Do-Not-Admit Versus Inpatient Surgery in an HMO: Determinants of Choice and the Implications for Medical Care Costs

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We develop a model for investigating the implications of policies that have encouraged a shift from inpatient to do-not-admit (DNA) surgery. We use discriminant function analysis on data for two surgical procedures from the Kaiser Permanente Medical Care Program of Portland, Oregon. Case attributes found to be significantly associated with the choice of surgery mode are surgeons' rate of inpatient surgery, number of chronic conditions per patient, time in surgery, number of procedures performed, and type of anesthesia used. Our estimates of cost savings provide support on economic grounds for the use of DNA surgery, for the types of surgery investigated. Our results also suggest that simple evaluation methods, based on the mean length of stay and on extrapolation of the proportion of DNA cases from the base year to the current year, may overestimate the cost savings derived from the shift to DNA surgery.

Because of the rapidly rising cost of health care, policy makers and providers are searching for more efficient ways to deliver medical care services. Do-not-admit (DNA), or ambulatory, surgery is a development that offers potential savings if it becomes the standard delivery mode for appropriate types of surgical cases.

One of the earliest reports on the use of DNA surgery (for over 7,000 operations at the Royal Glasgow Hospital for Children), was published in 1909. DNA surgery did not receive much attention in the United States until the early 1960s. The renewed concern at that time has been attributed to the development of safer anesthetic agents and techniques, high demand for hospital beds, and increased interest in early ambulation following surgery [1]. A number of hospitals in the United States set up DNA surgery units in the late 1960s. In 1968, the first freestanding surgical center was opened in Providence, Rhode Island. By 1976 there were an estimated 20 freestanding surgical centers in the United States, and by 1974, 2,600 of 7,000 hospitals had set up some form of DNA surgical unit, compared with only 1,400 in 1973 [2].

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There are several estimates of the number of surgeries that could be performed in the DNA mode [3,4,5,6]. These estimates range from 20 to 40 percent of all surgery; this includes many different procedures and surgical specialities. The diversity of ambulatory cases is illustrated by Reed and Ford, who report that 33,000 patients have been treated in the Phoenix Surgicenter since 1970, over 85 percent of them with general anesthesia [7]. The most common DNA procedure was diagnostic dilation and curettage, followed by laparoscopy and myringotomy, inequinal herinorahaphy, adenoidectomy, cystoscopy, and eye muscle operations. In a typical month with 233 DNA procedures, 106 were gynecological, 54 pediatric, and 52 otolaryngological.

Although a surgical procedure in itself may not warrant hospitalization, a patient may nonetheless be admitted. For example, Barton reports that only normally healthy patients and patients with mild systemic disease are accepted for DNA surgery [8]. Those who are below average in intelligence, have severe character disorders, are unable to get transportation home, or are uncooperative, hostile, or litigious are admitted for surgery.

In this article we develop a method for exploring the medical care cost and utilization implications of policies that encourage a shift from inpatient (INPT) to DNA surgery. We use data from the Kaiser Permanente Medical Care Program of Portland, Oregon, a large prepaid group-practice medical care system that has been extensively described in the literature [9]. Specifically, we do the following:

1. suggest a model for predicting the choice between DNA and INPT surgery for surgical procedures in which both modes are technically feasible;
2. test the choice model using data on two surgical procedures, dilation and curettage of the uterus and excisions of skin lesions;
3. use the choice model to estimate the medical care cost savings achieved in 1974 as a result of policy changes since 1967 that have encouraged utilization of the DNA mode; and
4. compare the savings estimate based on the choice model with savings estimates obtained by applying the simple proportions of DNA cases in the base year (1967) to cases in 1974.

Choice Model

We propose a methodology capable of determining the medical care cost savings achieved by a policy shift from INPT to DNA surgery between a base year and any subsequent year. In analyzing the general case where surgery may have been performed in either mode during the base year, we do not assume that all surgery using the DNA mode in a subsequent year would have used the INPT mode in the base year. It is therefore necessary to study how the attributes of particular cases were associated with the choice of surgery mode during the base year.

This approach asserts that the attributes of the case (delineated below) have some effect on the surgery mode decision, and that the impact of a policy change can be determined by observing how these attributes affect the decision before and after the policy change. (An estimate of subsequent-year cases by mode, made according to base-year policy and simple base-year proportions, would give a biased account of the effect of the policy change.)

Case Attributes

The choice of DNA or INPT surgery is influenced by patient factors, provider factors, and health care system factors. These factors are not necessarily mutually exclusive; for example, provider preferences interact with patient conditions and system characteristics to determine surgery mode. A full development of the path of this decision process is beyond the scope of this paper. We consider our approach to be a first step in modeling this process.

