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COMPARING CLINICAL INFORMATION WITH CLAIMS DATA: SOME SIMILARITIES AND DIFFERENCES

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Abstract—How well can hospital discharge abstracts be used to estimate patient health status? This paper compares information on comorbidity obtained from hospital discharge abstracts for patients undergoing prostatectomy or cholecystectomy at a Winnipeg teaching hospital with clinical data on preoperative medical conditions prospectively collected during an Anesthesia Follow-up study. The diagnostic information on cardiovascular disease, respiratory disease, and metabolic disorders showed considerable agreement, ranging from 65 to over 90% correspondence across the two data sets. Certain conditions noted by the anesthesiologist were often absent from the claims data; cardiovascular disease was recorded in the clinical data but absent from the claims for 31% of prostatectomy and 17% of cholecystectomy cases. Such patients were less likely to have been assigned a high score on the ASA Physical Status measure or to have high-risk diagnoses on the hospital file. Similar findings resulted from comparing the two sources in their ability to predict such adverse outcomes as mortality and readmission to hospital: the anesthesia file generally included less serious comorbidity.

Administrative data Clinical data Morbidity Adverse outcomes Anesthesia

INTRODUCTION

The use of population-based information for health services research is increasing as suitable administrative (claims) data become available and the costs of information processing drop [1]. The potential benefits of such data include: availability of population-based information in many jurisdictions; large numbers of cases; long-term follow-up; relatively low cost compared with primary data collection; and the possibility of record linkage to further increase the information available [2]. The large numbers of claims filed by physicians and hospitals for reimbursement and accounting purposes have advanced research on patient utilization of health services, small area variations in health service use, patient outcomes, and the occurrence and appropriateness of various treatment approaches for certain health problems [3–5]. Heavily influenced by health services research, an epidemiology of medical care is being developed using such data bases.

Clinical epidemiologists look at the world somewhat differently than do health services researchers. According to Feinstein and Spitzer [5a], the methods of clinical epidemiology involve a "combination of challenges in clinical

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sophistication about patients and observations, in epidemiologic strategies for studying groups of people, and in biostatistical procedures for analyzing the quantitative results". The danger of losing touch with the individual patient is sometimes noted [6].

A clinical epidemiologist typically collects information for a particular research project tailored to his special interests. To the degree that information is obtained by seeking out the patient, contact bias—bias due to relying on histories generated from patient-initiated contact with the health care system—can be minimized. On the other hand, clinical data have their own problems; physicians vary on the extent of agreement as to patient diagnosis, the completeness of patient history taken, and so forth [7–9].

Despite many common concerns, clinical epidemiologists and health services researchers are likely to disagree on the adequacy of hospital discharge abstracts for assessing patient health status. Two major issues which need to be discussed are:

1. What information on comorbidity is lost when hospital discharge abstracts, rather than clinical data, are used? What are the general characteristics of the different types of data collection?
2. What is the power of the two sorts of information in predicting poor outcomes?

This paper compares the degree of agreement and the predictive power of two Manitoba data sets, one derived retrospectively from hospital discharge abstracts (claims) and one from prospective clinical examations. Information on two common surgical procedures (prostatectomy and cholecystectomy) is analyzed.

METHODS

Claims data

In Manitoba, all medical and hospital care (with a few minor exceptions such as private room, cosmetic surgery, and some out-of-province care) is without user fees or usage limitations. A complete history of hospitalizations and surgery can be reconstructed for each individual registered in the province. Because out-of-province medical care is reimbursable by the Manitoba Health Services Commission and physicians operate under a fee-for-service system, both physician and patient have an incentive to document utilization. Physician and hospital claims show a high degree of agreement as to the procedure performed [10].

We have adapted for use with claims data the Charlson Comorbidity Index, which was developed and validated to predict short- and long-term mortality in chart-based analyses [11]. Using diagnoses recorded in hospital discharge abstracts, this index has been found to be a good predictor of the risk of mortality in surgical patients [4, 12]. In this (and other studies using claims) the index is constructed by a computer program; such a program is "blind" to the results of any other work with the data. The diagnoses used in the Comorbidity Index included: malignant neoplasms; myocardial infarction; congestive heart failure; peripheral vascular disease; cerebrovascular disease; connective tissue disease; chronic pulmonary disease; diabetes; dementia; hemiplegia; mild, moderate or severe liver disease; renal failure; ulcers.

