Using Computers to Identify Complications After Surgery

LESLIE L. ROOS, JR., PHD, SANDRA M. CAGEORGE, SM, EILEEN AUSTEN, RN, AND KATHLEEN N. LOHR, PHD

Abstract: We used the Health Services Commission data from Manitoba, Canada to identify complications resulting from hysterectomy, cholecystectomy, and prostatectomy which led to hospital readmissions. For each procedure, two specialists independently judged whether the readmissions were for surgery-related complications on the basis of liberally interpreted literature guidelines. Then, each pair of physicians met to resolve differences; only complications agreed upon by physicians were retained in our computer-based analysis.

The analysis was done in three steps: algorithms were developed using guidelines from the literature, physician input, and 1974 hospital claims; these were then modified using 1975 data; finally, the algorithms were tested with 1976 data. The computerized algorithms developed were compared with the clinical decisions of physician panels. The results showed high specificity, sensitivity, and predictive value. Given the increasing availability of routinely collected data bases, the possibilities for inexpensively monitoring the outcomes of different providers and institutions are appealing. More extensive validation and application of the methodology to a greater number of procedures are necessary to implement such a program. (*Am J Public Health* 1985; 75:1288–1295.)

Introduction

Quality of care is a major concern in any health care system; quality issues become particularly salient when cost constraints are severe. Since methods available to measure patient outcomes are generally poorly developed, specifying outcome indicators that are reliable, clinically valid, and nonintrusive would fill a definite need. Given the increasing availability of large routinely collected billing or medical record data bases, the possibilities for inexpensively monitoring the outcomes of care for different providers or institutions are growing. Because computerized information systems can identify potential problems much more quickly and cheaply than chart review by clinicians, knowing the extent to which computerized analysis can produce results similar to those derived from extensive clinical input is important.[1–3]

This paper uses the Health Services Commission claims data base, from Manitoba, Canada to identify clearly undesirable outcomes: complications resulting from three common elective surgical procedures. Complications leading to hospital readmissions were chosen both because of their importance as an outcome measure and because of the relative ease with which readmissions and accompanying diagnoses can be identified from health insurance data bases.

Methods

Data Base

The Manitoba data base has been built using histories generated from the population registry and from health insurance claims filed routinely with the Manitoba Health Services Commission (MHSC). These health insurance claims (hospital, medical, outpatient, and nursing home) are generally complete and, when appropriately used, highly reliable.[4]

Manitoba hospital claims closely correspond with information on the hospital medical record as to date of surgery, major surgical procedures performed, and important diagnoses (See Appendix A for details). Up to three diagnoses are coded on Manitoba hospital records.

The Manitoba data are population-based, designed to cover all individuals in the province. Nonparticipation in the Manitoba Health Plan is minimal as residents are not obliged to pay any premiums to register for insured benefits. In a few cases (from 1.5 to 2 per cent), various types of identifier problems appear on the registry; the most frequent of these problems necessitates an adjustment in birth year. Overall longitudinal follow-up is very good, comparing favorably with that in studies based on primary data collection.[2]

We focused on three procedures common in adults and believed to vary substantially in both per capita rates and indications for use: hysterectomy, cholecystectomy, and prostatectomy.[3] Surgery for malignancy was excluded from the analysis, as were emergency hysterectomy for intra-abdominal hemorrhage, cholecystectomy after prior gallbladder surgery, and prostatectomy as a revision of prior surgery.

The small numbers of individuals from outside the province receiving treatment in Manitoba and Manitobans using out-of-province hospitals were not included because of possible difficulties in tracing them through time. The Native Indian population was also excluded because responsibility for their health care is shared between federal and provincial authorities; their coverage in the claims system is known to be incomplete. In total, exclusions amounted to 14 per cent of hysterectomies (9 per cent for malignancies), 9 per cent of cholecystectomies (4 per cent malignancy-related), and 22 per cent of prostatectomies (17 per cent malignancy-related). Except for these exclusions, all readmissions following hysterectomy (N=1,245 readmissions), cholecystectomy (N=2,345), and prostatectomy (N=1,405) in the 1974–76 period were examined for this study. When only malignancies were excluded, results were very similar to those reported below.

Physician Panels

For each of the three procedures, we identified readmissions that might possibly be complications on the basis of liberally interpreted guidelines from the literature and consensus development conferences.[5–7] Initially, a large number of "possibles" (approximately 80 per cent more cases than were eventually chosen) were selected.

