Ontario hospitals—mergers, shorter stays and readmissions

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Abstract

Objectives

This article examines the association between readmissions of pneumonia and acute myocardial infarction (AMI) patients to Ontario hospitals in 1998/99, and reductions in length of stay and recent hospital administrative mergers.

Data source

The data are from the 1998/99 Discharge Abstract Database, maintained by the Canadian Institute for Health Information.

Analytical techniques

Cross-tabulations were used to assess unadjusted associations between hospital and patient characteristics and readmission risk. Hierarchical non-linear models were used to calculate odds of readmission, adjusting for hospital and patient characteristics.

Main results

Hospital characteristics that may indicate restructuring—a decrease in mean length of stay or a recent administrative merger—were not associated with readmission of pneumonia or AMI patients within 30 days of discharge. Patients with two or more related hospital admissions in the previous year were at increased risk of readmission.

Key words

acute care, pneumonia, acute myocardial infarction, budget cuts

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Throughout Canada, government health care spending was curtailed in the 1990s. This occurred in the province of Ontario in the latter part of the decade under the mandate of the Health Services Restructuring Commission. As hospital administrators dealt with the realities of "doing more with less," they sought greater efficiency, in part, through hospital closures, administrative mergers, reductions in the number of beds, and shorter lengths of stay for patients requiring acute care.

It has been suggested that in at least some situations reducing the mean length of hospital stays improves efficiency.[1] On the other hand, sudden reductions that are not accompanied by compensatory changes in clinical and hospital management practice may negatively affect patient outcomes or have other unintended consequences.[2,3] Some studies have concluded that shorter stays increase the risk of readmission,[4-7] while others have found no relationship, or even a reduced risk of readmission.[2,8-11]

Using the Discharge Abstract Database maintained by the Canadian Institute for Health Information, this analysis attempts to determine if pneumonia and acute myocardial infarction (AMI) patients admitted to the Ontario hospitals that experienced the sharpest declines in mean length of stay for these and related conditions between 1995/96 and 1998/99 had a higher risk of readmission than did their counterparts in hospitals where declines were less dramatic (see *Data source*, *Analytical techniques* and *Limitations*). It also explores the risk of readmission for patients admitted to hospitals that underwent an administrative merger. Pneumonia and AMI were selected because they involve different organ systems and both have relatively high readmission rates.[12]

Hospital characteristics not associated with readmission

In Ontario in 1998/99, 8.3% of patients who had been hospitalized for pneumonia were readmitted for the same or a related condition within 30 days of their discharge; for AMI patients, the figure was somewhat higher: 13.9%.

Neither of the two variables indicative of hospital restructuring were associated with the risk of readmission (see *Hospital characteristics*). Pneumonia and AMI patients who had been in hospitals where the average length of stay for related conditions had declined were no more or less likely to be readmitted than were patients who had been in hospitals where the average length of stay had increased (Table 1).

Data source

This analysis is part of Statistics Canada's person-oriented information initiative, whereby hospital separation records are linked to obtain information about the health care received by individuals and their eventual health outcomes. The data are from the Discharge Abstract Database (DAD), maintained by the Canadian Institute for Health Information (CIHI). CIHI receives information about separations (discharges or deaths) from hospitals across Canada. Each record contains dates of admission and separation, one or more diagnoses, the major clinical category for each diagnosis, age and sex.

This analysis is based on separation data for individual pneumonia or acute myocardial infarction (AMI) patients who were hospitalized in Ontario and readmitted for a related condition in 1998/99, the most recent year for which data were available. Ontario accounted for 50% of all records from hospitals reporting to the DAD system before 1998/99.

Hospital characteristics

The 1998/99 *mean length of stay* was used to group hospitals into quartiles. Only acute stays (60 days or less) that were related to pneumonia or AMI were used in the calculation. For pneumonia, the quartiles were: less than 5.7 days; 5.7 to less than 6.5 days; 6.5 to less than 7.4 days; and more than 7.4 days. For AMI, the quartiles were: less than 4.8 days; 4.8 to less than 5.5 days; 5.5 to less than 6.2 days; and more than 6.2 days.

Hospitals were classified according to the extent of *change in mean length of stay from 1995/96 to 1998/99*, where the mean was calculated as above. Hospitals were assigned to one of three categories: increase; small decrease (up to 0.75 days for pneumonia and up to 0.53 days for AMI); or large decrease. The two "decrease" categories were formed by splitting all hospitals with declining length of stay into two groups of equal size, hence, the different cut-offs. Hospitals for which the mean length of stay in either year was based on less than 100 separations were assigned a "missing" value because the measure was considered too unstable. If a 1998/99 hospital identification number could not be matched to the 1995/96 file, the change in mean length of stay was considered missing.

Recently merged hospitals were those identified by the Ontario Ministry of Health as having undergone an administrative merger between 1995/96 and 1998/99.[13]

Hospital *volume* was based on the total number of separations in 1998/99 for acute cases related to pneumonia or to AMI. Hospitals were grouped into volume quartiles by number of separations: for pneumonia—less than 117, 117 to 291, 292 to 800, and more than 800; for AMI—less than 160, 160 to 455, 456 to 1,256, and more than 1,256.

