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Variation in management of community-acquired pneumonia requiring admission to Alberta, Canada hospitals

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SUMMARY

Previous studies have shown small area variation in the rate of admission to hospital for patients with community-acquired pneumonia. We determined the rates of admission and length of stay for patients with community-acquired pneumonia in Alberta and the factors influencing admission rates and length of stay. Using hospital abstracts, hospital admissions for community-acquired pneumonia from 1 April 1994 to 31 March 1999 were compared. We classified Alberta hospitals according to geographical regions, by the number of beds, and by number of community-acquired pneumonia cases. There were 12 000 annual hospital discharges for community-acquired pneumonia costing over $40 million per year. The overall in-hospital mortality rate was 12% and the 1 year mortality rate was 26%. Compared with rural hospitals, regional and metropolitan hospitals admitted patients with greater severity of illness as demonstrated by greater in-hospital mortality, cost per case and comorbidity. Age–sex adjusted hospital discharge rates were significantly below the provincial average in both urban regions. Hospital discharge rates for residents in all rural regions and 4 of 5 regions with a regional hospital were significantly higher than the provincial average. After adjusting for comorbidity, the relative risk for a longer length of stay was 22% greater in regional hospitals and about 30% greater in urban hospitals compared to rural hospitals. Seasonal variation in the admission rate was evident, with higher rates in the winter of each year. We conclude that rural hospitals would be likely to benefit from a protocol to help with the admission decision and urban hospitals from a programme to reduce length of stay.

INTRODUCTION

The current escalating costs of providing health care services in Canada have been described as unsustainable. Some have suggested that the problem of escalating cost is due to inefficient allocation of existing resources [1]. If efficiency is important, it must be directed towards common diseases that have a large economic burden and where practice variation rather than case mix or severity drives the utilization of resources [2]. Strategies to increase efficiency require case management or clinical pathways that are effective in altering costs or outcomes [3] and where practice variation is provider or institutionally based rather than related to patient preferences [4].

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Community-acquired pneumonia may be a condition suitable for quality improvement initiatives [6] and where an impact would potentially have significant implications on resource allocation [8]. Community-acquired pneumonia has an annual incidence of 12 per 1000 adults of which approximately 15% of cases are admitted to hospital [5]; hospitalization consumes up to 90% of direct medical costs for this condition [7]. The 30-day mortality for pneumonia in adults requiring admission to hospital is 15% [6]. Most studies detailing practice variation or specific interventions have been restricted to teaching hospitals or large community based facilities [2, 3, 6]. We were not aware of a study of the variation in hospital care for community-acquired pneumonia within an entire province or state. Information at the provincial (state) level is critical in investigating the feasibility of quality improvement initiatives aimed at medium and smaller volume facilities. In these lower volume facilities, knowledge of existing practice variation and costs allow an estimation of the potential for change. The assessment of potential impact is the first step in initiating a quality improvement process. In this study we classified Alberta hospitals and health regions by number of community-acquired pneumonia cases and assessed if anticipated efficiency would make them suitable targets for a quality improvement programme.

METHODS

Databases

Two administrative health service databases were used and the analysis was done within the protected environment of Alberta Health and Wellness governed by provincial legislative guidelines on the confidentiality of health information. These were:

(1) Canadian Institute for Health Information's (CIHI) Inpatient Discharge Abstract Database (DAD) for the province of Alberta for 1994/5 to 1998/9;
(2) Alberta Health Insurance Plan Registry File for 1994–2000.

Inclusion criteria

Community-acquired pneumonia was defined as the most responsible diagnosis (MRD) or any of the other 15 diagnosis codes defined to be Type 1 (pre-admit comorbidity) with the ICD-9CM values of 480.x to 487.x (pneumonia) or 507.x (aspiration pneumonia) excluding 484.x (pneumonia of infectious diseases classified elsewhere) [9, 10]. Episodes were excluded from analysis if the patient was not an Alberta resident or not treated in an Alberta acute care facility, or if the episode fell into an adjacent diagnosis related group (ADRG) defining hospitalization for a surgical procedure, or if there had been any previous hospitalization within 10 days of the incident pneumonia case.

