one can always think of other variables that it would

Table 2: Effect of Selected Variables on Preoperative and Postoperative Lengths of Stay

	Dependent Variables				
	Preoperative Stay		*Postoperative Stay*		*Mean Score*
Selected Independent Variables	b-*coef.*	t-*score*	b-*coef.*	t-*score*	
Admission Class					
Admitted through ER	.43 †	(6.4)	.48 †	(3.5)	.296
Urgent admissions	.37 †	(4.9)	.23	(1.5)	.108
Referred by other facility	-.41 *	(2.2)	-2.75 †	(7.2)	.016
Left out: admitted by private physician					
Hour of Admission					
Admitted between 3 and 10 p.m.	.59 †	(9.3)	.097	(0.8)	.185
Day of Admission					
Admitted on Friday or Saturday	.31 †	(5.0)	.35 †	(2.7)	.162
Day of Discharge					
Discharged on Friday or Saturday	—	—	-.058	(0.6)	.314
Discharged on Monday	—	—	-.080	(0.6)	.128
Discharge Status					
Discharged to long-term care facility	.08	(0.7)	1.97 †	(8.6)	.062
Discharged to home care agency	-.26	(1.5)	1.30 †	(3.7)	.019
Left out: discharged routinely or to other health institution					
Percent Ambulatory Costs	-.007	(0.8)	-.054†	(3.1)	14.0%
Teaching Activity	-.016	(0.2)	-.071	(0.5)	.214
Ratio RNs to Other Nursing Personnel	-.13 *	(2.3)	.091	(0.8)	1.46
Ratio Nursing Personnel to Hospital Beds	.14	(0.9)	-.23	(0.7)	1.08
Ratio FT/PT Nursing Personnel	-.009	(0.9)	-.034	(1.6)	3.62

continued

Table 2: Continued

	Dependent Variables				
	Preoperative Stay		*Postoperative Stay*		*Mean Score*
Selected Independent Variables	b-*coef.*	t-*score*	b-*coef.*	t-*score*	
Occupancy Rate, Medical/Surgical beds	-.008†	(2.8)	-.022†	(3.6)	88.3%
Hospital Location					
Inner city	-.29 †	(3.8)	.13	(0.9)	.179
Rural	-.63 †	(4.6)	-.82 †	(2.9)	.069
Left out: urban or suburban					
Hospital Ownership					
For-profit	.39 †	(3.2)	.30	(1.2)	.051
Government owned	.29	(1.5)	1.01 †	(2.7)	.024
Left out: voluntary not-for-profit					
INTERCEPT	.89	—	7.84	—	1.00
$\bar{R}^2$	.27	—	.48	—	—

Note: The ordinary least-squares regression procedure was used to estimate the coefficients of the model. The equations used to estimate the coefficients reported in this table included other control variables. The complete equations, along with means and standard deviations for each variable, are reported in Appendix Table A1.

*Significant at the 95 percent confidence level.

†Significant at the 99 percent confidence level.

have been useful to include had data been available. In our case, the most important factor we were unable to measure was ancillary service use. Recent work by Hornbrook and Goldfarb [15] indicates that ancillary service use and LOS variables are determined simultaneously by many of the variables in our model. Thus, the model presented here should be interpreted as a "reduced form" model relating each independent variable to LOS. It is possible that the causal link between any independent variable and LOS could involve an intermediating relationship between that variable and ancillary service use.

The data for the eight surgical procedures were pooled and used to estimate one model. The effects of some variables on LOS may be different for patients undergoing different surgical procedures. Therefore, each estimated coefficient must be interpreted as the average impacts of a given variable on LOS for patients with varying medical problems.[12]

STUDY FINDINGS

This article focuses the discussion on the variables potentially most controllable by hospital managers. These variables reflect hospital preferences, policies, and organizational routines. The findings related to these factors are reported in Table 2, while the complete equations are presented in Appendix Table A1. The first column of Table 2 shows the direct effect of the selected independent variables on the adjusted length of preoperative stay, while the second column presents the equation with adjusted length of postoperative stay as the dependent variable. The table is constructed to highlight similarities and differences in the effects of each independent variable on pre- versus postoperative LOS. As the following discussion indicates, splitting up LOS into pre- and postoperative segments enhanced the interpretability of the results.