The teaching status of a hospital is not indicated in the Discharge Abstract Database. Hospital complexity level was based on the mean complexity of all acute stays in a hospital that were related to pneumonia or AMI. However, teaching hospitals would be expected to admit more complex cases. Case *complexity level*, which is assigned by the Canadian Institute for Health Information, takes into account the number and types of diagnoses listed on separation records. Values of 1 through 4 were given to increasing levels of case complexity, corresponding to "none," "complexity due to chronic conditions," "complexity due to serious conditions," and "complexity due to life-threatening conditions." Hospitals in the 80th percentile (1.64 or more for pneumonia; 1.45 or more for AMI) were defined as being of high complexity.

Table 1
Unadjusted probability of readmission within 30 days of acute index admission for pneumonia or acute myocardial infarction, by hospital characteristics, Ontario, 1998/99

	Pneumonia				Acute myocardial infarction			
		Readmissions within 30 days				Readmissions within 30 days		
	Total index admissions	Number	% of index admissions	Chi-squared†	Total index admissions	Number	% of index admissions	Chi-squared†
Total	**12,159**	**1,011**	**8.3**	**...**	**4,183**	**581**	**13.9**	**...**
Change in mean length of stay, 1995/96 to 1998/99								
Increase	6,604	547	8.3		1,468	213	14.5	
Small decrease	2,700	223	8.3	0.18	1,452	209	14.4	2.84
Large decrease	1,760	151	8.6		1,204	150	12.5	
Missing	1,095	90	...		59	9	...	
Recently merged								
Yes	1,212	92	7.6	0.93	75	11	14.7	0.04
No	10,947	919	8.4		4,108	570	13.9	
Mean length of stay, 1998/99								
Quartile 1 (shortest)	3,548	314	8.9		918	136	14.8	
Quartile 2	2,754	218	7.9	2.87	991	123	12.4	3.81
Quartile 3	2,757	235	8.5		1,369	185	13.5	
Quartile 4 (longest)	3,100	244	7.9		905	137	15.1	
Volume (separations)								
Quartile 1 (smallest)	530	48	9.1		183	27	14.8	
Quartile 2	1,468	108	7.4	3.60	636	79	12.4	1.40
Quartile 3	3,388	270	8.0		1,695	240	14.2	
Quartile 4 (largest)	6,773	585	8.6		1,669	235	14.1	
Complexity level								
High	3,808	308	8.1	0.37	813	105	12.9	0.80
Not high	8,351	703	8.4		3,370	476	14.1	

Data source: *1998/99 Discharge Abstract Database, Canadian Institute for Health Information*
† Used to test for independence between readmission and selected hospital characteristic
··· Not applicable

Similarly, a recent administrative merger was not related to the probability of readmission for either type of patient.

However, other hospital characteristics may influence the probability of readmission. Hospitals with a short average length of stay (regardless of whether it has recently declined) may be more efficient, or they may admit less serious cases than do hospitals where stays tend to be longer. Hospital volume—the number of admissions for the condition in question (in this case, conditions related to pneumonia and AMI)—may reflect access to technology or the severity of cases.[14] Volume may also be associated with bed occupancy rates. Hospitals with higher occupancy rates may discharge patients more quickly to meet the demand for beds, which, in turn, may be associated with readmissions. Further, an institution with a high average level of case complexity may be more likely to treat patients who will need to be readmitted. But as was true for the indicators of restructuring, average length of stay, hospital volume, and hospital complexity level were not related to the likelihood that pneumonia or AMI patients would be readmitted for a related condition within 30 days.

Related admissions important

To examine the association between readmissions and hospital restructuring, the characteristics of patients must also be taken into account[3,11,14-16] (see *Patient characteristics*). Age, for example, might be expected to be associated with the likelihood of readmission. And in fact, in 1998/99, the percentage of pneumonia patients who were readmitted to

Analytical techniques

Hospital separation records may have more than one coded diagnosis. The diagnosis accounting for the greatest part of the hospital stay, or the "most responsible diagnosis," is used in this analysis to classify hospital stays. *International Classification of Diseases, Ninth Revision* (ICD-9 and ICD·9·CM) codes[17,18] were used to identify admissions for pneumonia and acute myocardial infarction (AMI), consistent with other research done in Ontario.[12]

Hospital separation records were grouped by patient, based on a person identifier. Hospital stays for each patient were then grouped into admission episodes, each consisting of an initial, or index, admission and possibly some readmissions (flowchart). An index admission:

- was due to pneumonia or AMI, depending on the analysis;
- occurred between April 1, 1998 and March 31, 1999; and
- was preceded by a "wash-out" period of at least 30 days in which the patient did not have a related admission (the 1997/98 file was checked for related admissions in the 30 days before admissions occurring in April 1998).

A readmission:

- was due to or related to pneumonia or AMI, depending on the analysis; and
- occurred within the 30 days after the discharge date of an index admission (index admissions for which the discharge date was after March 1, 1999 were dropped because readmission information was not available for the full 30-day period).

Only *acute* index admissions (that is, the length of stay was 60 days or less) were retained for analysis. Index admissions were flagged to indicate if they were followed by one or more related admissions within 30 days. Those involving a transfer to or from another hospital were excluded, since the length of stay does not reflect the full amount of time spent in hospital. Patients younger than 2 were excluded.

Based on the above definitions, it is possible to have more than one index admission per patient. However, 98% of all index admissions in this analysis were the patient's only index admission.