Patient factors. The most important patient factors are the patient's physical condition and the specific conditions of the surgery. Generally, someone in poor health status is likely to have surgery performed in the INPT mode because of possible complications. Age may be a proxy for this factor if more specific data, such as existence of previous conditions, are not available. Specific conditions of the surgery include its extent and location, the type of anesthesia required, and the necessary postoperative procedures, such as catheterization and frequent change of dressing. As these factors become more critical, the likelihood of choosing the INPT mode should increase.

Economic considerations are another patient factor. They include the out-of-pocket price of each surgery mode, travel time from residence to hospital, the patient's wage rate, the disability time required for each mode, and the home resources available for patient care. As the relative cost of one mode rises, the likelihood of choosing that mode should diminish.

The patient's preferences are the final patient factor. Patients who prefer the extra security of the hospital to the comfort of home are more likely to request the INPT mode.

Provider factors. Provider preferences for surgery mode have an impact on patients' surgery mode decisions. Providers may fail to offer patients one of the options or may urge that one be adopted. If providers differ in their preference for surgery mode, the distribution of patients among surgeons will affect the relative proportion of INPT and DNA surgery. Thus, provider preference must be controlled when estimating the effects of other factors on choice of surgery mode.

System factors. For a given health care system or facility, the primary factor affecting the choice of surgery mode is the number of beds. If a hospital is operating at or near capacity, there will be pressure to shift cases to the DNA mode. This is true across hospitals at a given time a well as within a hospital over time.

Reimbursement policy is another important system factor. If care is paid for under a cost reimbursement fee-for-service system, rather than a system of prospective reimbursement or prepaid capitation payments, fewer cases will be shifted to the DNA mode. Of course, this factor also indirectly influences choice of surgery mode since it affects the capacity at which the hospital operates.

Discriminant Analysis

The choice model is operationalized by postulating a discriminant function that includes the choice between DNA and INPT surgery as the dependent variable and available measures of the patient, provider, and system factors as independent explanatory variables. This allows us to estimate linear parameters of the choice model while

making the two groups as statistically distinct as possible [10]. As in regression analysis, the coefficients provide a means to analyze the relative statistical significance and importance of the explanatory factors. In addition, the discriminant function allows us to classify other cases as to the likelihood of their being INPT or DNA. The classification coefficients provide a means to weight the cases by their particular characteristics. (This is the way in which the 1967 surgery policy will be imposed on the 1974 cases.)

We tested this methodology on a subset of data from the Portland Kaiser Permanente Medical Care Program's DNA surgery study [11,12]. We focused on patients who underwent either of two surgical procedures, dilation and curettage of the uterus (D&C)[1] or excisions of skin lesions,[2] performed as INPT or DNA during 1967 (base year) or 1974. We chose these procedures for analysis because of their frequency of occurrence; they represented over 50 percent of the DNA surgeries performed during 1974 in the Kaiser Permanente Medical Care Program. We examined 446 cases, about 20 percent of the two surgical procedures for the years 1967 and 1974. The cases were randomly selected.

Table 1 shows frequency distributions of the explanatory variables available to represent factors delineated in the choice model. There is considerable variation in the data for several variables, a necessary condition if these factors are to discriminate between DNA and INPT surgery. We obtained these data from chart reviews of the sample cases.

System variables. Since all patients and providers were associated with the Kaiser Permanente Medical Care Program, there were no direct economic motives for choosing one surgery mode over another. This prohibited investigation of an important policy issue: the effect on surgery mode choice of prepayment versus traditional fee-for-service/third party reimbursement. The system may, however, have an effect on choice through the expected availability of beds at the time of surgery; this is represented by the occupancy rate computed on the day of surgery. It is likely that DNA surgery will increase as occupancy increases. The frequency data for 1967 indicate that 67 percent of the DNA D&C cases were conducted when the bed occupancy rate was 90 percent or more, compared with 58 percent of the INPT cases. For Skin Lesions, the comparable figures are 67 percent DNA and 57 percent INPT. This trend, however, is not apparent for the 1974 D&C cases.

Provider variables. The only available indicators of physician preferences were the proportion of D&Cs and Skin Lesions performed in the INPT mode and the proportion of all surgery performed INPT. We assumed that physicians who preferred the INPT mode would have a relatively high rate of INPT surgery and that the likelihood of using the DNA mode would be inversely related to a physician's INPT rate. To avoid building in a tautological relationship, we calculated surgery rates from a broader experience than the sample, which constituted only 21 percent of the cases for the D&C rates and 32 percent of the cases for the INPT rates.