Abbreviated patient histories (covering two years before and two years after each procedure) based on the claims data were presented to two appropriate specialists who independently judged whether the readmissions were for surgery-

From the Departments of Business Administration and Social and Preventive Medicine, University of Manitoba (Roos, Cageorge, Austen), and the Rand Corporation (Lohr). Address reprint requests to Leslie L. Roos, Jr., PhD, Faculty of Administrative Studies, University of Manitoba, Winnipeg, Manitoba, R3T 2N2 Canada. This paper, submitted to the Journal March 18, 1985, was revised and accepted for publication June 27, 1985.
Editor's Note: See also related editorial p 1261 this issue.

related complications. The histories included all recorded utilization (hospital and ambulatory) with accompanying diagnoses in this period. These specialists did not know who performed the surgery or where the operation was done. When the physicians requested more information, data from admission/separation forms filed by the hospitals with the MHSC were provided. Additional information was requested for about 20 cases for each procedure for each year. These admission and separation forms, filled out by hospital records personnel using hospital medical records, contain the written diagnostic data prior to ICDA coding, admission diagnoses, and time of admission; pertinent descriptive case details including references to prior surgery are frequently included.

We assessed the interphysician reliability in coding complications. In general, reliability checks using the Manitoba data have approximated results obtained in clinical trials.[4] Comparing initial independent ratings as to whether or not a readmission was a complication characteristically generated kappa values between .4 and .6.[8] This measure corrects for the probability of chance agreement and kappas between .4 and .6 are generally seen as acceptable. One physician coded the same set of cholecystectomy complications twice several months apart; this "test-retest" kappa was .74.

Disagreements concerning the coding of readmissions as complications following hysterectomy were most marked for adhesions, both with and without obstruction. One physician coded all such adhesions as complications; the other thought the majority of them should not be seen as complications. The most significant disagreements about complications after cholecystectomy concerned pancreatitis (both acute and chronic), recurrent ventral hernia, and postoperative wound infection. Questions of timing were significant for disagreements between phsyicians concerning complications following prostatectomy. The major disagreement was whether or not orchitis and epididimitis should be considered complications if they occurred more than a month after surgery.

After coding the complications independently, each pair of physicians met to resolve differences. When compared with the initial independent ratings, the final decisions by the two physicians produced kappas in the .7 to .8 range. Only complications finally agreed upon by both physicians were retained in our analysis.

Computer Algorithms

The computer-based analysis of complications following surgery was done in three steps: first, algorithms were developed using 1974 hospital claims; second, these were modified using 1975 data; and, finally, the algorithms were tested with 1976 data. Using different years of observation avoids the biases associated with building and testing models with the same data set.

For each readmission diagnosis, a time limit (typically within 30, 60, or 90 days of discharge) was set on the basis of the literature review and physician input. We then identified complications by searching up to three diagnostic codes associated with the readmissions after surgery, using three- or four-digit ICDA-8 codes as required. Because the sequence of listed diagnoses is not used here, one of the main sources of error in working with hospital diagnoses is eliminated.[9,10] Although recording of diagnosis is most reliable when fine distinctions are avoided,[4,9] a number of four-digit ICDA-8 codes on the hospital file were used to identify appropriate diagnoses leading to readmissions. As described later, when results with these four-digit codes were compared with those using just three digits, differences were relatively slight. When no time limit was specified, readmissions up to two years after surgery were checked to see if they should be classified as complications.

The first readmission after surgery accounted for almost all of the complications leading to readmission and was easier to analyze with existing computer programs than second and subsequent readmissions. For example, of the 262 readmissions for complications following 1974–76 hysterectomies, a physician panel identified only four that did not occur on the first readmission. Consequently, analysis was restricted to the first readmission following the index hospitalization.

A number of diagnoses (e.g., postoperative hemorrhage, wound infection, or pulmonary embolism) indicate complications regardless of procedure. For certain diagnoses, the period between surgery and time of readmission (for the readmission to be counted a complication) varied among the different physician panels. Such time periods could be standardized with relatively little loss of accuracy. Specific diagnoses indicating complications relevant for each procedure (e.g., prolapse following a vaginal hysterectomy, postcholecystectomy jaundice) are also used. Appendix B presents this information, listing relevant ICDA-8 and ICD-9 codes.