A total of 12,159 index admissions for pneumonia, distributed among 171 hospitals, were retained for analysis. Index admissions for AMI totalled 4,183, from 93 hospitals.

Chi-square tests were used to determine unadjusted associations between hospital and patient characteristics and readmission risk.

To calculate the odds of readmission by a hospital's change in mean length of stay (for pneumonia or AMI, depending on the analysis) or by its merger status, while adjusting for other hospital and patient characteristics, hierarchical non-linear models were fitted using the software HLM for Windows, version 5.02.[19,20]

To gain additional insight into the role of hospital and patient characteristics on patient outcomes, similar analyses were conducted with in-hospital deaths as the outcome.

Readmission calculations were based on index admissions; that is, each readmission had to occur within 30 days after an index admission. By contrast, the calculations for in-hospital deaths were based on all separations in 1998/99, whether they were index admissions or readmissions. Consequently, the calculations of percentages and odds ratios for readmission were based on a lower number (denominator) than were the calculations of percentages and odds ratios for deaths.

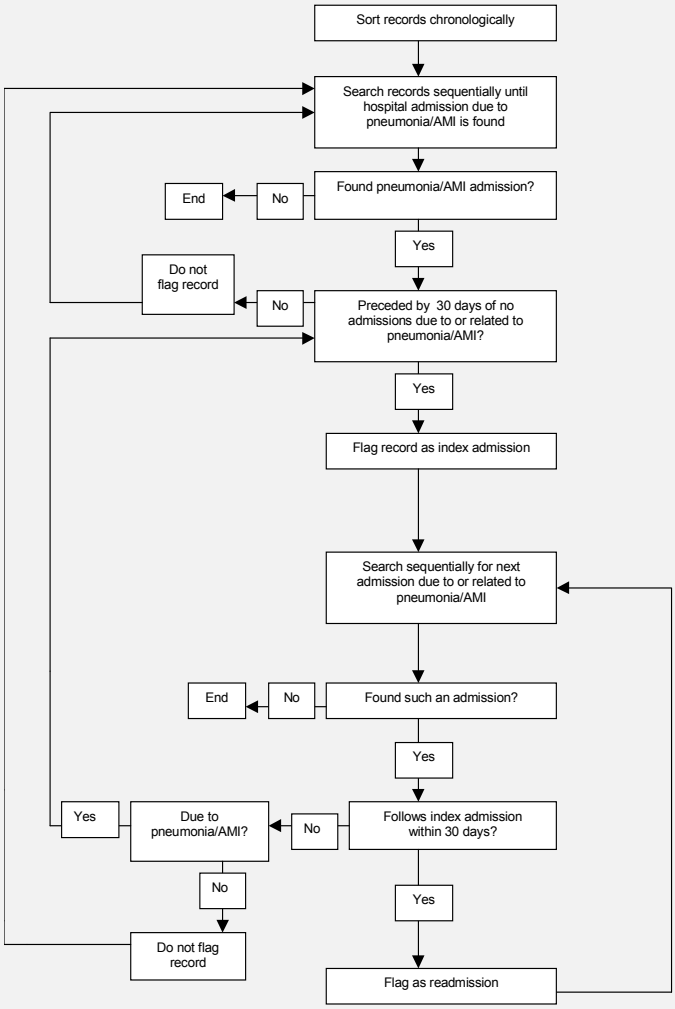

Table 2
Unadjusted probability of readmission within 30 days of acute index admission for pneumonia or acute myocardial infarction, by patient characteristics, Ontario, 1998/99

	Pneumonia				Acute myocardial infarction			
		Readmissions within 30 days				Readmissions within 30 days		
	Total index admissions	Number	% of index admissions	Chi-squared†	Total index admissions	Number	% of index admissions	Chi-squared†
Total	**12,159**	**1,011**	**8.3**	···	**4,183**	**581**	**13.9**	···
Sex								
Male	6,583	576	8.8	3.60	2,949	411	13.9	0.02
Female	5,576	435	7.8		1,234	170	13.8	
Age group								
2-11	2,031	140	6.9					
12-24	442	42	9.5		247‡	36	14.6	
25-44	1,378	101	7.3					
45-59	1,518	132	8.7	13.1*	1,137	165	14.5	0.90
60-74	3,162	258	8.2		1,674	223	13.3	
75+	3,628	338	9.3		1,125	157	14.0	
Related admissions in previous year								
0	10,912	864	7.9		3,799	509	13.4	
1	755	49	6.5	92.4*	231	24	10.4	42.2*
2+	492	98	19.9		153	48	31.4	
Case complexity								
None	9,114	754	8.3		3,523	499	14.2	
Due to chronic conditions	1,907	166	8.7		388	42	10.8	
Due to serious conditions	804	61	7.6	1.16	201	27	13.4	4.50
Due to life-threatening conditions	334	30	9.0		71	13	18.3	
Length of stay								
Quartile 1 (shortest)	2,856	223	7.8		888	120	13.5	
Quartile 2	3,757	322	8.6	5.89	1,565	222	14.2	
Quartile 3	3,021	232	7.7		563	73	13.0	0.73
Quartile 4 (longest)	2,525	234	9.3		1,167	166	14.2	

Data source: *1998/99 Discharge Abstract Database, Canadian Institute for Health Information*
† Used to test for independence between readmission and selected patient characteristic
‡ Ages 2 to 44 combined because of small cell size
** $p \leq 0.05$*
··· Not applicable

hospital within 30 days of discharge was lowest at ages 2 to 11 (less than 7%) and highest at ages 12 to 24 and 75 or older (more than 9%) (Table 2). By contrast, among AMI patients, readmission rates were around 13% or 14%, and the differences between age groups were not statistically significant.