HOSPITAL CHARACTERISTICS

After controlling for case mix and other medical-related factors, for-profit hospitals no longer have shorter average stays than voluntary hospitals. In fact, the preoperative stay in for-profit hospitals is significantly longer than in voluntary hospitals. This might indicate that the revenue-generating considerations, reinforced by the for-profit character of the hospital, translate into an increased ordering of diagnostic tests which subsequently lead to longer preoperative periods.

On average, surgical patients in government-owned hospitals stay 1 day longer postoperatively than do surgical patients in voluntary hospitals and 0.71 days longer than do patients in for-profit facilities. This result suggests that a closer look at postoperative care in public hospitals is warranted. Although it is possible that differences in patient needs contribute to this finding, the numerous control variables that hold constant the influence of these differences should minimize the likelihood that patient characteristics explain this postsurgery LOS difference. More likely, it results from differences in public versus nonpublic hospital practice patterns.

As expected, rural hospitals have significantly shorter pre- and postoperative stays than do other hospitals. The shorter preoperative stay is consistent with the presumed tendency in rural areas to order fewer diagnostic tests and to rely less on sophisticated diagnostic technology than in urban areas, while the greater availability of family support may well explain the shorter postoperative stay.

Assuming that the overall number of interns and residents per hospital bed is a good proxy for the degree of teaching activity on surgical units of a particular hospital, teaching activity itself does not have a significant effect on the length of a patient's hospital stay. Surgical cases discharged from hospitals with at least one resident or intern for every ten beds (21 percent of all cases under study) have insignificantly shorter average pre- and postoperative stays.[13]

OCCUPANCY RATE

The findings of this study clearly support the rationing hypothesis. Occupancy rates have a significantly negative effect on both components (pre- and postoperative) of hospital stays. The magnitude of this effect is quite small, but the observed effect is likely to be an underestimate of the real effect because only data on the yearly average occupancy rate are available.[14]

NURSING-RELATED VARIABLES

Three nursing variables are included in the analysis. It is hypothesized that, *ceteris paribus*, hospitals with (1) higher ratios of nurses to hospital beds, (2) higher ratios of registered nurses to licensed practical nurses and nurses aides, and (3) higher ratios of full-time to part-time nurses would experience relatively shorter lengths of stay. These ratios are presumed to reflect service intensity, quality of nursing care, and continuity of nursing care, which in turn should affect LOS.

As shown in Table 2, the effects of these variables on length of stay are usually not significant. The only variable which shows significance (at the 5 percent level) is the ratio of RNs to other types of nursing personnel. The shorter preoperative stay may indicate that RNs are better trained to detect certain patient problems and to communicate these problems more effectively to the physicians. The existing nursing shortage may well prevent RNs from employing all of their skills (e.g., inpatient management, emotional support, and discharge planning) which would have resulted in shorter postoperative stays.[15]

AMBULATORY CARE

The only variable that is available for all New Jersey hospitals and which presumably reflects the relative importance of ambulatory services across hospitals is the cost of ambulatory care as a percentage of total operating costs. The fact that hospitals with a relatively large proportion of ambulatory care costs tend to have shorter postoperative lengths of stay for surgical inpatients could be interpreted as evidence that some substitution of ambulatory care for inpatient care occurs. The effect on preoperative LOS is not significant.

ADMISSION-RELATED VARIABLES

The division of hospital stays into two segments reveals that the longer lengths of stay associated with emergency room admissions cannot be attributed solely to inefficiencies at the hospital level typical for unplanned admissions. Emergency admissions have, on average, longer preoperative stays as well as longer postoperative stays. A variety of factors may explain why these patients also stay longer in the hospital postoperatively. First, it could be that these admissions are medically different from the others, even after controlling for the above-described medical condition variables. For example, the crisis atmosphere in which the patient is brought into the hospital may result in slower postoperative recovery for physiological and/or psychological reasons. An alternative interpretation is that patients admitted through the emergency room are less likely to have a private physician. Those patients may have longer postoperative stays because of the hospital's awareness that further medical attention is unlikely after they have been discharged. Emergency room admissions also may signal an unstable social environment (especially in distressed areas), again resulting in delayed discharges because particular patients have no place available except the hospital in which to convalesce.