Finally, results based on the computer algorithms were compared with the judgments made by the two specialists using standard epidemiological criteria of sensitivity, specificity, and predictive value.[11] Taking the final decisions by the two physicians as "truth", we calculated the proportion of cases correctly identified by the computer as being complications (sensitivity) and the proportion of cases correctly identified as not being complications (specificity). Additional measures include "positive predictive value", the probability that a patient so classified by computer algorithm did have a complication, and "negative predictive value", the probability that our classification of a patient's readmission as not complication-related was correct. Positive predictive values are calculated by dividing the number in the "yes/yes" cell in the four-fold table by the number in the "yes" row. Negative predictive values are generated by dividing the number in the "no/no" cell by the number in the "no" row.

Results

Hysterectomy

Postoperative hemorrhage (28 per cent of the complications) was by far the most common problem causing readmission following hysterectomy (Table 1). Other frequent complications included postoperative wound infection, cystitis and associated infections, and incisional hernia/disruption of operative wound. There were relatively few hysterectomy-specific complications; vaginal enterocele or stricture and incontinence with repair each affected 6 per cent of the women.

The three-stage process of developing and modifying the model produced 1976 findings only slightly worse than those for 1974 and 1975 (Table 2). For the 1976 hysterectomy data, sensitivity (.84) and specificity (.98) were excellent. Combined 1974–76 data produced an overall average sensitivity of .90 and specificity of .98. Both positive and negative predictive values were consistently high (above .90). Using only three-digit ICDA-8 codes in the hysterectomy analysis somewhat reduced specificity and slightly increased sensitivity; changes were relatively small, ranging between one and five percentage points.

Cholecystectomy

The most common complications following cholecystectomy included incisional hernia/disruption of operative

TABLE 1—Percentages of General and Specific Diagnoses Accounting for Complications following Hysterectomy

Diagnostic Group	Per Cent of All Complications (N = 256)
General Diagnoses	
Postoperative hemorrhage	28
Postoperative wound infection, peritonitis, cellulitis	12
Cystitis, pyelonephritis, urinary tract infection	11
Incisional hernia, disruption of operative wound	10
Pelvic inflammatory disease	5
Fistula of bladder, postoperative fistula	4
Abdominal pain	4
Pulmonary embolism and infarction	3
All other general diagnoses (see Appendix B)	4
Specific Diagnoses	
Vaginal enterocele, stricture	6
Incontinence and repair (vaginal hysterectomy only)	6
Prolapse (vaginal hysterectomy only)	4
All other hysterectomy-related diagnoses (see Appendix B)	5

Based on applying computer algorithms to 1974–76 data.

TABLE 3—Percentages of General and Specific Diagnoses Accounting for Complications following Cholecystectomy

Diagnostic Group	Per Cent of All Complications (N = 295)
General Diagnoses	
Incisional hernia, disruption of operative wound	28
Postoperative wound infection, peritonitis, cellulitis	12
Pneumonia	8
Cystitis, pyelonephritis, urinary tract infection	4
Abdominal pain	4
Postoperative hemorrhage	2
Pulmonary embolism and infarction	2
All other general diagnoses (see Appendix B)	6
Specific Diagnoses	
Cholelithiasis	17
Cholecystitis, cholangitis	4
Other disease of gallbladder, biliary ducts	6
Acute pancreatitis	2
Gastroenteritis, colitis	2
All other cholecystectomy-related diagnoses (see Appendix B)	3

Based on applying computer algorithms to 1974–76 data.

wound (28 per cent) and postoperative wound infection, peritonitis and cellulitis (12 per cent). Over 30 per cent of all complications were specifically related to cholecystectomy; half of these had diagnoses of cholelithiasis (indicating a retained stone) at readmission (Table 3).

The cholecystectomy findings using all relevant diagnoses were comparable to those for hysterectomy with regard to sensitivity and specificity (Table 4). The positive predictive value of the computer algorithm was, however, considerably lower for cholecystectomy (.76 with 1976 data) than for hysterectomy (.93). When the analysis was repeated using three-digit ICDA-8 codes, specificity dropped by 4 percentage points while sensitivity increased slightly (1 percentage point).

Prostatectomy

The most frequent complications necessitating rehospitalization following prostatectomy were postoperative hemorrhage and readmission for revision (Table 5). Other frequent complications included stricture of the urethra, contracture of bladder sphincter, hematuria, and retention of urine. As compared with hysterectomy, a higher percentage of the diagnoses were specifically related to prostatectomy with correspondingly fewer in the general category.