The validity and reliability of the Manitoba claims data have been investigated extensively [13]. In a few cases (1.5–2.0%), various types of identifier problems make it difficult to retrace individuals through time. Overall, however, longitudinal follow-up is very good, comparing favorably with studies based on primary data collection [2].

Clinical data

A clinical data base has resulted from an Anesthesia Follow-up study carried out at a large tertiary teaching hospital in Winnipeg [14]. For each anesthetic administered to adult patients (obstetrics excluded), the attending anesthesiologist completed a form which included a qualitative description of preoperative medical conditions and drug usage occurring within 1 year prior to the surgery, variables relating to anesthetic technique, drugs and monitors, and the widely-used American Society of Anesthesiologists' (ASA) Physical Status score. The Physical Status score is based on both chart review and patient examination; this preoperative measure played a central role in both the Halothane Study and the Stanford Institutional Differences Study [15, 16]. Preexisting conditions were categorized as follows: respiratory diseases; history of myocardial infarction; other cardiovascular diseases; obesity; metabolic diseases; renal diseases; and other conditions. These conditions are important for preoperative assessment by the anesthesiologist. All data were checked by a specially trained nurse [the same individual throughout the study period (1979–1984)] and reviewed by the attending anesthesiologist before processing.

Analytical strategy

Several measures were used to compare the predictive power of claims data with that of the clinical data:

1. The presence of high-risk diagnoses as specified by the Comorbidity Index and generated from the hospital claims.
2. The Physical Status score from the Anesthesia Follow-up study.
3. Readmissions to a hospital for any reason within a specified time period.
4. Postsurgical mortality rates (deaths within specified time periods, whether they occurred in or out of a hospital).

The major groups of patients excluded from all analyses were those with associated malignancies (i.e. prostate or bladder malignancy in the case of prostatectomy and malignancies of the gallbladder or pancreas in the case of cholecystectomy). Direct transfers from the hospital where surgery took place to another hospital were not counted as readmissions. Deaths were identified from the registry files of the Manitoba Health Services Commission (MHSC). These files have been extensively checked against mortality data from the Office of Vital Statistics, and the overall accuracy of the MHSC data is quite high [17].

RESULTS

Correspondence of diagnostic information

The diagnostic information on the two data sets showed considerable, but not perfect, correspondence. If there were perfect correspondence, the comorbid conditions noted in Table 1 would appear on *both* the anesthesia and hospital event files or on *neither*. Most, but not all, of the patients specified as having particular medical problems in the hospital discharge abstracts also had these conditions indicated by the anesthesiologist. The computerized discharge abstracts for the index hospitalization missed certain types of comorbidity noted by the anesthesiologist. For example, concomitant cardiovascular disease was recorded in the clinical data but absent from the claims in 30.9% of the prostatectomies (P) and 17.4% of the cholecystectomies (C). If claims from hospitalizations during the 6 months prior to the index surgical procedure are combined with those from the index hospitalization ("event" data); the above percentages become 27% (P) and 16% (C). Whereas a preexisting condition was more likely to be recorded by the anesthesiologist than to appear on the hospital discharge abstract, the abstract only identified a small percentage of cases missed by the anesthesiologist. Among prostatectomy patients, between 3 and 4% of each specific category of comorbidity was noted on the hospital abstract but not on the anesthesia file; similarly, these figures for cholecystectomy patients varied between 2 and 6%.

Taking the anesthesia data as the "gold standard" permits presenting the data in terms of four-fold tables familiar to clinical epidemiologists. The absence of cardiovascular disease on many discharge abstracts from the hospitalization for prostatectomy translates into a fairly low sensitivity (0.43) (Table 2). Claims from the 6 months before surgery show much less cardiovascular comorbidity (sensitivity = 0.20) but high specificity (0.95). Constructing longer

Table 1. Recording of comorbidity in anesthesia and hospital files

	Cardiovascular disease (%)	Respiratory disease (%)	Metabolic disorders (%)	Any coexisting conditions (%)
Prostatectomy (n = 677)				
Anesthesia file only	30.9	17.6	6.1	12.9
Anesthesia and hospital event files	23.3	8.4	4.7	71.0
Hospital event file only	3.8	3.6	2.8	10.5
Neither file	42.0	70.5	86.4	5.6
Cholecystectomy (n = 712)				
Anesthesia file only	17.4	12.2	6.5	18.7
Anesthesia and hospital event files	14.3	7.4	3.4	49.9
Hospital event file only	3.8	6.0	2.0	12.0
Neither file	64.5	74.3	88.2	19.4

Data for prostatectomies and cholecystectomies at one Manitoba hospital, 1979–1984.