Severity of illness

Severe illness was defined as any of:

(1) transfer to hospital from a nursing home, long term care or continuing care institution;
(2) transfer from another acute care facility as defined by readmission to hospital for the diagnosis of pneumonia within 48 h of previous discharge;
(3) age 65 years or more (age at the fiscal year end was used);
(4) special care unit admission (defined by each hospital);
(5) diagnosis code of respiratory failure or arrest (ICD9-CM 518.81, 799.1);
(6) diagnosis code of hypotension or shock (ICD9-CM 458.xx, 758.5x);
(7) procedure code for ventilation greater than 96 h (ICD9-CM 96.72);
(8) procedure code for dialysis (ICD9-CM 39.95 54.98).

Other details of methods

Charlson's comorbidity index was calculated using established definitions [11, 12]. Length of stay was calculated as days between discharge and admission dates. Transfers and re-admissions within the first 48 h of discharge were attributed to the index admission and cumulative hospital length of stay calculated for an episode of pneumonia.

Alternative (not acute care) level of care days (determined by the treating physician) were subtracted from the length of stay. Alternative level of care corresponds to patients who were ready for hospital discharge but an appropriate facility (usually long-term care) was not available. All active hospital acute care beds in each year per resident region were surveyed and maintained in the provincial databases. Aboriginals registered with the Department of Indian Affairs and Northern Development are recorded within the Alberta Health Care Premium Registry databank.

Categorization of hospitals

All hospitals in Alberta are administered by an autonomous regional board in each of the 17 health regions. All three million residents of Alberta are enrolled in the public health care insurance plan reside in one of the 17 health regions. Two of these health regions were considered metropolitan with cities of nearly one million population in each. Five regions have cities with populations ranging from 20 000 to 70 000 and are designated regional centres. Hospitals admitting patients with community-acquired pneumonia were categorized into five groups on the basis of the average number of hospital discharges per year over the 5-year study period, geographic location, and medical school proximity:

(1) rural hospitals were categorized by number of pneumonia cases (50 and 108 representing the 50th and 75th percentiles) into: (a) less than 50 cases/year (77 hospitals), (b) 50–108 cases/year (27 hospitals);
(2) regional hospitals (5) were categorized for each of the five non-metropolitan regional health care cities (67–251 cases/year) and one high volume rural hospital (221 cases/year) was added to this group;
(3) metropolitan hospitals (7) hospitals were located in the metropolitan health regions of Calgary and Capital hospitals (92–813 cases/year);
(4) medical school metropolitan hospitals (2) were located adjacent to medical schools – one hospital in each of two metropolitan centres (493 and 610 cases/year).

Calculating distance to nearest and admitting hospital

Each case was mapped to the centre of a postal code and distances 'as the crow flies' between centroids calculated. Nearest hospital and actual admitting hospital distances to resident postal code were obtained for all non-urban residents (not residing in Calgary or Edmonton health regions). Urban resident distances were zero.

Hospital costs

In-patient cost per resource group number (RGN) was calculated using the provincially approved methodology as set out by the Provincial Costing Project and in accordance with the Provincial and National Management Information Systems guidelines [13, 14]. Total costs combine allocation and assignment of all direct and indirect costs associated with an inpatient encounter from the time a patient is admitted to the hospital to the time of discharge. All costs were estimated in 1998/9 and assumed similar for all the study years. The quality of the data reporting of costs in Alberta has been highly ranked by the Canadian Institutes for Health Information [15]. As such, the methodological issues that arise around collection of cost data in the United States [16], in part due to the use of prices rather than costs, and for centres in Canada that cost admissions on the basis of 'case-mix grouping', do not arise with the majority of the cost data considered in this analysis.

Clinical path costs

The major incremental cost of the pathway is due to the involvement of a nurse case manager. In one urban region, four nurses can follow 3000 patients annually within the city of Edmonton. Assuming labour costs of $70 000 per nurse and that 50% of pathway patients are hospitalized, the clinical pathway cost per hospitalized patient is approximately $95.

Outcomes

(1) Hospital discharge rate per health region;
(2) length of hospital stay per hospital discharge (excluding hospital deaths in order to exclude the effect of death in artificially decreasing length of stay);
(3) re-hospitilization between 0 and 30 days after index pneumonia hospital discharge date excluding re-hospitilization for pneumonia between 0 and 2 days (considered to be a hospital transfer and incorporated in the episode of care);
(4) incident pneumonia case associated with a second pneumonia case within 2–10 days of discharge (a pneumonia case between 0 and 2 days of discharge considered to be a hospital transfer);
(5) incident pneumonia case associated with a second incident pneumonia case within 11–30 days of discharge.