The computer algorithms predicted the complications selected by the physician panel quite well. All four measures of the accuracy of the algorithms are excellent for 1976, ranging between .89 and .98 (Table 6). When three-digit ICDA-8 codes were used, sensitivity and specificity were only slightly affected. However, the positive predictive value dropped from .91 to .78 because the number of false positives increased from 23 to 66 (summarizing across three years of data). Negative predictive value remained at .98 for the 1974–76 data.

TABLE 2—Accuracy of Computerized Algorithms for Identifying Complications following Hysterectomy

	Readmission Coded as Complication by Physician Panel								
	1974			1975			1976		
Readmission Coded as Complication According to Computer Algorithm		Yes	No		Yes	No		Yes	No
	Yes	76	10	Yes	92	9	Yes	64	5
	No	6	361	No	8	296	No	12	306
Measures of Accuracy of Computer Algorithms									
Sensitivity		.93			.92			.84	
Specificity		.97			.97			.98	
Positive predictive value		.88			.91			.93	
Negative predictive value		.98			.97			.96	
Sample Size									
N of cases		2045			1848			1795	
N of readmissions		453			405			387	
N of complications (on first readmission)									
Physician-coded		82			100			76	
Computer-coded		86			101			69	

TABLE 4—Accuracy of Computerized Algorithms for Identifying Complications following Cholecystectomy

	Readmission Coded as Complication by Physician Panel								
		1974			1975			1976	
Readmission Coded as Complication According to Computer Algorithms		Yes	No		Yes	No		Yes	No
	Yes	82	15	Yes	86	20	Yes	70	22
	No	10	761	No	13	663	No	9	594
Measure of Accuracy of Computer Algorithms									
Sensitivity		.89			.87			.89	
Specificity		.98			.97			.96	
Positive predictive value		.85			.81			.76	
Negative predictive value		.99			.98			.99	
Sample Size									
N of cases		3102			2763			2536	
N of readmissions		868			782			695	
N of complications (on first readmission)									
Physician-coded		92			99			79	
Computer-coded		97			106			92	

Time after Surgery as an Indicator

The readmissions/complications data might be analyzed in several ways. Our method of coding for complications incorporated both diagnosis and time since the surgical admission. However, looking at all readmissions in a short period after surgery might be useful if diagnostic data were unavailable. In addition, focusing on the 90 days after surgery might provide timely information for monitoring purposes.

When all readmissions in a short period after surgery are surveyed, many of the complications are identified. Of the 199 readmissions in the first month after 1974–76 hysterectomies, 154 (77 per cent) were coded as complications by the physician panel. As the time period was extended, the proportion of readmissions that were complications dropped. Only 184 (54 per cent) of the 341 readmissions in the first three months after hysterectomies were for complications. Of the total of 1,245 first readmissions within two years of hysterectomy, only 258 (21 per cent) were for complications.

Similarly, looking at readmissions during the first three months following 1974–76 cholecystectomies and prostatectomies, we observed that the percentage of complications tended to decrease over time. For cholecystectomy the complication/readmission ratio dropped from 51 per cent in the first month to 32 per cent after 90 days, and finally to 12 per cent (270 of 2,345 readmissions) over the full two years. Comparable figures for prostatectomy were 54, 36, and 19 per cent for the 30-day, 90-day, and two-year time periods.

Looking at just the first three months after surgery can provide an "early warning" of possible problems (Table 7). When all complications diagnoses were applied to hysterectomy data through 90 days after surgery, the computer correctly identified complication-related readmissions 93 per cent of the time and complication-free readmissions 89 per cent of the time. Sensitivity and specificity measures for the 90-day period were also quite good for cholecystectomy and prostatectomy. Both were .88 for cholecystectomy; for prostatectomy, sensitivity was .93 and specificity, .97.

TABLE 5—Percentages of General and Specific Diagnoses Accounting for Complications following Prostatectomy

Diagnostic Group	Per Cent of All Complications (N = 260)
General Diagnoses	
Postoperative hemorrhage	24
Pulmonary embolism and infarction	3
Incisional hernia, disruption of operative wound	3
All other general diagnoses (see Appendix B)	6
Specific Diagnoses	
Revision, transurethral resection, etc.	24
Stricture of urethra	13
Contracture of bladder sphincter	7
Hematuria	10
Retention of urine	7
Orchitis and epididymitis	3

Based on applying computer algorithms to 1974–76 data.