Other research has shown readmissions to be associated with the number of recent related admissions.[14,21,22] In Ontario, too, pneumonia and AMI patients who had had two or more related admissions in the previous year were more likely to be readmitted within 30 days than were those with no related admissions in that period.

Case complexity, which is derived by CIHI from the number and types of diagnoses on each discharge record, indicates additional health problems the patient may be experiencing. Surprisingly, this variable was not associated with readmission risk for either pneumonia or AMI patients. For example, readmission rates of pneumonia patients were between 8% and 9%, regardless of whether the patients had no other health problem or a life-threatening condition.

The probability of readmission did not differ substantially by the length of time that patients had been hospitalized.

Volume significant for pneumonia

Hospital and patient characteristics are not independent. For instance, a recent merger may affect hospital complexity level, and changes in a hospital's average length of stay may reflect the case complexity of individual patients. But even when all the factors were considered simultaneously in multivariate analysis, no significant association emerged between readmissions and the two restructuring variables for pneumonia or AMI patients (Tables 3 and 4).

Hospital volume, however, was significantly associated with readmissions of pneumonia patients, a finding not present in the bivariate analysis.

Patient characteristics

Separation records for which the most responsible diagnosis had an ICD-9 code of 481, 4822, 4823, 4829, 483, 485, 486, or 487 were considered *pneumonia* cases.[17] *Acute myocardial infarction (AMI)* cases were those with an ICD-9 code of 410, or an ICD·9·CM code of 4100, 4101, 4102, 4103, 4104, 4105, 4106, 4107, 4108 or 4109.[17,18]

For all identified hospital stays, the 12-month period preceding the date of admission was searched for *related admissions in the previous year*: 0, 1, or 2 or more. In the pneumonia analysis, related admissions were those for which the most responsible diagnosis was in the major clinical category of respiratory diseases and conditions (for example, pneumonia or bronchitis). For acute myocardial infarction (AMI), related stays referred to all conditions and diseases of the circulatory system. The ICD-9 codes that correspond to these groups are in reference material from the Canadian Institute for Health Information.[23]

For the analysis of pneumonia patients, six age groups were specified: 2 to 11, 12 to 24, 25 to 44, 45 to 59, 60 to 74, and 75 or older. Because AMI is relatively uncommon at younger ages, for the analysis of AMI patients, four age groups were specified: 2 to 44, 45 to 59, 60 to 74, and 75 or older.

Case complexity was based on the number and type of diagnoses on a discharge record (derived by CIHI). Four categories (coded 1 to 4) were established: none, and complexity due to chronic, serious, or life-threatening conditions.

For the bivariate analysis, *length of stay* was grouped into quartiles. For pneumonia, the quartiles were: 0 to 2 days; more than 2 to 4 days; more than 4 to 7 days; and more than 7 to 60 days. For acute myocardial infarction (AMI), the quartiles were: 0 to 4 days; more than 4 to 6 days, more than 6 to 7 days; and more than 7 to 60 days. In the multivariate analysis, this variable was treated as continuous.

Table 3
Adjusted odds ratios for readmission within 30 days of acute index admission for pneumonia, by hospital and patient characteristics, Ontario, 1998/99

	Adjusted odds ratio	95% confidence interval
Hospital characteristics		
Change in mean length of stay, 1995/96 to 1998/99		
Increase†	1.00	...
Small decrease	0.98	0.84, 1.15
Large decrease	1.01	0.87, 1.17
Recently merged		
Yes	0.85	0.70, 1.03
No†	1.00	...
Mean length of stay, 1998/99		
Quartile 1 (shortest)	1.19	0.95, 1.50
Quartile 2	0.99	0.78, 1.25
Quartile 3	1.10	0.88, 1.37
Quartile 4 (longest)†	1.00	...
Volume (separations)		
Quartile 1 (smallest)	1.00	0.54, 1.88
Quartile 2	0.75*	0.62, 0.91
Quartile 3	0.89	0.75, 1.06
Quartile 4 (largest)†	1.00	...
Complexity level		
High	0.94	0.77, 1.14
Not high†	1.00	...
Patient characteristcs		
Sex		
Male	1.12	0.98, 1.27
Female†	1.00	...
Age group		
2- 11†	1.00	...
12-24	1.42	0.98, 2.04
25-44	1.16	0.87, 1.54
45-59	1.34	0.98, 1.82
60-74	1.24	0.98, 1.56
75+	1.43*	1.11, 1.84
Related admissions in previous year		
0†	1.00	...
1	0.73*	0.54, 1.00
2+	2.86*	2.31, 3.55
Case complexity		
None†	1.00	...
Due to chronic conditions	1.01	0.83, 1.22
Due to serious conditions	0.87	0.64, 1.18
Due to life-threatening conditions	0.98	0.64, 1.51
Length of stay	1.01	1.00, 1.03

Data source: *1998/99 Discharge Abstract Database, Canadian Institute for Health Information*
Note: *Because of rounding, some confidence intervals with 1.00 as lower/upper limit are significant.*
† Reference category
** $p \leq 0.05$*
... Not applicable

Patients in hospitals in the second volume quartile (reporting between 117 and 291 pneumonia separations) had significantly lower odds of readmission than did patients in hospitals in the fourth volume quartile (more than 800 pneumonia separations). The association may reflect a referral bias if sicker patients are referred to larger hospitals. It is also possible that clinical and/or hospital management practices differ between larger and smaller institutions.