Statistical analysis

Age–sex standardized rates and the 95% confidence intervals (95% CI) were calculated for hospital discharge rates. The indirect standardization method was

used with 1998/9 provincial age–sex rates (18–34 years old, 10 year increment afterwards up to 74 years old, 75 and over for each sex) as standard rates. In order to calculate standard error for the standardized rates, patient's ages at a fixed date were necessary as patient may have more than one hospital discharge in a year. Age at the fiscal year end was used for the rates and their standard errors. Overall rates between regions and Alberta in any one year and between years for any one region or Alberta were compared using *T*-statistic [17]. If the *T*-statistic was significant, individual rate differences were compared using the overall 95% CI, while adjusting for multiple comparisons. Multiple comparisons were made when contrasting the 4-yearly rates to that of the average 5-year rate and the 17 regions to the overall Alberta rate. The age–sex adjusted hospital discharge rate was compared between geographically defined health regions by 95% CIs and the overall provincial rate.

Because of the large sample size and ability to make numerous significant contrasts, only contrasts not analysed by modelling were made in the descriptive analyses. Seasonal variation was compared using a two-way ANOVA with year and season and their interaction as factors (SAS 8 [SAS Institute Inc. Cary, NC 2000] using generalized linear model least square means [Proc GLM]). Significance was defined as $P<0{\cdot}05$.

A forward stepwise selection of factors was used (SAS 8) to determine the order of importance of the factors influencing each outcome variable. For the length of stay analysis, we used the natural log transformation as the data were right skewed. Covariates were age (18–44, 45–64, 65–74, 75–84, 85+), sex, year of hospital discharge, *per capita* number of acute care beds per resident region in each study year, hospital type and distance as defined above, exported case (i.e. service region not equal to recipient region), urban or non-urban resident region, aboriginal treaty status, nursing home transfer to hospital, transfer to another hospital, special care unit admission, diagnosis code of respiratory failure/arrest, diagnosis code of hypotension/shock, procedure code for ventilation greater than 96 h, procedure code for dialysis, and number of comorbid diagnoses (0, 1, 2, >2). The unit of analysis was hospital discharge with some patients being hospitalized on multiple occasions per year. We attempted to adjust for correlations in hospital discharges within the same subject, but it did not result in substantial differences from those under the assumption of zero correlation. Therefore, we opted to report results of a simpler approach based on multiple linear and logistic models [18, 19]. To control the large sample size effect on statistical significance, we used one-third random samples from the hospital discharges data for statistical modelling [20]. The results were validated with the entire data to test for bias in the sample.

RESULTS

During the 5 years of the study there were 43 642 acute care hospital discharges for 36 516 unique patients with community-acquired pneumonia. Patients ($n=4935$) had at least one repeated admission during the 5 years (discharges per patient: mean 1·26, median 1, range 1–16). Hospital discharges decreased by 8% in 1995/6 compared with 1994/5 and were still lower than 1994/5 in the last year of our study (1998/9) by 4% (Table 1). The variation over the 5 study years in special unit admission, designation of alternate level of care, mortality and 30-day re-admission was small.

During the study period age–sex adjusted hospital discharge rates for residents in the 17 health regions were significantly below the provincial average in the two urban health regions (4 and 10) and not different from the provincial average in one regional health region (1). Hospital discharge rates for residents for all other health regions were significantly higher than the provincial average (Fig. 1). The average number of hospital beds per 1000 population during the study period was 2·4, 2·5 and 2·3 in rural, regional, and urban regions respectively. The Spearman correlation between the 5 year averaged age–sex adjusted separations and hospital beds per 1000 population in the 17 health regions was weak at 0·29 ($P>0{\cdot}05$).

The monthly patterns of hospital admissions for each of the 5 study years are shown in Figure 2. Approximately 42% of all admissions occurred between December and March. Admissions during the winter quarter (January to March) were significantly greater than the other three-quarters (which were all similar). Although the yearly total hospital discharges were stable over the study period, there was a significantly increasing trend in the winter quarter and a decreasing trend in other quarters, leading to significant interactions between season and year. The noted seasonal variation came from the fiscal years 1997/8 and 1998/9, when the winter quarter admissions nearly doubled those of the other quarters. Demographic features of the study population are given in Table 2. The cohort of patients with community-acquired pneumonia was

Table 1. *Hospital discharges (%) in acute care hospitals for treatment of community-acquired pneumonia in Alberta*