Patient variables. No data were available on indirect economic factors such as wage rates, sick leave provisions, and availability of care at home. In this system, there are no price

Table 1:
Specifications and Frequency Distributions of Explanatory Variables

Variables	Measurement	1967 D&Cs DNA (N=43)	1967 D&Cs INPT (N=53)	1967 D&Cs Total	1967 Skin Lesions DNA (N=36)	1967 Skin Lesions INPT (N=63)	1967 Skin Lesions Total	1974 D&Cs DNA (N=73)	1974 D&Cs INPT (N=58)	1974 D&Cs Total	1974 Skin Lesions DNA (N=60)	1974 Skin Lesions INPT (N=60)	1974 Skin Lesions Total
Hospital Occupancy Rate	*Actual*												
0.80-0.84		0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.17	0.19	0.27	0.19	0.23
0.85-0.89		0.33	0.42	0.37	0.33	0.43	0.39	0.57	0.61	0.59	0.53	0.69	0.61
0.90-0.94		0.51	0.43	0.47	0.50	0.40	0.44	0.22	0.22	0.22	0.20	0.12	0.16
0.95-1.00		0.16	0.15	0.16	0.17	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Surgeon INPT Rate	*Actual*												
Unknown		0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.26	0.12	0.03	0.12	0.08
0.10-0.20		0.16	0.08	0.11	0.00	0.00	0.00	0.82	0.62	0.73	0.57	0.30	0.43
0.21-0.40		0.37	0.32	0.34	0.72	0.36	0.50	0.17	0.10	0.14	0.32	0.40	0.36
0.41-0.60		0.40	0.36	0.38	0.28	0.60	0.48	0.00	0.00	0.00	0.03	0.03	0.03
0.61-0.80		0.07	0.24	0.17	0.00	0.02	0.01	0.00	0.00	0.00	0.05	0.10	0.08
0.81-0.99		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.05	0.02
Age	*Actual*												
0-15		0.02	0.02	0.02	0.08	0.13	0.11	0.01	0.07	0.04	0.05	0.03	0.04
16-25		0.19	0.21	0.20	0.11	0.25	0.20	0.31	0.48	0.38	0.18	0.32	0.25
26-35		0.39	0.37	0.39	0.14	0.13	0.13	0.45	0.31	0.39	0.20	0.26	0.23
36-45		0.21	0.12	0.16	0.11	0.14	0.14	0.11	0.05	0.08	0.17	0.15	0.16
46-55		0.12	0.13	0.12	0.17	0.18	0.17	0.11	0.04	0.08	0.08	0.10	0.09
56-65		0.05	0.06	0.05	0.25	0.07	0.14	0.01	0.00	0.01	0.17	0.03	0.10
66-75		0.02	0.07	0.05	0.08	0.10	0.09	0.00	0.00	0.00	0.12	0.04	0.08
75+		0.00	0.02	0.01	0.06	0.00	0.02	0.00	0.05	0.02	0.03	0.07	0.05
Chronic Conditions	*Dummy*												
None	0	0.86	0.57	0.70	0.67	0.68	0.68	0.78	0.71	0.75	0.67	0.59	0.63

One or more	1	0.14	0.43	0.30	0.33	0.32	0.32	0.22	0.29	0.25	0.33	0.41	0.37
Surgery Problems	*Dummy*												
None	0	0.60	0.68	0.65	0.83	0.83	0.83	0.70	0.81	0.75	0.85	0.75	0.80
One or more	1	0.40	0.32	0.35	0.17	0.17	0.17	0.30	0.19	0.25	0.15	0.25	0.20
Time in Surgery	*Dummy*												
0–10 min.		0.77	0.53	0.64	0.22	0.02	0.09	0.78	0.48	0.65	0.13	0.01	0.07
11–30 min.		0.23	0.42	0.33	0.50	0.24	0.33	0.20	0.43	0.30	0.44	0.50	0.47
30+ min.	Intercept	0.00	0.05	0.03	0.28	0.74	0.58	0.02	0.09	0.05	0.43	0.49	0.46
Number of Procedures	*Dummy*												
One	0	1.00	0.89	0.94	0.89	0.68	0.76	0.99	0.72	0.87	0.97	0.67	0.82
Greater than one	1	0.00	0.11	0.06	0.11	0.32	0.24	0.01	0.28	0.13	0.03	0.33	0.18
Anesthesia	*Dummy*												
Local	Intercept	0.00	0.00	0.00	0.86	0.06	0.35	0.25	0.10	0.18	0.82	0.10	0.46
General		0.95	0.89	0.92	0.14	0.81	0.57	0.60	0.53	0.57	0.13	0.80	0.47
Other		0.05	0.11	0.08	0.00	0.13	0.08	0.15	0.37	0.25	0.05	0.10	0.07

incentives to choose one mode over another.