Table 4
Adjusted odds ratios for readmission within 30 days of acute index admission for acute myocardial infarction, by hospital and patient characteristics, Ontario, 1998/99

	Adjusted odds ratio	95% confidence interval
Hospital characteristics		
Change in mean length of stay, 1995/96 to 1998/99		
Increase†	1.00	...
Small decrease	1.02	0.82, 1.27
Large decrease	0.89	0.71, 1.12
Recently merged		
Yes	1.13	0.64, 2.00
No†	1.00	...
Mean length of stay, 1998/99		
Quartile 1 (shortest)	1.07	0.82, 1.40
Quartile 2	0.86	0.63, 1.19
Quartile 3 and 4 (longest)†	1.00	...
Volume (separations)		
Quartile 1 (smallest)	1.01	0.57, 1.79
Quartile 2	0.83	0.60, 1.15
Quartile 3	0.99	0.76, 1.29
Quartile 4 (largest)†	1.00	...
Complexity level		
High	0.86	0.70, 1.06
Not high†	1.00	...
Patient characteristcs		
Sex		
Male	1.00	0.85, 1.19
Female†	1.00	...
Age group		
2-44†	1.00	...
45-59	1.01	0.68, 1.49
60-74	0.90	0.60, 1.35
75+	0.91	0.63, 1.31
Related admissions in previous year		
0†	1.00	...
1	0.77	0.50, 1.18
2+	3.09*	2.08, 4.58
Case complexity		
None†	1.00	...
Due to chronic conditions	0.75*	0.57, 0.99
Due to serious conditions	0.93	0.63, 1.37
Due to life-threatening conditions	1.37	0.74, 2.55
Length of stay	1.01	0.99, 1.03

Data source: *1998/99 Discharge Abstract Database, Canadian Institute for Health Information*
† Reference category
** $p \leq 0.05$*
··· Not applicable

A US study that controlled for demographic, clinical and hospital characteristics found that the risk of unplanned readmission to the same institution increased with hospital size.[15] However, this applied to heart failure/shock and nutritional/metabolic disorders, not to pneumonia. An Australian study using a range of diagnoses found that the association between hospital size and unexpected readmission to the same hospital varied by urban/rural status.[24] In rural settings, the risk of readmission increased with hospital size, but decreased with hospital size in urban settings. The study, however, did not account for demographic characteristics or clinical factors, such as severity, complexity or even type of diagnosis. In this analysis of 1998/99 Ontario data, it was only when adjusting for the selected patient and hospital factors that the association with volume emerged for pneumonia patients.

When all the factors were taken into account, the odds that pneumonia and AMI patients would be readmitted did not differ significantly by whether they were male or female or by their length of stay in hospital. However, for both pneumonia and AMI patients with at least two related admissions in the previous year, the odds of readmission were about three times the odds for those with no related admissions in that period.

The effect of age on readmission of pneumonia patients was apparently independent of the other factors, as the odds of readmission of those aged 75 or older were significantly high, compared with patients aged 2 to 11. By contrast, the odds of readmission of AMI patients did not vary by age.

In-hospital deaths

The lack of association between many variables and readmission of pneumonia or AMI patients may, to some extent, be explained by the exclusion of the most serious cases that would have had the highest probability of readmission—those that ended in death during hospitalization. In fact, several

Limitations

With regard to patient welfare, "readmission" as defined in this analysis must be interpreted with caution. In the Ontario hospital data on which this study is based, planned readmissions cannot be distinguished from unplanned readmissions. A Manitoba study, however, found that in 1992/93, 75% to 90% of readmissions for selected diagnoses were unplanned.[2]

This analysis tries to reduce unrelated readmissions by including only those involving the same organ system as the index admission. As a result, some readmissions that were a consequence of the index diagnosis, but affected another organ system, were ignored. Conversely, a patient might have been hospitalized more than once for treatment involving the same organ system, even though the hospitalizations were unrelated.

A 30-day period to track readmissions is arbitrary. Yet even when 15 or 60 days was used as the readmission period in hierarchical non-linear models, the hospital restructuring variables were not significantly associated with readmission (data not shown).

Excluding patients who died in hospital during their index admission diluted associations between readmission and some factors, notably age and case complexity, since the most severe cases were not part of the analysis. As well, because out-of-hospital deaths could not be detected, patients who died after they were discharged remained in the group at risk of readmission and were counted as not being readmitted. Had it been possible to adjust the figures to remove patients no longer "eligible" for readmission because of death, the associations might have been stronger.