Urgent admissions have significantly longer preoperative stays than the other (mostly elective) admissions. This raises some doubts about the urgency of medical intervention. The insignificant effect on postoperative stays may suggest that urgent admissions are not all that different, medically speaking, from elective admissions. So it is not unlikely that urgent admissions have longer preoperative stays only because the patients (as well as the hospitals) are less prepared for immediate surgery at the time of admission.

Patients referred by other facilities (other hospitals or long-term care facilities) tend to have shorter preoperative stays (significant at the 5 percent level) and much shorter postoperative stays (almost 3 days shorter) than patients referred by a private physician. Presumably, these patients have been admitted for a specific procedure and, once this procedure has been performed, the referral facility resumes the care of these patients. They may be atypical, then, since their duration of stay in the hospital is spread over more than one facility.

The variable "admitted between 3 p.m. and 10 p.m." has a very significant, positive effect on preoperative LOS. The insignificant effect of those "late admissions" on postoperative average stays indicates that admission time probably is the crucial factor here. The regression coefficient suggests that a majority of those cases (a substantial number of whom are elective admissions) stay at least 1 day longer preoperatively than the patients admitted before 3 p.m. or after 10 p.m. The most likely explanation for this effect is that certain diagnostic tests and physician consultations may be postponed until the day after admission. The finding is also consistent with past observation that the waiting time for receiving the results of lab tests is shorter for cases admitted in the morning than for cases admitted in the afternoon due to daily routines in hospital laboratories.

Patients admitted on a Friday or Saturday have, as expected, significantly longer preoperative stays. However, those patients also have significantly longer postoperative stays. In the past, some researchers have attributed the effect of end-of-the-week admissions on total LOS completely to the inefficiency inherent in admitting surgical patients just before the weekend, when elective surgeries usually are not performed. The observation that more than 50 percent of that effect is related to the postoperative LOS forces us to consider other possible explanations. One possibility is that Friday and Saturday admissions are more severely ill. It has been pointed out to us that emergency admissions over the weekend are more likely to be serious emergency cases than emergency admissions during the week. An alternative interpretation is that the same driving forces which lead to Friday and Saturday admissions also lead to delayed discharges (e.g., revenue-generating considerations and pressures of the patient's family).

DISCHARGE-RELATED VARIABLES

Patients discharged to a long-term care facility have significantly longer postoperative stays than those discharged routinely (holding all other factors constant). Yet this variable has no significant effect on preoperative stays. These findings support the hypothesis that organizational dynamics are the predominant factors leading to delays in transferring patients to long-term care facilities.[16] These dynamics may be caused by a shortage of suitable facilities and by the complexity of eligibility requirements.

Patients discharged to home care agencies also have significantly longer postoperative stays but preoperative stays similar to those of routinely discharged patients. Further study of patient characteristics, such as marital status and nursing care requirements, and of the dynamics of the home health care industry (e.g., are there similarities to the long-term care situation?) could bring some clarification to the longer postoperative stays of these patients.

One final set of variables considered here is the day of the week the patient is discharged. Three groups of patients are distinguished: those discharged on Fridays or Saturdays, those discharged on Mondays, and those discharged on other days of the week. We had expected that patients discharged just before the weekend would have shorter stays than patients discharged just after the weekend, primarily because the service activity in hospitals presumably slows down during the weekend (e.g., fewer physician visits). Our results show, however, that average postoperative stays are virtually identical for the three groups of patients.

SUMMARY AND DISCUSSION

The analysis presented in this paper provides information that is important both for hospital managers and for regulators interested in determining how hospitals might operate more efficiently.[17] Specifically, the analysis suggests where efforts to shorten hospital stays are best directed. The analysis also indicates some empirical findings that deserve closer scrutiny, with a more fine-tuned analytical research design than the large-scale empirical analysis used here.