Patient characteristics available for the analysis were age and number of chronic conditions. The very young and the very old are more likely to need the added security and care available in a hospital. The frequency data indicate that age is directly associated with the DNA mode, except for D&Cs in 1967. For example, 81 percent of the DNA Skin Lesion excisions were performed on persons 26 years of age and older, compared with 62 percent for the INPT mode. The comparable figures for 1974 were 77 percent DNA and 65 percent INPT.

Because of the greater risk of complications, persons with one or more chronic conditions would be more likely to use the INPT mode. The 1967 frequencies indicate that a substantially greater proportion of INPT D&Cs than of DNA D&Cs had one or more chronic conditions (0.43 vs 0.14). The Skin Lesion cases, however, showed no differences on this factor.

Additional variables. We analyzed several additional characteristics of surgical cases: problems related to the surgery, time in surgery, use of multiple surgical procedures, and type of anesthesia.[3] Although these factors are unspecified before surgery, when the surgery mode is chosen, they become useful proxies for case difficulty. It should also be noted that, in a limited number of cases, the mode is switched from DNA to INPT during or after surgery.

With the exception of Skin Lesions in 1974, the frequency data do not associate surgical problems with the INPT mode. The DNA mode is associated with less time in surgery than is the INPT mode for both D&Cs and Skin Lesions in 1967 and 1974.

When more than one surgical procedure is carried out, the data show that the surgery mode is more likely to be INPT; this was expected since multiple procedures are associated with the more serious cases. We expected that general anesthesia and such methods as spinal, block, and regional anesthesia would be associated with the INPT mode, while local anesthesia would be associated with the DNA mode. The frequency data contradict this expectation for D&Cs while strongly supporting it for Skin Lesions.

If other case attributes jointly determine anesthesia and surgery mode, that is, if anesthesia is endogenous, a strong correlation between anesthesia and other case attributes is implied, a consequence that would distort the discriminant model described below. Another concern is that anesthesia type completely determines surgery mode. The available evidence, however, does not indicate problems along either of these lines. Anesthesia was not strongly correlated with other explanatory factors; in no case were the simple correlations greater than 0.4, and in most cases they were below 0.1. Surgeons report that anesthesia is but one factor out of the many weighed in the surgery mode decision [12].

Estimate Equations

We had two related objectives in developing the choice model for surgery mode. The first objective was to explain the surgery policy in the base year with regard to system, provider, and patient characteristics; we therefore estimated a full discriminant function with all important variables. The second objective was to obtain the best predictive model for classifying the cases; we therefore selected the discriminant function that classifies the largest number of cases correctly

with the fewest variables. We then used the final equations to estimate the number of INPT cases diverted to DNA in 1974 by the policy shift from INPT to DNA between the base year (1967) and 1974.

Tables 2 and 3, using 1967 data, present the full discriminant functions (model I) and the final discriminant functions (model II) for D&Cs and Skin Lesions, respectively. The correct classification rate and the Chi-square statistic indicate the overall ability of the equations to classify the cases correctly and to discriminate between the two groups on the basis of their attributes. The univariate *F*-ratios indicate the statistical significance of the differences between means for the DNA and INPT cases for particular variables; the standardized coefficients indicate the importance of each variable in discriminating between the two groups.

The results should be considered in light of certain limitations on the data.

Table 2:
Discriminant Function Estimates for D&Cs, 1967
(N = 96)

	Model I	
Variables*	**Unstandardized Coefficients (Univariate F-ratio)†**	**Standardized Coefficients**
Hospital Occupancy Rate	-0.045 (0.211)	-0.118
Surgeon INPT Rate	-0.023 (3.711)	-0.387
Age	0.009 (0.192)	0.130
Chronic Conditions	-1.495 (10.640)	-0.690
Surgery Problems	0.408 (0.569)	0.196
Time in Surgery (min)		
0-10	1.074 (6.111)	0.519
11-30	0.054 (3.620)	0.026
Number of Procedures	-1.962 (5.375)	-0.477
Anesthesia		
General	-1.138	-0.316
Other	(1.373)	
Constant	4.486	
Correct Classification Rate	0.719	
X^2	18.375	

*For the dependent variable, DNA = 1 and INPT = -1.
†The critical *F*-value at the 0.05 level of significance is 3.955.