Sensitivity Testing

Because of the possibilities for using these techniques with American Medicare data, separate runs were made for cholecystectomy and prostatectomy patients aged 65 and older. The elderly received 20 per cent of the cholecystectomies and 73 per cent of the prostatectomies; there were not enough elderly hysterectomy patients for a separate analysis. Results from the elderly data were very similar to those from the full population; the largest difference resulted from a positive predictive value of .77 for the elderly cholecystectomy patients (versus .81 for the adult cholecystectomies as a whole).

Important Clinical Indicators

Three interesting patterns emerged from our analyses. First, three classes of general diagnoses associated with readmissions stand out as reasonably good indicators of surgical misadventure in the index hospitalization: postoperative hemorrhage (following hysterectomy and prostatectomy), postoperative wound infection (following hysterectomy and cholecystectomy), and incisional hernia (following hysterectomy and cholecystectomy). If a screening program had to restrict itself to only a small number of "sentinel event" indicators, these diagnostic categories would probably be high on the list. Although postoperative wound infection is a notoriously subjective diagnosis, the strength of our method is that only wound infections requiring readmission are picked up.

TABLE 6—Accuracy of Computer Algorithms for Identifying Complications following Prostatectomy

		Readmission Coded as Complication by Physician Panel							
		1974			1975			1976	
Readmission Coded as Complication According to Computer Algorithms		Yes	No		Yes	No		Yes	No
	Yes	77	5	Yes	79	8	Yes	81	10
	No	8	359	No	7	374	No	8	389
Measures of Accuracy of Computer Algorithms									
Sensitivity		.91			.92			.91	
Specificity		.99			.98			.97	
Positive predictive value		.95			.91			.89	
Negative predictive value		.98			.98			.98	
Sample Size									
N of cases		995			1031			986	
N of readmissions		449			468			488	
N of complications (on first readmission)									
Physician-coded		85			86			89	
Computer-coded		82			87			91	

Second, the usefulness of general diagnoses varies across procedures; the general diagnoses accounted for at least two-thirds or more of complications for hysterectomy and cholecystectomy, but for only about one-third of the prostatectomy complications. Third, no single general diagnosis was a useful indicator across all three surgical procedures studied, although postoperative hemorrhage alone picked up one-fourth of the readmissions for hysterectomy and prostatectomy.

Hospital-Based vs Population-Based Information

Problems may arise when provincial, state, or federal hospital claim systems lack identifying numbers which can track patients through the system. This problem of tracing patients who have surgery in one hospital and enter another owing to a postsurgical complication was explored using 1975–76 Manitoba cholecystectomy data. Of Winnipeg patients with complications (N=67, as coded by physicians), 85 per cent were readmitted to the same Winnipeg hospital. A much lower percentage of rural patients (55 per cent, N=78) returned to their hospital of surgery; because many such individuals come to tertiary care centers for major surgery, following patients through the system is essential for tracing complications among rural patients. More generally, when population-based data on all inpatient care are not fully available from hospital-oriented studies, research on complication and mortality rates will systematically underestimate true figures. Without the ability to follow individuals across hospitals, quality of care committees and physician panels based in a single institution will be working with incomplete data on their own hospital.

Discussion

The present approach has been applied to a limited set of procedures. In Manitoba and elsewhere, appropriate physician specialties will need to participate in developing equiv-

TABLE 7—Comparing Complications after Hysterectomy: Physician Panel versus Computer Algorithm Month-by-Month; 1974–76 Combined

		Readmission Coded as Complication by Physician Panel							
		30 Days			60 Days			90 Days	
Readmission Coded as Complication According to Computer Algorithms		Yes	No		Yes	No		Yes	No
	Yes	145	9	Yes	168	13	Yes	172	18
	No	9	36	No	11	79	No	12	139
Measure of Accuracy of Computer Algorithms									
Sensitivity		.94			.94			.93	
Specificity		.80			.86			.89	
Positive predictive value		.94			.93			.91	
Negative predictive value		.80			.88			.92	
Sample Size									
N of readmissions		199			271			341	
N of complications (on first readmission)									
Physician-coded		154			179			184	
Computer-coded		154			181			190	

alent algorithms for other procedures. For wider application, algorithms should be generated and validated for both operations common among the elderly (e.g., lens procedures) and those affecting other age groups (e.g., cesarean section, tonsillectomy and/or adenoidectomy). Although procedures which may involve either side of the body are intrinsically more difficult to work with, preliminary analysis of the complications following hip replacement surgery indicates that useful algorithms can be constructed. The same techniques may be tested out for medical admissions, including those common in the elderly.