The finding that patients admitted to the hospital after 3 p.m. experience average stays that are 0.59 days longer than other stays raises questions about the appropriateness of such late-in-the-day admissions. Since the model includes variables that measure the urgency of the admission and the type of medical problem that resulted in the admission, it is not likely that the 0.59 extra day is associated with characteristics of the patients admitted after 3 p.m. Unless an argument can be made that the extra half-day substantially improves quality of care, late afternoon admissions for elective surgeries should be eliminated. It would seem quite justifiable for insurers to require medical justification before reimbursing for the first day of an episode if the admission occurred after a certain hour in the day.

The finding that Friday and Saturday admissions lead to both longer preoperative stays and longer postoperative stays forces a reexamination of how to interpret the commonly found positive relationship between weekend admission and LOS. Before pushing to eliminate weekend surgical admissions, we need to determine whether our results indicate that patients admitted on weekends are less healthy than other patients and thus need extra time in the hospital both before and after surgery, or whether our results can be interpreted as evidence that providers who make weekend admissions are simply less efficient in terms of days of care both in the preoperative and postoperative phases of a hospital episode.

Occupancy rates were found to influence both preoperative and postoperative stays. This result is in line with Roemer's Law, which would suggest that stays would be lengthened when there are empty hospital beds. Similarly, we would expect rationing to occur in periods of tight bed supply so that those patients most in need of hospital beds would be able to find available space. From a planning point of view, our result supports the idea that reductions in availability of hospital beds in a community will decrease utilization.

The fact that patients discharged to long-term care facilities have almost 2-day-longer postoperative stays than other patients and that patients discharged to home care have average stays that are 1.37 days longer than routinely discharged patients is further evidence of how shortages of alternative care on the East Coast increase hospital utilization (see also [1]). The problem of administrative days, or days awaiting admission to out-of-hospital programs, is a growing problem in many states.

On first consideration, a simple solution to the problem seems to be to build more nursing homes or to increase the availability of noninstitutional extended care. The federal and state governments tend to be skeptical of this solution, because it would likely raise the total costs of the Medicare and Medicaid programs. This could happen for two reasons. If the hospital beds, made available by moving patients more quickly from hospitals to some type of extended care, are used by new patients who otherwise would not have been hospitalized (i.e., if

Roemer's Law is operating), then government and other insurers will see their total costs increase. The costs of the new extended care will not be offset by lower hospital costs unless total hospital utilization is reduced with a simultaneous increase in extended care. Insurers also fear that newly available extended care might be partially utilized by new demands for the care rather than by the existing demand represented by hospital patients awaiting placements in extended care programs. To the extent that the demand for extended care increases as its supply increases, the backup of hospital patients awaiting placement would remain.

If federal and state governments insist on holding constant real expenditures on Medicare and Medicaid, the solution to the hospital backup problem must come in the form of simultaneous reductions in hospital care and increases in extended care. At least in the short run, this might be accomplished by converting acute care beds to extended care beds as currently demonstrated through the swing-bed programs that are being sponsored on an experimental basis by the Health Care Financing Administration and The Robert Wood Johnson Foundation.

A final set of results that warrant the attention of hospital managers and regulators is the variation in average stays across different types of hospitals. Although for-profit hospitals have shorter unadjusted preoperative stays than voluntary hospitals, after adjusting for differences in patient mix and other factors, the for-profits had significantly longer preoperative stays. More detailed examination of reasons for this is required.

Government-owned hospitals were found to have 1-day-longer postoperative stays than voluntary hospitals after adjusting for the numerous variables included in the model. Again, this finding suggests that a thorough examination of postoperative care in public hospitals might lead to ideas for improving the performance of these hospitals.

In summary, most findings reported in this analysis are consistent with the theory that hospital policies and organizational routines influence the physician's decision making on LOS. Relative inefficiencies in admission scheduling, operation scheduling, and discharge planning do appear to exist. The segmentation of total LOS into pre- and postoperative stays has helped to clarify the relationship between these factors and the duration of hospital episodes.