Table 3:
Discriminant Function Estimates for Skin Lesions, 1967 (N = 97)

	Model I		Model II	
Variables*	**Unstandardized Coefficients (Univariate F-ratio)†**	**Standardized Coefficients**	**Unstandardized Coefficients**	**Standardized Coefficients**
Hospital Occupancy Rate	-0.006	-0.016		
	(0.410)			
Surgeon INPT Rate	-0.021	-0.260		
	(12.065)			
Age	0.010	0.188		
	(5.379)			
Chronic Conditions	-0.170	-0.080		
	(0.026)			
Surgery Problems	0.021	0.008		
	(0.010)			
Time in Surgery (min.)				
0-10	0.846	0.244		
	(13.130)			
11-30	0.937	0.444		
	(7.462)			
Number of Procedures	0.122	0.053		
	(5.499)			
Anesthesia				
General	-3.083	-1.536	-3.43	-1.71
	(71.287)			
Other	-3.660	-1.003	-3.81	-1.04
	(5.131)			
Constant	2.674		2.25	
Correct Classification Rate	0.909		0.909	
X^2	66.273			

*For the dependent variables, DNA = 1 and INPT = -1.
†The critical F-value at the 0.05 level of significance is 3.951.

The sample size (about 100 cases) for any given discriminant function is relatively small. In addition, data on some important patient characteristics—including the wage rate, family income, and care at home—were not available. Inclusion of these factors would probably diminish the importance of the clinical factors and improve the ability of the equations to classify cases correctly.

The D&C equation (Table 2) classified 71.9 percent of the cases correctly. The factors that were significant at the 0.05 level were chronic conditions, time in surgery, and number of procedures. The surgeon INPT rate was significant at the 0.1 level. All of these factors had the expected algebraic signs. The more serious or complicated cases, as indicated by these factors, tended to be INPT rather than DNA. Having a surgeon with a relatively high rate of INPT cases made the INPT mode more likely for a patient. Hospital occupancy rate, surgery problems, and type of anesthesia had no significant effects. We made several attempts to obtain a reduced equation that would predict as accurately as the full equation, but failed. We therefore used the full D&C equation for the cost analysis.

The proportion of misclassified cases provides information about the error inherent in the function. Table 4 presents cross-tabulations of the actual mode of surgery versus the mode of surgery predicted by the discriminant functions for D&Cs and Skin Lesions for 1967. Thirty percent of the actual INPT cases were predicted DNA, and approximately 26 percent of the actual DNA cases were predicted INPT. We discuss these errors in the next section.

The Skin Lesions equation (Table 3) classified 90.4 percent of the cases correctly. With the exception of hospital occupancy rate, chronic conditions, and surgery problems, the variables were significant at the 0.05 level. The significant factors had the expected signs, with the exception of number of procedures, where a positive sign indicated that cases with more procedures tend to be done DNA; the standardized coefficient of 0.053 for this factor, however, indicates its small effect in the classification equation.

This procedure differs from that for D&Cs in that age is significant whereas chronic conditions are not, and in the overwhelming importance of the type of anesthesia in discriminating between surgery modes. In contrast to the D&C equation, only 6 percent of the actual INPT cases were predicted DNA, and only 14 pecent of the actual DNA cases were predicted INPT.

Since anesthesia was such an important factor, we were able to reduce the Skin Lesion discriminant model to that single factor and still correctly classify the same percentage of cases. The simplified model (model II) is presented in Table 3; it was used for predictive purposes in the cost analysis.

Cost Analysis

We compare two methods of estimating the medical care cost effects of the policy change from INPT to DNA surgery: the discriminant method used for the choice model, and a proportions method. The former is preferable because it is conceptually superior, but it is also more difficult to implement. The latter might be recommended for its efficiency if the two methods yielded similar estimates. Both of these methods require estimates of the average length of stay, the cases shifted to DNA, the number of cases

Table 4:
Classification of 1967 Cases Based on 1967 Discriminant Functions

		Predicted		
		DNA	INPT	N
D&Cs				
Actual	DNA	32	11	43
	INPT	16	37	53
	N	48	48	96
Skin Lesions				
Actual	DNA	31	5	36
	INPT	4	59	63
	N	35	64	99

shifted, the cost per patient day, and other cost effects.