	Year 94/5	Year 95/6	Year 96/7	Year 97/8	Year 98/9	Average during 5 year period
Annual number (%) of hospital discharges	9141 (21)	7726 (18)	8260 (19)	9149 (21)	9366 (21)	43 642
Age–sex standardized hospital discharge rate per 1000 adults	4·81	3·98	4·14	4·45	4·43	4·36
Special care unit admissions	7·46	8·80	8·60	7·88	8·38	8·20
Alternative level care designation (%)	1·28	1·71	1·80	2·22	2·36	1·88
Mean (median) length of stay in days	9·46 (6)	8·75 (6)	9·06 (6)	9·04 (6)	9·40 (6)	9·16 (6)
All cause 30 day re-admissions (%)	15·47	17·28	17·72	17·35	18·02	17·15
Incident pneumonia associated with a second non-incident pneumonia within 2–10 days of discharge (%)	2·06	2·28	2·20	2·22	2·35	2·22
Incident pneumonia associated with a second incident pneumonia within 11–30 days of discharge (%)	1·55	1·67	2·13	2·06	1·78	1·84
In-hospital mortality (%)	10·4	11·8	11·8	12·2	11·4	11·6
One year mortality for pneumonia patients (%)	22·7	26·2	27·7	26·8	26·4	26·1
Total hospital costs (in $1000)	$39 327	$35 565	$37 994	$41 625	$42 642	$197 154
Average costs (in 1998/9 $) per discharge	$4302	$4603	$4600	$4551	$4553	$4518

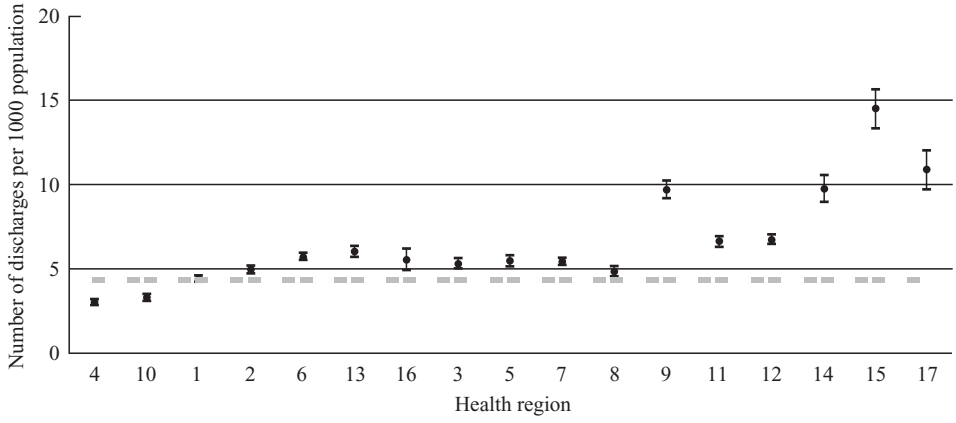

Fig. 1. Age–sex adjusted hospital discharge rates per 1000 for community-acquired pneumonia in the 17 Alberta health regions during 1994/5–1998/9. Bars indicate 95% confidence interval and dashed line is provincial average. Rates were adjusted using indirect standardization as described in methods. Regions 4 and 10 are urban, regions 1, 2, 6, 13 and 16 contain a regional hospital, regions 3, 5, 7, 8, 9, 11, 12, 14, 15, 17 are rural.

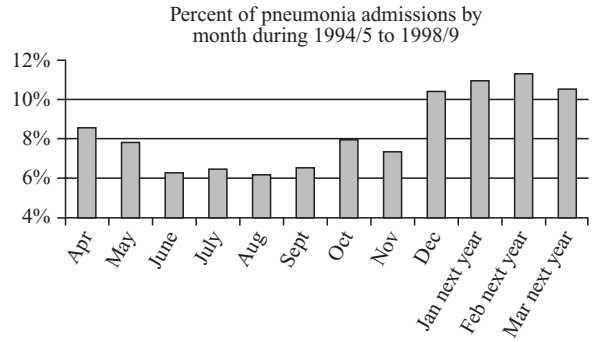

Fig. 2. Monthly variation expressed as percent annual hospital admissions for community-acquired pneumonia during 1994/5–1998/9. Each season consists of 3 months with winter defined as the months of January to March.

predominantly elderly (mean age 66 years compared with the mean age of 44 years in the 1998/9 population of adults in Alberta) and 63% had one or more comorbidities. The all cause in-hospital and 1-year mortality rates were 11·6 and 26·1% respectively. Mortality was higher for males, the elderly, those patients transferred from a nursing home, those patients with greater comorbidity and severe pneumonia (Table 2).