These results strongly suggest that quality-of-care auditing or screening can be carried out with computerized measures that require neither direct patient contact nor medical record review. Because the Manitoba data may be of substantially higher quality than those produced in some other North American settings,[12] checks on data quality need to precede adoption in each potential setting. Although readmission alone is a useful indicator, coding accuracy is important to the identification of complications. Thus, some attention to possible "opportunistic coding practices" on the part of hospitals might be necessary if the techniques described here were used for monitoring purposes.[13] Hospitals might conceivably encourage longer lengths of stay to protect themselves against the comparatively small number of cases needing readmissions because of postdischarge problems, but such behavior could be picked up relatively easily by systems in place to monitor length of stay.

When data from ambulatory claims are available (as is the case with Manitoba and with Medicare in the United States), several additional analyses may be appropriate. Analysis of postsurgical ambulatory visits should help deal with the possibility of patients with complications not being readmitted to a given hospital (perhaps a hospital under pressure because of its complication rate). Such work would be valuable for its own sake; frequently other complications, such as strictures following prostatectomy, are treated on an outpatient basis.

The information generated by the types of monitoring described in this report can have great payoffs in facilitating quality assessment. Standards committees could efficiently use the computer to specify particular procedures for review in more depth. Because a sizable percentage of the Manitoba patients having postsurgical complications did not return to the hospital where the surgery took place, physicians doing the operations may get an overly optimistic view of their results. Some experts believe that accurate feedback to providers and their hospitals might have beneficial effects,[3] although others are markedly less hopeful.[14]

Applying clinically validated, computerized algorithms to program monitoring is particularly important for the American Medicare program, since prospective PROs (peer review organizations) must specify patient care quality improvements in five areas. One objective focuses on reducing avoidable postoperative or other complications; another explicitly concerns readmissions owing to substandard care in a previous admission. Furthermore, assessing patient outcomes nonintrusively is considered highly desirable in order to use review resources efficiently and yet be as broad-based as possible.

Once the original design decisions are made, high-level computer languages permit establishing and maintaining a monitoring/quality assurance system at a relatively low cost. Development of a series of relatively simple, physician-validated computerized rules that will dependably identify complication-related readmissions has enormous potential as part of a process to monitor the safety of both existing and new surgical procedures.[15] Because cost-control systems based on hospital claims are being increasingly adopted, the importance and feasibility of montioring quality of care for large numbers of patients is quite clear. Quality assurance and cost containment can be linked in a highly efficient manner.

APPENDIX A
Reliability and Validity of Manitoba Surgical Claims Data

Previous analysis of the Manitoba claims data compared hysterectomies for which surgeons billed with those recorded in the hospital file. Ninety-four per cent of the records showed an identical match: e.g., when an abdominal hysterectomy was recorded in the hospital discharge, the surgeon billed for this procedure. Discrepancies were typically of two kinds: minor differences in dates and surgeons' billing for a more extensive procedure associated with an abdominal malignancy. (In this case, the hysterectomy was secondary; usually the more extensive procedure was also recorded in the hospital claim.) Results for other procedures were generally similar.

Diagnoses on the hospital claims corresponded closely with those on the hospital medical record. A set of checks using Manitoba Health Services Commission (MHSC) data and records from one Winnipeg hospital found 95 per cent (37 of 39) of diagnoses for gallbladder patients to be identical. Similar high levels of agreement were noted for serious coronary problems diagnosed in four Winnipeg and four rural hospitals.[4]

Although a previous study of medical record coding among myocardial infarction patients indicated that a few secondary and tertiary diagnoses on the hospital claims may not appear on the medical records, several lines of evidence suggest that few complications are missed by the computerized methods discussed in this paper. We independently coded admission/separation forms for 50 cholecystectomies. A number of these forms had multiple diagnoses (18 had two and 10 had three diagnoses). In two instances, a fourth diagnosis might have been added, but only three diagnoses were permitted on the hospital claim.