Length of stay. The simpler approach is to use the mean length of stay for all cases of the same surgery type in the current year (1974). This yields estimates of 2.24 days for D&Cs and 3.73 days for Skin Lesions. These estimates, however, are biased upwards to the extent that INPT cases are more severe or complicated than cases shifted to DNA. A more conservative version of this single-figure approach was used by Marks et al. [13]. Estimates of length of stay were made by the project surgeon from a sample chart review of each procedure. The surgeon estimated what the minimum length of stay would have been had the patients been admitted. The estimates—1.5 days for D&Cs and 2.0 days for Skin Lesions—were based on the assumption that patients were in good health status and that no complications were expected.

The preferred approach is to specify a length-of-stay equation for 1974 INPT patients as a function of their conditions and characteristics. The equation would predict the length of stay for each case shifted to DNA. We specified a length-of-stay equation that included the same system and patient variables that appeared in the full discriminant model. We then reduced the models to equations whose parameters are presented in Table 5. This yielded average length-of-stay estimates of 2.04 for D&Cs and 2.60 for Skin Lesions; these estimates fall between the extreme values given above.

Cases shifted to DNA. We used the 1967 discriminant functions (Tables 2 and 3) to classify persons in the 1974 group according to surgery mode. Persons who were classified as INPT, but actually received DNA surgery, constitute an estimate of the shift from INPT to DNA between the base year and 1974 (Table 6). The discriminant function permits identification of the misclassified cases; individuals' characteristics can be used in conjunction with the length-of-stay equation to estimate the length of stay for each case.

The simpler approach is to assume that if the 1967 surgery policy existed in 1974, the proportion of DNA and INPT cases would be the same. The estimate of the number of cases shifted

Table 5:
Final Length-of-Stay Estimates, 1974

Variables	D&Cs Coefficients (Standard Errors)	Skin Lesions Coefficients (Standard Errors)
Time in Surgery (min).		
0-10	-2.15	
	(0.71)	
11-30	-2.60	
	(0.72)	
Number of Procedures		1.68
		(0.73)
Anesthesia		
General		-5.00
		(1.16)
Other		-5.44
		(1.52)
Constant	4.40	7.72
	(0.65)	(1.17)
R^2	0.16	0.32

Table 6:
Classification of 1974 Cases Based on 1967 Discriminant Functions

		Predicted		
		DNA	INPT	N
D&Cs				
Actual	DNA	60	13	73
	INPT	26	32	58
	N	86	45	131
Skins Lesions				
Actual	DNA	49	11	60
	INPT	6	54	60
	N	55	65	120

from INPT to DNA would be based on the difference between the actual number of INPT cases in 1974 and the number predicted by applying the 1967 proportions to the total number of 1974 surgeries. The problem with this approach is that it fails to adjust for possible differences in case characteristics between current- and base-year cases.

Cost per patient day. We estimated the cost per day for inpatient care in 1977 dollars by adding the inpatient routine labor cost ($41.42) and the average inpatient routine nonlabor

cost ($69.60), which includes such indirect costs as depreciation and administrative overhead. The total cost per day ($111.02) excludes prescription drugs and medical supplies charged to the patient. Hospital costs are augmented by the cost of daily physician visits, which are required for inpatients; our estimate of this cost was based on the assumption that the first physician visit would be relatively long and would be valued at 3.0 California Relative Value Studies (CRVS) units. We assigned each subsequent visit 1.33 units, assuming that two thirds of all subsequent visits are routine (1.0 unit) and one third are nonroutine (2.0 units). We applied a $12 conversion factor, obtained from the 1977 Kaiser Permanente fee schedule, to the CRVS units to estimate the dollar value of the visits.

Other cost effects. Analysis of a chart review and interviews with physicians indicated that preoperative and operative phases are not significantly or systematically affected by surgical mode [13]. However, DNA patients who have had general anesthesia generally require a longer time in the recovery room. Inpatients are taken back to their hospital rooms before they are ambulatory, but DNA patients must remain in the recovery room until they are ambulatory. We based our estimates of extra costs for DNA cases on a recovery room cost per minute of $0.438 and the difference in average recovery time between DNA and INPT cases. This factor was relatively low for Skin Lesions because a large proportion of those cases are handled with local anesthesia and do not require time in the recovery room.

Table 7 presents estimates of cost savings for D&Cs and Skin Lesions using the two methods. The estimates of cases shifted to DNA and of hospital days saved were converted to dollars by applying the per diem and physician visit cost data. These savings were then reduced by estimating the cost of the extra recovery room time required by DNA patients.

The D&C results indicate a close correspondence between the two methods for estimates of INPT cases averted by the shift in policy and for estimates of the average length of stay. The total savings estimated by the two methods differed by 19 percent ($3,252 under the discriminant method versus $3,858 under the proportions method).