Compared with rural hospitals, regional and metropolitan hospitals admitted patients with greater severity of illness as demonstrated by greater hospital mortality, cost per case and comorbidity (Table 3). Special care unit admissions were highest in regional hospitals compared with medical school referral hospitals or metropolitan hospitals. Thirty-day re-admissions were higher in rural hospitals compared with all other hospital types. The outcome variable on all cause hospital re-admission was modelled using multiple regression (Table 4) after adjustment for modifying factors described above. The factor of specific interest was hospital type. The estimated odds ratio for hospital re-admission after adjustment for other factors was 0·75 (95% CI 0·64–0·89) for regional hospitals and 0·82 (95% CI 0·67–0·99) for metropolitan hospitals compared to rural hospitals. Greater comorbidity and older age increase the relative risk for all cause re-admission. When restricted to re-admissions for pneumonia only, both greater comorbidity and older age also increased the odds of re-admission within 2–10 days of hospital discharge. Only comorbidity increased the odds of re-admission for pneumonia between 11 and 30 days of hospital discharge. We have not presented these results here, but they are available on request from the authors. Calculated distances to nearest and actual admitting hospital were not retained within the model.

One measure of hospital efficiency (length of stay) was compared among hospital types. Length of stay was relatively similar in Alberta during the 5-year study period. In general, length of hospital stay increased from rural to regional to urban hospitals. The results of the log length of stay regression are shown in Table 5. After adjusting for other factors, regional and urban hospitals demonstrated a larger estimated relative risk for a longer length of stay compared with rural hospitals.

DISCUSSION

Community-acquired pneumonia is a common reason for hospital admission in Alberta. The annual hospitalization rate of 4 cases per 1000 results in 12 000 annual hospital discharges at a cost of over 40 million dollars. The incidence of community-acquired pneumonia and subsequent hospitalization varies between countries and if clinical or administrative data are used to define the illness [21, 22]. The all cause in-hospital mortality rate is 12% and 1-year mortality rate is 26%. The rate of hospital discharges is greater than the provincial average in rural health regions. In contrast, after adjusting for other factors, length of hospital stay is greater in urban and regional hospitals compared to rural hospitals. Utilization analysis may be helpful in targeting quality improvement initiatives specific to the needs of different hospitals and health regions. The existing practice environment in urban hospitals may limit hospital admissions. The existing practice environment in rural regions and some health regions with a regional hospital make the appropriateness of hospital admission a target for quality improvement. Conversely the existing practice environment in urban hospitals makes the length of stay (i.e. time between hospital admission and discharge) a more likely target for quality improvement compared with rural hospitals. Regions with regional hospitals have an increased length of stay and most have a higher admission rate. Therefore, the decision to admit and discharge may both be quality improvement targets. Quality improvement targets vary and should be specific to the hospital type and/or geographic location.

Hospital admission for community-acquired pneumonia demonstrates seasonal variation [23] and efforts to improve the appropriateness of admission might be best timed at peak periods. In this manner, total programme costs could be distributed amongst other

Table 2. *Patient characteristics* (*number and percent*) *for community-acquired pneumonia hospital discharges in Alberta during 1994/5–1998/9 and for hospital discharges ending in a patient death*