Table 2. Cardiovascular disease among prostatectomy patients—hospital claims vs clinical judgment

		Cardiovascular disease (as judged by anesthesiologist)			
		Present	Absent	Sensitivity	Specificity
Cardiovascular disease on hospital claims:					
(a) From hospitalization for surgical event	Present	158	26		
	Absent	209	284	0.43	0.92
(b) From 6 months before surgery	Present	73	14		
	Absent	294	296	0.20	0.95
(c) From either (a) and/or (b)	Present	186	38		
	Absent	181	272	0.51	0.88

Data for prostatectomies at one Manitoba hospital, 1979–1984. Positive predictive value ranged from 0.83 to 0.86. Negative predictive value ranged from 0.50 to 0.60.

histories or using ambulatory visit claims would undoubtedly pick up somewhat more comorbidity. Combining both the event (prostatectomy) and prior history information from hospital claims increases sensitivity vis-à-vis cardiovascular disease (from 0.43 to 0.51). The estimates of specificity drop only slightly (from 0.92 to 0.88), indicating the accuracy of claims in confirming the absence of cardiovascular disease. Table 3 notes similar trends for respiratory conditions. Sensitivity increases from 0.32 to 0.37 with the addition of prior history data, while specificity decreases only slightly (from 0.95 to 0.93).

Severity and comorbidity

The anesthesia file records a greater proportion of patients with coexisting medical conditions than does the hospital discharge file. To determine if the hospital claims highlighted only "serious" comorbidity (compared to perhaps "any" comorbidity by the anesthesiologists), we looked at the relationship between these judgments and other measures of severity and comorbidity. If a specific comorbid condition is seen as "serious", then the anesthesiologist should assign that patient a high Physical Status score ($\geqslant 3$). Similarly, sicker patients should be more likely to have a diagnosis categorized as high-risk by Charlson *et al.* [11].

Table 4 shows that over 50% of prostatectomy patients with cardiovascular, respiratory, or metabolic disease were considered seriously ill by the anesthesiologist (i.e. given a Physical Status score of $\geqslant 3$). However, a lower proportion of these cases had a high-risk Charlson diagnosis (24, 34 and 47% respectively). Moreover, cases with a comorbid condition on the hospital file were more likely to have a high Physical Status score and *much* more likely

Table 3. Respiratory disease among prostatectomy patients—hospital claims vs clinical judgment

		Respiratory disease (as judged by anesthesiologist)			
		Present	Absent	Sensitivity	Specificity
Respiratory disease on hospital claims:					
(a) From hospitalization for surgical event	Present	57	24		
	Absent	119	477	0.32	0.95
(b) From 6 months before surgery	Present	25	12		
	Absent	151	489	0.14	0.98
(c) From either (a) and/or (b)	Present	65	34		
	Absent	111	467	0.37	0.93

Data for prostatectomies at one Manitoba hospital, 1979–1984. Positive predictive value ranged from 0.66 to 0.70. Negative predictive value ranged from 0.76 to 0.81.

Table 4. Variation in comorbidity and Physical Status score by data sources

Data sources used (*n* with specified condition)	Percentage of cases having: One or more high-risk diagnoses*	Physical Status score of ⩾3
Cardiovascular disease present in:		
Anesthesia file ($n = 367$)	24	53
Hospital event file ($n = 184$)	42	55
Prior hospital claims ($n = 87$)	34	67
Respiratory disease present in:		
Anesthesia file ($n = 176$)	34	57
Hospital event file ($n = 81$)	72	68
Prior hospital claims ($n = 37$)	46	76
Metabolic disorders present in:		
Anesthesia file ($n = 73$)	47	52
Hospital event file ($n = 51$)	63	55
Prior hospital claims ($n = 20$)	50	60
Any comorbid condition present in:		
Anesthesia file ($n = 568$)	25	43
Hospital event file ($n = 552$)	28	41
Prior hospital claims ($n = 211$)	27	50
All prostatectomy cases ($n = 677$)	22	36

*The Charlson Comorbidity Index is based on the first four diagnoses recorded on the hospital claims from the surgical ("event") hospitalization.
Prior hospital claims were from hospital admissions in the 6 months before the admission for surgery.

to have a high-risk diagnosis. (Some, but not all, of the cardiovascular diseases would be considered "high-risk".) Having a metabolic disorder was associated with a high score on both the ASA Physical Status and Charlson measures.