In contrast, the total savings estimated for Skin Lesions differed by over 100 percent ($3,765 versus $7,779). This was due to a much lower estimate of average length of stay (2.60), using the length-of-stay equation, than of overall average length of stay (3.73). In addition, the estimated number of cases diverted to DNA after the policy change was 11 using the discriminant function and 16 using the simple proportions without adjustment for case characteristics.

Although the discriminant method is conceptually more appealing because case characteristics are used to adjust the estimates, it is not without problems. Since 1967 discriminant functions fail to classify all cases correctly, they are not perfect descriptions of the base-year decision process. Thus, when the classification equations are applied to 1974 data, we can expect some errors in the classifications [14]. We are concerned with the actual DNA cases in the current year that would have been INPT in the base year. Errors occur when one of the cases is misclassified. With the discriminant method, errors in which INPT is misclassified as DNA result in an underestimate of the cost savings.

Table 7:
Estimated Medical Care Cost Savings from DNA Surgery:
A Comparison of Two Methods
(1977 Prices)

Method	Estimated Average Length of Stay (days)	Per Diem Costs	Physician Visit Costs	Total Routine Inpatient Costs	Less Added Recovery Room Costs	Total Saved per DNA Case	INPT Surgeries Averted	Total Savings
D&Cs								
Discrimnant Function and Length-of-Stay Equation	2.04	$226.48	$52.56	$279.04	$28.91	$250.13	13	$3252
Proportions and Mean Length of Stay	2.24	248.68	55.80	304.48	28.91	275.57	14	3858
Skin Lesions								
Discriminant Function and Length-of-Stay Equation	2.60	288.65	61.56	350.21	7.45	342.26	11	3765
Proportions and Mean Length of Stay	3.73	414.10	79.56	493.66	7.45	486.21	16	7779

Conversely, errors in which DNA is misclassified as INPT result in an overestimate of the cost savings. Qualitatively, the errors are in opposite directions; to the extent that they offset each other, the discriminant method provides an unbiased estimate of the shift to DNA.

Similarly, the length-of-stay equations are not perfect predictors of length of stay, as evidenced by the adjusted R^2s (Table 5). They do, however, indicate that some case characteristics are significantly associated with length of stay, and the estimated average length of stay generated by the equations can be adjusted for these characteristics.

Another way to examine the impact of the policy change between the base year and the current year is to compare the full discriminant choice models for the two time periods: a change in the choice parameters should reflect the change in policy. Specifically, if DNA surgery was generally encouraged by the surgery department, we should expect to find that the coefficient values of the determinants of surgery choice are lower in subsequent years than in the base year.

Although we have no statistical test of the difference in coefficients, several of the 1974 coefficient estimates presented in Tables 8 and 9 are lower than the 1967 estimates for the same variable presented in Tables 2 and 3. For Skin Lesions, age, time in surgery, and use of general anesthesia are less strongly correlated with the choice of surgery mode in 1974 than in 1967. The reverse is true for number of procedures. The coefficient comparisons are more ambiguous for the D&C cases. Surgeon INPT rate, number of chronic conditions, and time in surgery are all less important in 1974 than in 1967, as expected, but number of procedures and "other" anesthesia are slightly more important in 1974 than in 1967. Interestingly, the discriminant function correctly classified cases to about the same degree when applied to either the 1967 or the 1974 data.

Summary and Conclusions

One of the purposes of the choice model is to predict the number of surgical cases shifted from INPT to DNA given a change in policy between a base year and any subsequent year. The choice model permits adjustment for changes in case attributes; in order for this to be an improvement over a simple extrapolation of the proportion of DNA cases in the base year to the subsequent year, case attributes have to be significantly associated with choice of surgery mode, and the distribution of attributes has to change so that their effects are not cancelled.

In analyzing data from the Kaiser Permanente Program, we found several case attributes to be significantly associated with the choice of surgery mode. For D&Cs, significant attributes associated with INPT surgery included surgeon INPT rate, chronic conditions, time in surgery, and number of procedures. For Skin Lesions, surgeon INPT rate, age, time in surgery, number of procedures, and anesthesia were all significant attributes.