	All pneumonia hospital discharges ($n=43\,642$)	All cause in-hospital mortality for pneumonia hospital discharges ($n=4693$)	All cause one year mortality for pneumonia hospital discharges ($n=11\,370$)
Female	21 070 (48)	1954 (42)	4633 (41)
Age group (years)			
18–44	8058 (18)	182 (3·9)	461 (4·1)
45–64	8441 (19)	571 (12)	1508 (13)
65–74	8664 (20)	910 (19)	2359 (21)
75–84+	11 412 (26)	1590 (34)	3877 (34)
85+	7067 (16)	1440 (31)	3165 (28)
Aboriginal treaty status	2799 (6)	29 (0·6)	240 (2·1)
Transfer from nursing home	1531 (4)	432 (9·0)	968 (8·5)
Transfer to another hospital	943 (2)	1 (0·02)	315 (2·8)
Urban region of residence	18 443 (42)	2665 (57)	5837 (51)
Exported from home region	5247 (12)	510 (11)	1387 (12)
Separation alternate level of care designated	822 (1·9)	99 (2·1)	413 (3·6)
Special care unit admission	3578 (8·2)	926 (20)	1405 (12)
Comorbidity (0)	16 316 (37)	562 (12)	1655 (15)
Comorbidity (1)	14 705 (34)	1405 (30)	3791 (33)
Comorbidity (2)	7937 (18)	1477 (31)	3374 (30)
Comorbidity (>2)	4684 (11)	1279 (27)	2550 (22)
Chronic obstructive pulmonary disease	14 363 (33)	1510 (32)	4060 (36)
Diabetes	5403 (12)	710 (15)	1733 (15)
Malignancy	3505 (8·0)	1053 (22)	2439 (21)
Congestive heart failure	8492 (19)	1618 (35)	3682 (32)
Vascular (acute myocardial infarction, peripheral vascular disease, cerebral vascular disease	6319 (14)	1440 (31)	2738 (24)
Hypotension/shock	997 (2·3)	413 (8·8)	576 (5·1)
Respiratory arrest/failure	2027 (4·6)	877 (19)	1183 (10)
Ventilation for more than 96 h	617 (1·4)	259 (5·5)	326 (2·9)
In-hospital dialysis	282 (0·65)	75 (1·6)	135 (1·2)

Note: The percent of deaths are by hospital discharge in Table 2 whereas in Table 1 death rate is per person.

programmes with a complementary seasonal variation (i.e. trauma). Mortality for those hospitalized with community-acquired pneumonia is high, probably related to its occurrence in those with serious chronic diseases and the elderly [24]. This study does not directly specify what practice differences among rural, regional and urban hospitals might lead to treatment variations. The numbers of hospital beds per 1000 population was not dramatically different among regions nor were hospital beds per 1000 population correlated to the hospital discharge rate. Comparative bed counts may not be reflective of the pressures exerted to fill these beds. Urban and regional hospital beds may have greater pressures exerted because of their use in referred cases from rural regions and medical services not provided in non-tertiary or non-teaching hospitals. Distance from home to hospital was not predictive of any outcome such as length of stay or re-admission so that it was not associated with practice patterns in specific regions.

Algorithms to help clinicians decide upon hospital admission and discharge have been devised, validated and published [3, 4, 25–28]. These guidelines are robust even in the elderly [29] and may decrease mortality [22]. Despite clinical guidelines, considerable variation exists in the treatment of community-acquired

Table 3. *Hospital discharges for community-acquired pneumonia by hospital type during 1994/5–1998/9*

Hospital type	Number (%) of hospitals in this category	Number (%) of total hospital discharges	% special care unit admissions	% alternate level of care designation	Mean (median) length of stay in days	% without comorbidity	Average (S.D.) no. of comorbidities	% 30 day re-admissions	% in-hospital mortality for pneumonia patients	Average hospital costs ($) per pneumonia discharge by hospital category
Rural (<50 cases per year)	77 (65)	9136 (21)	2·4	0·9	7·52 (5)	27·3	0·76 (0·91)	18·2	6·7	$3501
Rural (50–108 cases per year)	27 (23)	9367 (21)	4·4	1·5	7·62 (5)	26·9	0·81 (0·95)	18·5	8·0	$3542
Regional	6 (5)	5828 (13)	14·3	1·6	9·46 (6)	12·8	1·1 (1·1)	16·3	12·1	$4551
Urban (metropolitan)	7 (6)	13 795 (32)	9·5	2·4	10·58 (7)	23·5	1·32 (1·18)	15·5	15·2	$5250
Urban (hospitals in proximity to a medical school metropolitan)	2 (1)	5516 (13)	14·7	3·1	10·56 (7)	9·5	1·36 (1·22)	18·0	15·1	$5991

pneumonia within larger Canadian hospitals [2]. From the clinicians' perspective, variability in the decision to admit depends upon perceived availability of outpatient intravenous antibiotics, home care and identification of the low risk patient [4]. Physicians' estimation of pneumonia severity is greater than that obtained using a standardized tool [30]. Physicians believed that diagnostic evaluation, treatment of comorbid illness, completion of a standard course of antibiotics, and wait for long term care may delay discharge in clinically stable patients [25]. Patients stay in hospital 2–4 days after stabilization [3]. Medical outcomes, however, were similar in patients admitted to hospitals with the shortest length of stay compared to the longest length of stay [31]. A randomized trial in one urban Alberta health region demonstrated an average 2-day reduction in length of hospital stay using a clinical pathway [3]. Thus even if our study did not adjust adequately for case severity and mix, a decrease in length of stay is possible even for these urban hospitals patients who had the greatest comorbidity. Hospitalization costs in the United States are comparable with those reported in this study (US$5942) with a potential savings of US$680 with a 1 day length of stay reduction [32].