Few additional complications were produced from the second and third diagnoses of the 232 complications after hysterectomy identified by both the computerized algorithms and the physician panels; 214 (92 per cent) were generated from primary diagnoses. Of the post-cholecystectomy complications, 218 of 238 were from the primary diagnoses; equivalent figures for prostatectomy were 245 out of 266 (92 per cent). Because relatively few complications are identified from the second and third diagnoses, possible differences among providers in the number of diagnoses reported seem relatively unimportant.

Coding error appears minimal. The work on cholecystectomies mentioned above found two coding errors (digits transposed) among the diagnoses. Analysis of admission and separation forms used to resolve questions in coding complications after prostatectomy showed complete agreement between written diagnoses and those coded on 35 out of 36 forms. The 36th form indicated a minor discrepancy for only one of the three diagnoses coded.

APPENDIX B
Diagnoses, ICDA-8 Codes, ICD-9-CM Codes and Time of Readmission Used to Study Complications of Surgery at Readmission

Diagnoses/Complications	ICDA-8 Codes	ICD-9-CM Codes	Time of Readmission* (h=hysterectomy, c=cholecystectomy, p=prostatectomy)
General Complications			
Diagnosis			
Postoperative hemorrhage	998.1,629.5	998.1,623.8	90 days
Anemia (not included for prostatectomy)	280,285	280,285	30 days
Postoperative wound infection, peritonitis, cellulitis	998.5,567,682.9	998.5,567,682.9	90 days
Pelvic inflammatory disease	616.0	614	120 days
Pulmonary embolism and infarction	450	415.1	90 days (h) 60 days (c) 45 days (p)
Phlebitis and thrombophlebitis	451	451	90 days (h) 60 days (c) 45 days (p)
Other venous embolism and thrombosis	453	453	90 days (h) 60 days (c) 45 days (p)
Cystitis, pyelonephritis, urinary tract infection	595,590.1,599.0 (590.1 alone for prostatectomy)	595,590.1,590.8,599.0	60 days (h) 30 days (c,p)
Pneumonia (not included for prostatectomy)	485,486	485,486	90 days (h) 30 days (c)
Incisional hernia, disruption of operative wound	551.2,553.2,998.3	551.2,552.2,553.2,998.3	Any time
Fistula of bladder, postoperative fistula	596.0,998.6	596.1,596.2,619.0	Any time
Abdominal pain (not included for prostatectomy)	785.5	789.0	30 days
Other surgical complication	998.9	998.8,998.9	30 days
Hysterectomy-related Complications			
Diagnosis			
Vaginal enterocele, stricture	623.3,629.7	618.6,623.2	Any time
Prolapse (vaginal hysterectomy only)	623.9	618.8,618.9	Any time
Incontinence and repair (vaginal hysterectomy only)	786.2 and opcode 71.4 or opcode 57.4	788.3 and opcode 70.5 or opcode 59.5	Any time
Cystocele and repair	opcode 71.4 at event, 623.0 & opcode 71.4 at readmission	opcode 70.5 at event, 618.0 & opcode 70.5 at readmission	Any time
Retention, obstruction of ureter	786.1,593.3	788.2,593.3,593.4	15 days
Vaginitis, vulvitis	622.1	616.1	30 days
Other disease of uterus	625.9	621.8,621.9	Any time
Cholecystectomy-related Complications			
Diagnosis			
Cholecystitis, cholangitis	575	575.0,575.1,576.1	Any time
Cholelithiasis	574	574	Any time
Other disease of gallbladder, biliary ducts	576	575.2 *to* 575.9, 576.2 *to* 576.9	Any time
Jaundice	785.2	782.4	90 days
Gastroenteritis, colitis	009.2	009.0,009.1	30 days
Intestinal obstruction, peritoneal adhesions	560,568	560,568	30 days
Acute pancreatitis	577.0	577.0	30 days
Gastritis, duodenitis	535	535	30 days
Prostatectomy-related Complications			
Diagnosis			
Revision, transurethral resection, etc.	opcode 58.1–58.3	opcode 60.2–60.6	Any time
Stricture of urethra	598	598.2	Any time
Contracture of bladder sphincter	596.2	596.0	Any time
Hematuria	789.3	599.7	60 days
Retention of urine	786.1	788.2	60 days
Orchitis and epididymitis	604	604	30 days

*When a time period such as 60 days is indicated, the period is understood to be within those 60 days.