Our study sought to control for all available measures reflecting differences in case mix and patient characteristics. Yet, unexplained variation in severity of illness and social environment may still exist. The possibility that this may have influenced the results of some of the variables, presumed to reflect organizational patterns and hospital preferences, cannot be ruled out. Incorporating such factors as nursing diagnoses and certain socioeconomic variables (e.g., living arrangements) into the empirical model would test this possibility. An alternative approach is to develop separate models for relatively homogenous populations. For example, the general model could be applied separately to rural, suburban, and urban areas.

In addition, we recommend that interested parties, including third-party payers and hospital management, conduct more in-depth analyses concerning how organizational routines in specific hospital departments might inhibit operational efficiency, both in the diagnostic phase and in the recovery phase of a patient's stay in the hospital. For certain nonsurgical diagnoses, a separate analysis of the LOS segment related to the treatment phase also should be considered.

NOTES

1. This, of course, assumes that shortening hospital stays does not coincide with an increase of readmissions and unnecessary hospital admissions. The fact that areas with shorter average hospital stays tend to experience higher admission rates may indicate that cost-containment efforts focused on length of stay could become counterproductive.
2. For a discussion of how varying reimbursement regulations influence length of stay, see Knickman and Foltz [1].
3. For a more in-depth discussion of the findings of all of the independent variables, see Cannoodt [2, Chapters 5–7].
4. See Jacobs [4] for a review of the literature relating to economic models of hospitals.
5. See Cannoodt [2, Chapter 2], for more detail.
6. It should be noted that in aggregate studies, occupancy rates generally are computed as: (LOS × ADMISSIONS)/(BEDS × 365). Thus, the dependent variable (LOS) appears in the numerator of the occupancy rate variable.
7. The eight procedures are implantation of heart pacemaker, suprapubic prostatectomy, vaginal hysterectomy, hip replacement, complete mastectomy, appendectomy, hemorrhoidectomy, and cesarean section.
8. Major reliability problems with discharge abstract information are well documented. The New Jersey State Department of Health, aware of the potential hazards of an unreliable database for its per case reimbursement system, has made extra efforts to remove from the original files all cases with incomplete or apparently inaccurate information. Certain outliers, identified by the New Jersey Department of Health and reviewed by a panel of physicians, also have been excluded from the database. For the purpose of our analyses we have employed several strategies to further enhance the reliability of the data. One of the strategies has been to exclude all data from patients who died in the hospital. Furthermore,

common surgical procedures rather than diagnoses have been selected as units of analysis because they are less likely to be subject to reporting biases and because this circumvents the admitting-versus-discharge diagnosis issue. Particular principal diagnoses have been used to control for possible medical condition differences across cases with the same surgical procedures with the reported principal diagnoses. The results are reassuring; in at least 95 percent of the cases, the principal diagnosis appears consistent with the surgical procedure selected.

9. The physician characteristics are measured at the county level because these were the least aggregated data available. It would be far better to link an individual's length of stay to characteristics of that individual's doctor. The county variables are included as a "second best" alternative.
10. Health system variables are measured at the county level because counties appear to represent the most appropriate geographical boundaries of health systems in New Jersey. Standard Metropolitan Statistical Areas (SMSAs) would be the other logical choice, but some counties in New Jersey are not in an SMSA.
11. Since LOS is divided into two components, it is possible that the error term in the preoperative equation is correlated with the error term in the postoperative equation. If so, the equations are termed "seemingly unrelated" regressions, and the efficiency of the estimators can be improved with a generalized least-squares procedure. Because our sample size was so large, we decided that the gains in efficiency would not be substantial. Ordinary least-squares estimators are unbiased even if the equations are "seemingly unrelated."
12. Results disaggregated by surgical procedure are reported in Cannoodt [2].
13. At one point, we introduced the ratio of interns and residents to hospital beds as an independent variable to check whether the results could have been influenced by the (arbitrarily chosen) cutoff point. The results of both measures are essentially the same.
14. If physicians of a particular hospital respond to a very high occupancy rate in a particular month, then the patients admitted during that month are expected to have a relatively short preoperative stay and the patients discharged during that month are expected to have a relatively short postoperative stay. However, the relationship between occupancy rate and pre- and postoperative stay for these patients will be difficult to detect when the annual average occupancy rate is used as a proxy for the occupancy rate of that month, and when that particular hospital has a relatively low occupancy rate for the rest of the year compared with the annual occupancy rates of other hospitals. This is, of course, an extreme situation, but it suggests that the occupancy rate at admission time and at discharge time for each patient would have been a more accurate measure for testing the rationing hypothesis. The occupancy rate at admission time is expected to have a larger impact on the preoperative period, while the occupancy rate at discharge should have a larger impact on the postoperative period.
15. For a further discussion of the nursing factors and the validity of the measures used, see Cannoodt [2, pp. 54 and 109–10].
16. If patients discharged to long-term care facilities had longer stays only because they were more seriously ill than other patients, we would expect