The omission of index admissions involving a transfer to or from another hospital may systematically exclude particular types of patients whose readmission rates may be different. Indeed, other work has shown that a transfer to a special care unit is significantly predictive of readmission.[25]

A number of characteristics of patients and hospitals that might influence readmission risk were not available. For instance, discharge readiness, access to home care, access to specific therapies, and whether patients were discharged to the home or to an institution could not be taken into account. Some data on the administrative files were used as a proxy for missing variables, but the ability of the proxy variables to capture the information is limited.

Reporting and coding consistency across hospitals is unknown. Studies have shown that approximately 20% to 25% of the "most responsible"diagnoses are not coded accurately, and are often a coexisting condition.[26,27]

Finally, these results pertain only to pneumonia and acute myocardial infarction, and only in Ontario, so the results cannot be generalized to other diagnoses or to other jurisdictions.

demographic variables that were not related to readmission were related to in-hospital death. The odds of dying in hospital were significantly high for older patients, compared with younger ones (Appendix Tables B and C). As expected, the odds of dying were high for patients with additional health problems, compared with those whose cases were not complex. Female pneumonia patients had lower odds of dying in hospital than did their male counterparts, but for female AMI patients, the odds of dying were higher.

As well, one restructuring factor was significantly related to in-hospital deaths of pneumonia patients. Those in recently merged hospitals had significantly lower odds of dying than did pneumonia patients in other hospitals.

Changes in mean length of stay were not associated with in-hospital deaths. However, pneumonia patients in hospitals with relatively short average stays in 1998/99 had significantly low odds of dying, compared with those in hospitals with the longest average stays. And for both pneumonia and AMI patients, the odds of dying were significantly low in hospitals with a high average level of complexity.

Concluding remarks

In this analysis of Ontario data, hospital characteristics that may indicate restructuring—a decrease in average length of stay or a recent merger—were not associated with readmissions of pneumonia or acute myocardial infarction patients. The only association between these two variables and in-hospital deaths was low odds of dying for pneumonia patients in recently merged institutions. Nonetheless, the relationship between hospital restructuring and readmissions is difficult to interpret. The hospital and patient characteristics associated with readmission are complex. Many potentially influential factors are not available from the Discharge Abstract Database (DAD).

Moreover, the outcome variable itself is limited. While it has been suggested that hospitals with lower readmission rates have a higher quality of care,[2,28,29] this assumption is not universally accepted.[30,31] Readmissions may be of four general types:

complication of a previous admission; recurrence of disease; planned treatment; and unrelated new diagnosis.[32] In this analysis, it was not possible to distinguish planned and unplanned readmissions. And even if unplanned readmissions could be identified, in order to reflect an adverse patient outcome, "expected" but unplanned readmissions should be omitted from the analysis.[24] The lack of association between case complexity and readmission may be evidence of this limitation in the outcome variable, particularly when such a strong pattern is observed between in-hospital death and case complexity.

These limitations of the analysis point to data gaps, some of which present an opportunity to improve the DAD system in the future. ●

References

1 Brownell MD, Roos NP. Variation in length of stay as a measure of efficiency in Manitoba hospitals. *Canadian Medical Association Journal* 1995; 152(5): 675-82.

2 Harrison ML, Graff LA, Roos NP, et al. Discharging patients earlier from Winnipeg hospitals: does it adversely affect quality of care? *Canadian Medical Association Journal* 1995; 153(6): 745-51.

3 Leyland AH. Examining the relationship between length of stay and readmission rates for selected diagnoses in Scottish hospitals. *IMA Journal of Mathematics Applied in Medicine and Biology* 1995; 12(3-4): 175-84.

4 Rotstein Z, Barabash G, Noy S, et al. Allocation of emergency ward patients to medicine departments: increasing physicians' incentive to shorten length of stay. *Public Health Review* 1996; 24(1): 37-48.

5 MacIntyre CR, Brook CW, Chandraraj E, et al. Changes in bed resources and admission patterns in acute public hospitals in Victoria, 1987-1995. *The Medical Journal of Australia* 1997; 167(4): 186-9.

6 Sin DD, Tu JV. Are elderly patients with obstructive airway disease being prematurely discharged? *American Journal of Respiratory and Critical Care Medicine* 2000; 161(5): 1513-7.

7 Wickizer TM, Lessler D, Boyd-Wickizer J. Effects of health care cost-containment programs on patterns of care and readmissions among children and adolescents. *American Journal of Public Health* 1999; 89(9): 1353-8.

8 South M. Reduction in length of hospital stay for acute childhood asthma associated with the introduction of casemix funding. *The Medical Journal of Australia* 1997; 167(1): 11-3.

9 Meikle SF, Lyons E, Hulac P, et al. Rehospitalizations and outpatient contacts of mothers and neonates after hospital discharge after vaginal delivery. *American Journal of Obstetrics and Gynecology* 1998; 179(1): 166-71.

10 McCormick D, Fine MJ, Coley CM, et al. Variation in length of hospital stay in patients with community-acquired pneumonia: are shorter stays associated with worse medical outcomes? *American Journal of Medicine* 1999; 107(1): 5-12.

11 Holloway JJ, Medendorp SV, Bromberg J. Risk factors for early readmission among veterans. *Health Services Research* 1990; 25(1 Pt 2): 213-37.

12 Basinski ASH, Thériault M-E. Patterns of hospitalization. In: Goel V, Williams JI, Anderson GM, et al (eds). *Patterns of Health Care in Ontario. The ICES Practice Atlas, 2nd Edition.* Ottawa: Canadian Medical Association, 1996: 197-246.