The total distributions of case attributes for 1967 (base year) and 1974, presented in Table 1, indicate that the changes tended to offset each other in the D&C group; for Skin Lesions they tended to cause a higher prediction for the DNA mode, leading to a lower estimate of the number of cases shifted from INPT to DNA than that obtained from a simple extrapolation. Estimates for D&C cases shifted from INPT to DNA were similar for the discriminant and proportions methods; estimates for Skin Lesion cases were lower with

Table 8:
Discriminant Function Estimates for Skin Lesions, 1974
(N = 120)

	Model I	
Variables*	**Unstandardized Coefficients (Univariate F-ratio)†**	**Standardized Coefficients**
Hospital Occupancy Rate	0.032	0.099
	(0.341)	
Surgeon INPT Rate	-0.010	-0.199
	(14.20)	
Age	0.004	0.080
	(2.51)	
Chronic Conditions	-0.198	-0.096
	(0.567)	
Surgery Problems	-0.243	-0.098
	(1.87)	
Time in Surgery (min.)		
0-10	0.512	0.128
	(9.08)	
11-30	-0.336	-0.168
	(0.827)	
Number of Procedures	-1.20	-0.465
	(20.87)	
Anesthesia		
General	-2.69	-1.35
	(95.16)	
Other	-1.79	-0.474
	(1.07)	
Constant	-0.765	
Correct Classification Rate	87.5%	

*For the dependent variable, DNA = 1 and INPT = -1.
†The critical *F*-value at the 0.05 level of significance is 3.934.

the discriminant method than with the proportions method.

We estimated medical care cost savings by applying cost per patient day and physician visit charge data to days saved, the latter determined by averaging 1974 inpatient days and using an equation for length of stay. The savings estimate was reduced by an estimate for the extra recovery room cost for DNA patients.

Depending on the surgical procedure, the simple proportions and mean-length-of-stay approach to cost savings estimation may seriously overstate the economic advantages of DNA surgery. The discriminant and proportions methods produced similar cost savings estimates for D&Cs, but for Skin Lesions, the discriminant-method estimate was only half that of the proportions method.

Table 9:
Discriminant Function Estimates for D&Cs, 1974
(N = 131)

	Model I	
Variables*	**Unstandardized Coefficients (Univariate F-ratio)†**	**Standardized Coefficients**
Hospital Occupancy Rate	-0.036 (1.04)	-0.126
Surgeon INPT Rate	-0.027 (3.73)	-0.276
Age	0.022 (2.28)	0.279
Chronic Conditions	-0.983 (0.929)	-0.428
Surgery Problems	0.312 (2.14)	0.136
Time in Surgery (min.)		
0-10	0.757 (13.73)	0.363
10-30	-0.371 (8.11)	-0.171
Number of Procedures	-1.75 (22.79)	-0.590
Anesthesia		
General	-0.587 (0.609)	-0.292
Other	-1.20 (8.19)	-0.519
Constant	3.52	
Correct Classification Rate	74.8%	

*For the dependent variable, DNA = 1 and INPT = -1.
†The critical F-value at the 0.05 level of significance is 3.918.

Both methods provide some support for the DNA mode on economic grounds, for D&Cs and Skin Lesions.

More work is required to understand the full medical-economic implications of large-scale shifts from INPT to DNA surgery. Once the circumstances under which certain procedures should be performed in the DNA mode are identified, our understanding of the choice mechanism will have to be improved so that policies that encourage appropriate use of DNA surgery can be adopted. Future studies should examine patient economic characteristics such as income, wage rate, and payment system (i.e., prepayment or fee-for-service). If fee-for-service is used, the effect of third party insurance on the choice between DNA and INPT should be determined. Our re-

sults indicate that the characteristics of patients and the preferences of providers should be controlled when examining policy variables. Finally, a full economic evaluation requires that we determine the social cost implications of a shift to DNA surgery, including time lost from work and the recovery cost imposed on the household.

END NOTES

[1]D&Cs are performed for diagnosis and treatment of various uterine conditions, including termination of pregnancy and diagnosis of atypical vaginal bleeding. The cervix of the uterus is gradually dilated to enable insertion of a curette, a small, loop-shaped blade on a long handle. The curette is then used to scrape away the lining of the uterus. (In our analysis we excluded D&Cs performed during normal deliveries. Such D&Cs are not the primary reason for hospitalization and do not increase the length of stay.)

[2]Excisions of skin lesions (referred to in the text as Skin Lesions) are most commonly performed on cysts, tumors, moles, and other benign growths, all of which require similar surgical treatment. Treatments of traumatic conditions—chiefly the debridement of wounds, fractures, and burns—are also included in this category.

[3]Medical records were examined to determine whether there were problems related to the surgery or the condition of the patient during the year following surgery. For Skin Lesions, this included problems such as wound abscess, abscesses of pilonieal cysts, and ulcerated wounds. Problems were indicated with the D&C cases when the procedure failed to correct the condition for which the surgery was performed. These patients often returned for more surgery. Excess bleeding was another problem associated with some D&C cases.

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