To more closely consider the possibility that the anesthesia file was recording less serious comorbidity, we checked those cases identified *only* on the anesthesia file and those noted *only* on a hospital file (either from the surgical event or in the prior 6 months) (Table 5). The cardiovascular and respiratory cases from the anesthesia file were less likely to be given a high score on the ASA Physical Status measure or to have a high-risk diagnosis than were cases identified from *both* the anesthesia file and a hospital file. The small numbers of cases noted on the hospital files alone gave inconsistent results.

Predicting poor outcomes

The anesthesia and hospital files were compared in their ability to predict two adverse outcomes: readmission to hospital within 90 days and death within 1 year. In predicting readmission to hospital, the anesthesia file and hospital file had about the same predictive power (Table 6). For example, 17% of the patients with any comorbidity and 17% of the patients from the anesthesia file were readmitted. However, having had a 6-month history of these comorbid conditions was much more likely to predict readmission.

Both the hospital event and 6-months prior files were more helpful in predicting mortality within 1 year than was the anesthesia file (Table 7). This provides additional support for our hypothesis that the anesthesia file is identifying less serious comorbidity. Although not presented in Tables 6 or 7, combining information from the anesthesia file and one or more hospital files generally showed little improvement in predictive power. In the combined file, the larger amount of comorbidity noted in the anesthesia data tended to greatly outweigh the contribution of that in the hospital claims.

DISCUSSION

This study found a small number of cases identified with a comorbid condition on the hospital file but not the clinical file. Such differences can have several origins. First of all, a given preexisting condition may not have been noticed by the anesthesiologist (or mentioned by the patient). Secondly, the anesthesiologist may disagree with the attending physician as to diagnosis. Moreover, the hospital discharge abstract will pick up a few postoperative problems, which could not have been noted preoperatively

Table 5. Using several data sources together: comorbidity and Physical Status score

Data sources used (n with specified condition)	Percentage of cases having: One or more high-risk diagnoses*	Physical Status score of ≥3
Cardiovascular disease present in:		
Anesthesia file only ($n = 209$)	11	47
Anesthesia + hospital event files ($n = 158$)	41	61
Hospital event file only ($n = 26$)	50	19
Anesthesia file only ($n = 294$)	21	48
Anesthesia file + prior hospital claims ($n = 73$)	37	73
Prior hospital claims only ($n = 14$)	21	36
Respiratory disease present in:		
Anesthesia file only ($n = 119$)	14	46
Anesthesia + hospital event files ($n = 57$)	74	79
Hospital event file only ($n = 24$)	67	42
Anesthesia file only ($n = 151$)	30	51
Anesthesia file + prior hospital claims ($n = 25$)	56	92
Prior hospital claims only ($n = 12$)	25	42
Metabolic disorders present in:		
Anesthesia file only ($n = 41$)	29	59
Anesthesia + hospital event files ($n = 32$)	69	44
Hospital event file only ($n = 19$)	53	74
Anesthesia file only ($n = 63$)	46	49
Anesthesia file + prior hospital claims ($n = 10$)	50	70
Prior hospital claims only ($n = 10$)	50	50
All prostatectomy cases ($n = 677$)		

Prior hospital claims were from hospital admissions in the 6 months before the admission for surgery.

by the anesthesiologist. However, the Anesthesia Follow-up study has shown new postoperative morbidity to be very low compared with preoperative comorbidity. In the overall research on 112,000 anesthetics [14], 4% of the patients reported a myocardial infarction in their past; however, <0.04% of the patients had a myocardial infarction within the first 2 days of their postsurgical hospitalization.

On the other hand, in a large number of cases the anesthesiologist rated a comorbid condition but the hospital claim did not. What might account for these differences? The anesthesia file is a clinical data file compiled by one group of specialists. Anesthesiologists are essentially concerned with only the next few hours of a patient's life, with getting a patient through the operation. Therefore, they will focus on the cardiovascular, respiratory, and metabolic systems. Such severe health problems as metastatic cancer are of less relevance to the anesthesiologist since they do not affect the administration of the anesthetic.