13 Ontario Ministry of Health. *Ontario Master Numbering System*, 2000.

14 Anderson GF, Steinberg EP. Predicting hospital readmissions in the Medicare population. *Inquiry* 1985; 22(3): 251-8.

15 Thomas JW, Holloway JJ. Investigating early readmission as an indicator for quality of care studies. *Medical Care* 1991; 29(4): 377-94.

16 Weissman JS, Stern RS, Epstein AM. The impact of patient socioeconomic status and other social factors on readmission: a prospective study in four Massachusetts hospitals. *Inquiry* 1994; 31(2): 163-72.

17 World Health Organization. *Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death.* Based on the recommendations of the Ninth Revision Conference, 1975. Geneva: World Health Organization, 1977.

18 US Department of Health and Human Services. *The International Classification of Diseases, 9th Revision, Clinical Modification, ICD-9-CM, Third Edition.* DDHS Publication No. (PHS) 89-1260. Washington DC: US Department of Health and Human Services, 1989.

19 Bryk AS, Raudenbush SW. *Hierarchical Linear Models.* Newbury Park, California: Sage Publications, Inc., 1992.

20 Raudenbush S, Bryk A, Cheong YF, et al. *HLM 5 Hierarchical Linear and Nonlinear Modeling.* Chicago: Scientific Software International, 2000.

21 Phillips RS, Safran C, Cleary PD, et al. Predicting emergency readmissions for patients discharged from the medical service of a teaching hospital. *Journal of General Internal Medicine* 1987; 2(6): 400-5.

22 Colledge NR, Ford MJ. The early hospital readmission of elderly people. *Scottish Medical Journal* 1994; 39(2): 51-2.

23 Canadian Institute for Health Information. *CMG 1997 Directory for Use with Plx (ICD-9)*. Ottawa: Canadian Institute for Health Information, 1997.

24 Ansari MZ, Collopy BT, Booth JL. Hospital characteristics associated with unplanned readmissions. *Australian Health Review* 1995; 18(3): 63-75.

25 Ludke RL, Booth BM, Lewis-Beck JA. Relationship between early readmission and hospital quality of care indicators. *Inquiry* 1993; 30(1): 95-103.

26 Ashton CM, Kuykendall DH, Johnson ML, et al. The association between the quality of inpatient care and early readmission. *Annals of Internal Medicine* 1995; 122(6): 415-21.

27 Chen E, Naylor CD. Variation in hospital length of stay for acute myocardial infarction in Ontario, Canada. *Medical Care* 1994; 32(5): 420-35.

28 Ashton CM, Wray NP. A conceptual framework for the study of early readmission as an indicator of quality of care. *Social Science and Medicine* 1996; 43(11): 1533-41.

29 Holloway JJ, Thomas JW, Shapiro L. Clinical and sociodemographic risk factors for readmission of Medicare beneficiaries. *Health Care Financing Review* 1988; 10(1): 27-36.

30 Weissman JS, Ayanian JZ, Chasan-Taber S. Hospital readmissions and quality of care. *Medical Care* 1999; 37(5): 490-501.

31 Thomas JW. Does risk-adjusted readmission rate provide valid information on hospital quality? *Inquiry* 1996; 33(3): 258-70.

32 Farmer RG, Kay R, Achkar E, et al. Hospital readmissions: a re-evaluation of criteria. *Cleveland Clinic Journal of Medicine* 1989; 56(7): 704-8.

Appendix

Table A

Unadjusted probability of in-hospital death for acute hospital admission† for pneumonia or acute myocardial infarction, by hospital and patient characteristics, Ontario, 1998/99

	Pneumonia				Acute myocardial infarction			
		In-hospital deaths				In-hospital deaths		
	Total admissions	Number	% of total admissions	Chi-squared‡	Total admissions	Number	% of total admissions	Chi-squared‡
Total	**13,556**	**1,397**	**10.3**	**...**	**4,858**	**675**	**13.9**	**...**
Hospital characteristics								
Change in mean length of stay, 1995/96 to 1998/99								
Increase	7,404	800	10.8	4.89	1,726	258	15.0	2.18
Small decrease	2,987	287	9.6		1,680	228	13.6	
Large decrease	1,945	185	9.5		1,388	184	13.3	
Missing	1,220	125	10.2		64	5	7.8	
Recently merged								
Yes	1,359	147	10.8	0.43	88	13	14.8	0.06
No	12,197	1,250	10.3		4,770	662	13.9	
Mean length of stay, 1998/99								
Quartile 1 (shortest)	3,845	297	7.7		1,070	152	14.2	
Quartile 2	3,008	254	8.4	78.6*	1,125	134	11.9	10.0*
Quartile 3	3,143	386	12.3		1,580	211	13.4	
Quartile 4 (longest)	3,560	460	12.9		1,083	178	16.4	
Volume (separations)								
Quartile 1 (smallest)	577	47	8.2		213	30	14.1	
Quartile 2	1,601	133	8.3	13.2*	724	88	12.2	6.0
Quartile 3	3,815	427	11.2		1,951	256	13.1	
Quartile 4 (largest)	7,563	790	10.5		1,970	301	15.3	
Complexity level								
High	4,361	553	12.7	39.2*	965	152	15.8	3.5
Not high	9,195	844	9.2		3,893	523	13.4	
Patient characteristics								
Sex								
Male	6,175	599	9.7	4.49*	3,319	370	11.2	66.06*
Female	7,381	798	10.8		1,539	305	19.8	
Age group								
2-11	2,036	5	0.3					
12-24	447	5	1.1		266§	19	7.1	
25-44	1,424	46	3.2					
45-59	1,603	85	5.3	907.12*	1,188	51	4.3	279.79*
60-74	3,480	318	9.1		1,894	220	11.6	
75+	4,566	938	20.5		1,510	385	25.5	
Related admissions in previous year								
0	12,123	1,207	10.0		4,358	558	12.8	
1	872	117	13.4	15.18*	306	76	24.8	43.45*
2+	561	73	13.0		194	41	21.1	
Case complexity								
None	9,577	463	4.8		3,854	331	8.6	
Due to chronic conditions	2,239	332	14.8		489	101	20.7	
Due to serious conditions	1,084	280	25.8	1,709.61*	353	152	43.1	602.37*
Due to life-threatening conditions	656	322	49.1		162	91	56.2	