these patients to have both longer preoperative and postoperative stays.

17. It should be pointed out that this study has been conducted with data from 1978, just before New Jersey started implementing the per case reimbursement system. The new reimbursement system has been designed to improve hospital efficiency in general and to keep lengths of stay down in particular. A follow-up study of how hospital behavior changes due to the new reimbursement system and how these changes affect lengths of stay could provide valuable information about the influence of such a system on hospital organization and LOS determination.

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APPENDIX

Table A1: Means and Standard Deviations and Regression Coefficients for Each Independent Variable Included in the Preoperative and Postoperative Length of Stay Models

Independent Variables	$\bar{X}$	*Standard Deviation*	*Coefficients** *Preop LOS*	*Postop LOS*
Primary Procedures				
Appendectomy	.127	.333	−.21	.46
Suprapubic prostatectomy	.065	.246	2.91 ‡	3.33 ‡
Vaginal hysterectomy	.157	.363	.29 †	−1.43 ‡
Hip replacement	.185	.388	1.45 ‡	10.30 ‡

continued

Table A1: Continued

Independent Variables	X̄	*Standard Deviation*	*Coefficients** *Preop LOS*	*Postop LOS*
Complete mastectomy	.170	.375	1.26 ‡	.72 †
Heart pacemaker insertion	.143	.350	4.64 ‡	3.20 ‡
Hemorrhoidectomy	.078	.269	.79 ‡	-3.00 ‡
Left out: cesarean section	.075	–	–	–
Primary Diagnoses (see Appendix Table A2)				
PD 1	.003	.050	.53	-2.15 †
PD 2	.023	.148	-1.10 ‡	4.25 ‡
PD 3	.014	.115	.28	-2.71 ‡
PD 4	.073	.259	-1.43 ‡	-3.51 ‡
PD 5	.004	.006	5.79 ‡	5.94 ‡
PD 6	.007	.085	-.27 ‡	-5.77 ‡
PD 7	.005	.073	.54	-1.07
PD 8	.002	.044	-.32	-1.75
PD 9	.005	.068	.36	1.73 †
PD 10	.001	.029	.41	-2.59
PD 11	.007	.085	.52	.99
PD 12	.017	.128	.10	-1.21 ‡
PD 13	.007	.083	.50	-2.63 ‡
PD 14	.014	.118	-.63 ‡	-4.71 ‡
PD 15	.001	.037	-.50	-4.05 ‡
Left out: all other PDs	.817	–	–	–
Severity of Illness				
With secondary diagnosis	.255	.436	.17 ‡	.81 ‡
With multiple diagnoses	.389	.488	.83 ‡	2.37 ‡
Left out: without secondary diagnosis	.356	–		
With secondary procedure	.204	.403	.26 ‡	.70 ‡
With multiple procedures	.464	.499	.50 ‡	1.66 †
Left out: without secondary procedure	.332	–	–	–
Socioeconomic/Health Status Index	18.86	5.03	-.028‡	-.033‡
Admission Class				
Admitted through ER	.296	.457	.43 ‡	.48 ‡
Urgent admissions	.108	.310	.37 ‡	.23
Referred by other facility	.016	.127	-.41 †	-2.75 ‡
Left out: admitted by private physician	.580	–	–	–
Admission Time				
Admitted between 3 and 10 p.m.	.185	.388	.59 ‡	.107
Admitted on Friday or Saturday	.162	.368	.31 ‡	.35 ‡