If more detailed diagnostic data were available from the Anesthesia Follow-up study, analyses based on finer levels of discrimination might be useful. A revised version of the anesthesia data collection instrument includes such more detailed information; additional comparisons will be possible in the future. Certain

Table 6. Readmission rates within 90 days of prostatectomy by data source for patients with specific comorbidities

	Percentage readmitted by where condition was recorded					
	Anesthesia file		Hospital event file		Prior hospital claims	
Comorbidity	%	(n)	%	(n)	%	(n)
Cardiovascular disease	16.9	(367)	18.5	(184)	29.9†	(87)
Respiratory disease	17.6	(176)	23.5	(81)	48.7†	(37)
Metabolic disorders	9.6	(73)	5.9*	(51)	15.0	(20)
Any coexisting condition	17.4	(568)	17.0	(552)	24.6†	(211)

The overall readmission rate within 90 days after surgery was 16.4% ($n = 111$ of 677 cases). All ns refer to the number of patients with the specified condition recorded in a particular data file. Readmission rates were compared with the overall probability of readmission using a χ^2 test for the comparison of independent proportions; significant differences are indicated by $^*p < 0.05$ or $^\dagger p < 0.01$.

Table 7. Mortality rates within 1 year of prostatectomy by data source for patients with specific comorbidities

	Percentage mortality by where condition was recorded					
	Anesthesia file		Hospital event file		Prior hospital claims	
Comorbidity	%	(*n*)	%	(*n*)	%	(*n*)
Cardiovascular disease	10.9	(367)	16.3†	(184)	19.5†	(87)
Respiratory disease	15.9†	(176)	27.2†	(81)	27.0†	(37)
Metabolic disorders	20.6†	(73)	17.7*	(51)	35.0†	(20)
Any coexisting condition	9.7	(568)	9.8	(552)	13.7*	(211)

The overall mortality rate within 1 year after surgery was 8.4% (n = 57 of 677 cases). All ns refer to the number of patients with the specified condition recorded in a particular data file. Individual rates were compared with the overall mortality rate using a χ^2 test for the comparison of independent proportions; significant differences are indicated by $^*p < 0.05$ or $^\dagger p < 0.01$.

comorbidities may be particularly likely to be missed using claims data; the importance of such omissions will, no doubt, vary with the purpose of the research.

Besides identifying patients with less comorbidity and less severe illness, what other advantages might primary data collection have? Variables relating to subjective outcome (perceived health status) and symptom relief are not available from claims, yet are important for the assessment of health care technologies [18]. On the other hand, risk adjustment using claims appears to work quite well; primary data collection may be unnecessary for such adjustment, both in studies comparing hospitals and in those comparing alternative treatments [19, 20].

Primary data collection does avoid the contact biases associated with claims. The variation in small area hospitalization rates for most conditions means that risk adjustment based on preoperative histories and outcome measurement based on postsurgical hospitalizations will be slightly biased. The more likely is hospitalization (for factors other than just patient health status), the more likely that some diagnoses will be recorded. However, analyses of the predictors of mortality and hospitalization have shown certain characteristics of small areas (such as bed supply and physician propensity to hospitalize) to be statistically significant, but relatively unimportant, compared with various measures of patient morbidity [19].

The linkages between population-based health services research and clinical epidemiology are reinforced by our work. Not only do decisions have to be made as to choice of methodology, but a growing number of studies are combining clinical and claims data [21, 22]. Understanding the structure of the claims data is important to assure the acceptance of population-based research; the costs are such as to render it very expensive to study entire populations using clinical data. Our findings also emphasize the importance of insurers' collecting and organizing data such that individual histories (dependent on a unique personal identifier) can be generated for research purposes. Knowledge of the morbidity associated with a patient's prior hospitalizations is clearly important.

These findings point in several directions. The relative strength of the claims data in predicting postoperative outcomes (particularly when the previous 6-month history is included) suggests its relevance for health services research. That the comorbidity data based on previous claims histories are more specific than at least one type of clinical data is particularly interesting. As various data bases become more widely used, testing the generalizability of these Manitoba findings should be on the research agenda. As insurers and regulators become more concerned with evaluating the outcomes of medical care, such research will assume increasing importance.

Longer-term, the research also points toward clinical applications. With proper precautions vis-à-vis confidentiality, this information from claims might be incorporated into a computerized history available for clinicians. "Smart cards" carried by individual patients might provide an easy way to access patient histories. Building such a data base would allow health care professionals to access information from visits to other hospitals, which is currently difficult to obtain. Canadian provincial insurance systems and American Medicare data, both of which organize information on a population base, would be particularly well-suited for such pilot work.