Data source: *1998/99 Discharge Abstract Database, Canadian Institute for Health Information*

† Comprises index admissions and readmissions

‡ Used to test for independence between in-hospital death and selected hospital or patient characteristic

§ Ages 12 to 44 combined because of small cell size

** $p \leq 0.05$*

··· Not applicable

Table B

Adjusted odds ratios for in-hospital death for pneumonia admission,† by hospital and patient characteristics, Ontario, 1998/99

	Adjusted odds ratio	95% confidence interval
Hospital characteristics		
Change in mean length of stay, 1995/96 to 1998/99		
Increase‡	1.00	...
Small decrease	1.01	0.81, 1.25
Large decrease	0.96	0.77, 1.21
Recently merged		
Yes	0.72*	0.53, 0.97
No‡	1.00	...
Mean length of stay, 1998/99		
Quartile 1 (shortest)	0.64*	0.51, 0.80
Quartile 2	0.75*	0.60, 0.94
Quartile 3	1.08	0.89, 1.32
Quartile 4 (longest)‡	1.00	...
Volume (separations)		
Quartile 1 (smallest)	0.71	0.45, 1.11
Quartile 2	0.82	0.63, 1.05
Quartile 3	1.09	0.87, 1.35
Quartile 4 (largest)‡	1.00	...
Complexity level		
High	0.71*	0.59, 0.87
Not high‡	1.00	...
Patient characteristcs		
Sex		
Male	1.14	1.00, 1.31
Female‡	1.00	...
Age group		
2-11‡	1.00	...
12-24	6.86*	1.32, 35.76
25-44	22.59*	6.15, 82.94
45-59	27.34*	7.17, 104.31
60-74	52.61*	14.02, 197.33
75+	133.11*	35.49, 499.24
Related admissions in previous year		
0‡	1.00	...
1	1.26	1.00, 1.58
2+	1.11	0.78, 1.59
Case complexity		
None‡	1.00	...
Due to chronic conditions	2.55*	2.12, 3.06
Due to serious conditions	6.08*	4.85, 7.63
Due to life-threatening conditions	17.34*	13.55, 22.19

Data source: *1998/99 Discharge Abstract Database, Canadian Institute for Health Information*
† Comprises index admissions and readmissions
‡ Reference category
** $p \leq 0.05$*
··· Not applicable

Table C

Adjusted odds ratios for in-hospital death for acute myocardial infarction admission,† by hospital and patient characteristics, Ontario, 1998/99

	Adjusted odds ratio	95% confidence interval
Hospital characteristics		
Change in mean length of stay, 1995/96 to 1998/99		
Increase‡	1.00	...
Small decrease	0.77	0.57, 1.05
Large decrease	0.74	0.55, 1.00
Recently merged		
Yes	1.61	0.79, 3.27
No‡	1.00	...
Mean length of stay, 1998/99		
Quartile 1 (shortest)	0.93	0.66, 1.29
Quartile 2	0.87	0.60, 1.26
Quartile 3 and 4 (longest)‡	1.00	...
Volume (separations)		
Quartile 1 (smallest)	1.17	0.60, 2.26
Quartile 2	0.96	0.60, 1.54
Quartile 3	0.91	0.61, 1.34
Quartile 4 (largest)‡	1.00	...
Complexity level		
High	0.69*	0.48, 0.98
Not high‡	1.00	...
Patient characteristcs		
Sex		
Male	0.59*	0.49, 0.72
Female‡	1.00	...
Age group		
2-44‡	1.00	...
45-59	0.53	0.27, 1.02
60-74	1.49	0.85, 2.61
75+	3.48*	1.84, 6.56
Related admissions in previous year		
0‡	1.00	...
1	1.93*	1.40, 2.66
2+	1.61	0.96, 2.70
Case complexity		
None‡	1.00	...
Due to chronic conditions	3.40*	2.68, 4.30
Due to serious conditions	10.83*	7.90, 14.84
Due to life-threatening conditions	66.11*	33.82, 129.24

Data source: *1998/99 Discharge Abstract Database, Canadian Institute for Health Information*
† Comprises index admissions and readmissions
‡ Reference category
** $p \leq 0.05$*
··· Not applicable