continued

Table A1: Continued

Independent Variables	$\bar{X}$	Standard Deviation	Coefficients* Preop LOS	Postop LOS
Discharge Time				
Discharged on Friday or Saturday	.314	.464	—	-.061
Discharged on Monday	.128	.333	—	-.08
Discharge Status				
Discharged to long-term care facility	.062	.242	.080	1.97 ‡
Discharged to home care agency	.019	.135	-.26	1.30 ‡
Left out: discharged routinely or discharged to other health institution	.919	—	—	—
Insurance Coverage				
No insurance	.028	.164	.05	-.28
Commercially insured	.141	.348	-.02	.12
Medicare	.382	.486	.20 ‡	-.26
Other government reimbursement (mostly Medicaid)	.057	.232	.11	-.02
Left out: other reimbursement schemes	.392	—	—	—
Reviewed by PSRO	.167	.373	.02	-.20
Age	53.84	22.19	.003	.06 ‡
Race				
Black	.081	.272	.30 ‡	.86 ‡
Left out: all other races	.919	—	—	—
Percent Ambulatory Costs	14.02	3.77	-.01	-.05 ‡
Density (Population per 1,000 Square Miles	6.09	6.15	-.07	.03 ‡
GPs per 10,000 Population	1.55	.31	.55 ‡	1.04 ‡
Teaching Activity	.214	.410	-.02	-.07
Occupancy Rate Medical/Surgical Beds	88.28	9.80	-.01 ‡	-.02 ‡
Medical/Surgical Beds per 1,000 Population	3.06	.91	.14 ‡	-.36 ‡
Adj. Long-Term Care Beds per 1,000 Elderly Population	28.03	10.57	.00	.01 †
RNs/LPNs and Other Nursing Personnel	1.46	.47	-.13 †	.09
Ratio Nursing Personnel to Beds	1.08	.213	.14	-.23

continued

Table A1: Continued

Independent Variables	$\bar{X}$	*Standard Deviation*	*Coefficients** *Preop LOS*	*Postop LOS*
FT/PT Nursing Personnel	3.62	3.60	-.01	-.03
Hospital Location				
Inner city	.179	.384	-.29 ‡	.13
Rural	.069	.254	-.63 ‡	-.82 ‡
Left out: urban or suburban	.752	—	—	—
Hospital Ownership				
For-profit	.051	.220	.39 ‡	.30
Government owned	.024	.152	.29	1.01 ‡
Left out: voluntary not-for-profit	.925	—	—	—
Percent Board-Certified Surgeons	65.00	11.17	.011	-.03 ‡
Percent FMG Surgeons	31.32	12.68	-.004	-.01
Average Age Surgeons	46.43	2.53	-.03 ‡	-.02
Percent General Surgeons	55.28	12.56	.01	.02 ‡
Constant Term	1.00	.00	.89	7.84
$\bar{R}^2$	—	—	.27	.48
Sample Size	27,384	27,384	27,384	27,384
Degrees of Freedom	—	—	27,324	27,324

*The ordinary least-squares regression procedure was used to estimate each of the two length of stay models (preoperative stay and postoperative stay).
†Significant at the 95 percent confidence level.
‡Significant at the 99 percent confidence level.

Table A2: Primary Diagnoses Controlled for in Regression Models

PD 1.	Hypertensive heart disease
PD 2.	Acute myocardial infarction (AMI)
PD 3.	Ischemic heart disease except AMI
PD 4.	Arrythmia and slowed conduction
PD 5.	Circulatory dysfunction in brain
PD 6.	Complications of medical and surgical care
PD 7.	Disease of the circulatory system
PD 8.	Diseases of the female reproductive system
PD 9.	Cancer of the male reproductive system
PD 10.	Urinary stones
PD 11.	Cancer of the female reproductive system
PD 12.	Arthritis
PD 13.	Diseases of the bone and bone tissue lining
PD 14.	Diseases of the breast
PD 15.	Congenital anomalies