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REFERENCES

1. Roos LL, Roos NP, Sharp SM. Monitoring adverse outcomes of surgery using administration data. **Health Care Fin Rev** 1987; 7 (Suppl.): 5–16.
2. Roos LL, Nicol JP, Cageorge SM. Using administrative data for longitudinal research: comparisons with primary data collection. **J Chron Dis** 1987; 40: 41–49.
3. Wennberg JE, Roos NP, Sola L, Schori A, Jaffe R. Use of claims data systems to evaluate health care outcomes: mortality and reoperation following prostatectomy. **JAMA** 1987; 257: 933–936.
4. Roos NP, Wennberg JE, Malenka DJ *et al.* Mortality and reoperation after open and transurethral resection of the prostate for benign prostatic hyperplais. **N Engl J Med** 1989; 320: 1120–1124.
5. Roper WL, Winkenwerder W, Hackbarth GM, Krakauer H. Effectiveness in health health care: an initiative to evaluate and improve medical practice. **N Engl J Med** 1988; 319: 1197–1202.

5a. Feinstein AR, Spitzer WO. Happy anniversary: an impending change of name. **V Chron Dis** 1987; 40: 1–2.

6. Sackett DL. Basic research, clinical research, clinical epidemiology, and general internal medicine. **J Gen Intern Med** 1987; 2: 40–47.
7. Koran LM. The reliability of clinical methods, data and judgements (Part 1). **N Engl J Med** 1975; 293: 642–646.
8. Koran LM. The reliability of clinical methods, data and judgements (Part 2). **N Engl J Med** 1975; 293: 695–701.
9. Walter SD, Clarke EA, Stitt LW. A comparison of physician and patient reports of pap smear histories. **J Clin Epidemiol** 1988; 41: 401–410.
10. Roos LL, Sharp SM, Wajda A. Assessing data quality: a computerized approach. **Soc Sci Med** 1989; 28: 175–182.
11. Charlson ME, Pompei P, Ales KL, McKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. **J Chron Dis** 1987; 40: 373–383.
12. Roos LL, Sharp SM, Cohen MM, Wajda A. Risk adjustment in claims-based research: the search for efficient approaches. **J Clin Epidemiol** 1989; 42: 1193–1206.
13. Roos LL, Roos NP, Cageorge SM, Nicol JP. How good are the data? Reliability of one health care data bank. **Med Care** 1982; 20: 266–276.
14. Cohen MM, Duncan PG, Pope WDB, Wolkenstein C. A survey of 112,000 anesthetics at one teaching hospital (1975–83). **Can Anaesth Soc J** 1986; 33: 22–31.
15. Bunker JP, Forrest WH Jr, Mosteller F, Vandam LD, Eds. **The National Halothane Study**. Bethesda, Md: National Institute of General Medical Sciences; 1969.
16. Flood AB, Scott WR. **Hospital Structure and Performance**. Baltimore, Md: Johns Hopkins University Press; 1987.
17. Wajda A, Roos LL. Simplifying record linkage: software and strategy. **Comput Biol Med** 1987; 17: 239–248.
18. Wennberg JE, Mulley AG, Hanley D, Timothy RP, Fowler FJ, Roos NP, Barry MJ, McPherson K, Greenberg ER, Soule D, Bubolz T, Fisher E, Malenka D. An assessment of prostatectomy for benign urinary tract obstruction: geographic variations and the evaluation of medical care outcomes. **JAMA** 1988; 259: 3027–3030.
19. Roos NP, Roos LL, Mossey JM, Havens BJ. Using administrative data to predict important health outcomes: entry to hospital, nursing home, and death. **Med Care** 1988; 26: 221–239.
20. MacLean L, Richman A, Garner B. Adaptive decisions in the use of hospital beds. **Health Serv Res** 1987; 21: 741–754.
21. Abrams HB, Detsky AS, Roos LL, Wajda A. Is there a role for surgery in the acute management of infective endocarditis? A decision analysis and medical claims database approach. **Med Decis Making** 1988; 8: 165–174.
22. Barry MJ, Mulley AG, Fowler FJ, Wennberg JE. Watchful waiting vs. immediate transurethral resection for symptomatic prostatism: the importance of patients' preferences. **JAMA** 1988; 259: 3010–3017.