ACKNOWLEDGMENTS

This paper will be presented at a Health Services Research workshop at the November 1985 American Public Health Association Annual Meeting in Washington, DC. The authors gratefully acknowledge the help of the Manitoba Health Services Commission. Marsha Cohen, Rudy Danzinger, Joel Kettner, Arthur Majury, John McBeath, James Mitchell, and Ernest Ramsey generously contributed their time to the coding of complications. The useful comments on earlier versions of the manuscript by John Bunker, John Eisenberg, Hal Luft, and Eugene Vayda are all acknowledged with thanks. This research was supported by National Health Research and Development Project No. 6607-1197-44 and by Career Scientist Award No. 6607-1314-48 to Dr. Roos. Dr. Lohr was supported in part by the Health Insurance Study grant to the Rand Corporation from the US Department of Health and Human Services and in part by the Health Policy Center grant to the Rand Corporation from the Health Care Financing Administration of the US Department of Health and Human Services. Interpretations and viewpoints contained in this paper are the authors' own and do not necessarily represent the opinions of the supporting institutions.

REFERENCES

1. Lohr KN, Brook RH, Kaufman M: Quality of care in the New Mexico Medicaid program (1971–1975). Med Care (Suppl) 1980; 18:1–129.
2. Roos NP: Hysterectomies in one Canadian province: a new look at risks and benefits. Am J Public Health 1984; 74:39–46.
3. Wennberg JE: Dealing with medical practice variations: a proposal for action. Health Affairs 1984; 3:6–32.
4. 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.
5. Chilton CP, Morgan RJ, England HR, Paris AMI, Blandy JP: A critical evaluation of the results of transurethral resection of the prostate, Br J Urol 1978; 50:542–546.
6. Jenkins VR: Unnecessary—elective—indicated? Audit criteria of the American College of Obstetricians and Gynecologists to assess abdominal hysterectomy for uterine leiomyoma. QRB 1977; 3:7–21.
7. Brook RH, Fink A, Solomon DH, Kosecoff J, Chassin M: A review of the literature on cholecystectomy: findings, complications, utilization rates, costs, efficacy, and indications. R-3204/2-CWF/PMT/HF, Santa Monica, CA: Rand Corporation, 1985.
8. Fleiss JL: Statistical Methods for Rates and Proportions. New York: John Wiley and Sons, 1981.
9. Demlo LK, Campbell PM: Improving hospital discharge data: lessons from the National Hospital Discharge Survey. Med Care 1981; 19:1030–1040.
10. Simborg DW: DRG creep. A new hospital-acquired disease. N Engl J Med 1981; 304:1602–1604.
11. Sackett DL, Haynes BB, Tugwell P: Clinical Epidemiology: A Basic Science for Clinical Medicine. Boston: Little, Brown and Co, 1985.
12. Johnson AN, Appel GL: DRGs and hospital case records: implications for Medicare case mix accuracy. Inquiry 1984; 21:128–134.
13. Stern RS, Epstein AM: Institutional responses to prospective payment based on diagnosis-related groups: implications for cost, quality, and access. N Engl J Med 1985; 312:621–627.
14. Schroeder SA: ReViews: a medical educator. Health Affairs 1984; 3:55–62.
15. Smits HL, Watson RE: DRGs and the future of surgical practice. N Engl J Med 1984; 311:1612–1615.

Prevention '86 Calls for Abstracts on Intervention Strategies

"Prevention '86: Assessing the Benefits of Intervention" is the title for the third annual national preventive medicine meeting sponsored by the Association of Teachers of Preventive Medicine and the American College of Preventive Medicine, to be held April 3–6, 1986, at the Westin Peachtree Plaza Hotel, Atlanta, Georgia.

The Prevention '86 program will focus on the evaluation and assessment of prevention intervention strategies and other matters of current interest relating to health promotion and disease prevention. Attendance of approximately 500 physicians and senior-level health professionals is anticipated.

Abstracts for submitted papers sessions and poster sessions are invited, and must be postmarked no later than *November 15, 1985.*

Prevention '86 is also co-sponsored by the Centers for Disease Control, Office of Disease Prevention and Health Promotion (DHHS), Aerospace Medicine Association, American Association of Public Health Physicians, American Public Health Association, Association of Preventive Medicine Residents, Association of Schools of Public Health, Association of State and Territorial Health Officials, National Association of County Health Officers, and U.S. Conference of Local Health Officers.