Small area variation studies such as ours are plagued with the unanswerable question 'which rate is right?' [33]. In our study, regional differences in hospital discharge rates existed. While it is theoretically possible to interpret our data as implying that discharges from rural hospitals were too early and that urban hospitals had too stringent criteria for admissions, we discounted this interpretation. It would seem implausible that clinicians would both admit too many patients and simultaneously discharge pneumonia patients inappropriately too early. The literature on practice patterns for community-acquired pneumonia does not note a high frequency of inappropriate early hospital discharges. Further, data from other studies and a locally validated clinical pathway demonstrated just the opposite [3] – a decrease in length of stay did not increase untoward effects [3, 31]. There exists a limited ability in Canada to deny appropriate admissions – only delay is possible. Patients inappropriately denied initial hospital admission would likely return and be admitted at a later date. As the Alberta health system in comprehensive we did not 'lose' patients to other jurisdictions or hospital systems. Even death after the initial hospital denial is not a plausible explanation for lower admission rates as 75% of patients in Canada die in hospital [34]. The

Table 4. *Multiple logistic regression for any re-hospitalization between 2 and 30 days after index pneumonia hospital discharge date*

	Odds ratio	95% CI
Comorbidity (1)*	1·65	1·46–1·87
Comorbidity (2)*	2·28	1·97–2·64
Comorbidity (>2)*	2·52	2·12–3·01
Urban region of residence	0·82	0·69–0·98
Special care unit admission	1·60	1·35–1·90
Transfer from home region	1·36	1·18–1·56
Rural (50–108 cases per year)†	NS	
Regional†	0·75	0·64–0·89
Urban (metropolitan)†	0·82	0·67–0·99
Urban (metropolitan hospitals in proximity to a medical school)†	NS	
Female	0·84	0·76–0·92
In-hospital dialysis	2·29	1·36–3·88
Age group (years)		
45–64‡	NS	
65–74‡	1·24	1·05–1·47
75–84‡	1·31	1·11–1·55
85+‡	1·44	1·20–1·72
Hypotension/shock	1·45	1·03–2·03
Aboriginal treaty status	1·26	1·05–1·52
Transfer from nursing home	0·74	0·55–0·99

Note for reference group where * reference is comorbidity (0), † reference is rural (less than 50 cases per year), and ‡ reference is age 18–44. The order of factors entry into the model is from top to bottom and indicate their relative order of significance.

Table 5. *Multiple linear regression for log length of hospital stay**

	Relative risk	95% CI
Age group (years)		
45–64§	1·25	1·20–1·30
65–74§	1·48	1·42–1·54
75–84§	1·66	1·60–1·74
85 years and over§	1·91	1·82–2·00
Comorbidty (1)†	1·17	1·13–1·21
Comorbidity (2)†	1·40	1·35–1·46
Comorbidty (>2)†	1·58	1·50–1·66
Transfer to another hospital	2·25	2·07–2·45
Rural (50–108 cases per year)‡	NS	
Regional‡	1·22	1·17–1·28
Urban (metropolitan)‡	1·28	1·24–1·33
Urban (metropolitan hospitals in proximity to a medical school)‡	1·27	1·21–1·34
Special care unit admission	1·29	1·22–1·37
Mechanical ventilation greater than 96 h	1·93	1·67–2·23
Respiratory failure/arrest	1·33	1·23–1·44
Aboriginal treaty status	0·85	0·81–0·90
Hypotension/shock	1·21	1·09–1·35
Female	1·05	1·02–1·07
Transfer from nursing home	0·90	0·83–0·97
In-hospital dialysis	1·20	1·01–1·43

* Excludes length of stay for those dying in hospital. Note for reference group where † reference is comorbidity (0), ‡ reference is rural (less than 50 cases per year), and § reference is age 18–44 years and the order of factors entry into the model is from top to bottom and indicate their relative order of significance.

importance of rate differences and potential for impact upon care received require clinical judgement. Utilization analysis provides a quantification of existing differences: larger as in hospital discharge rates; less in length of stay; and small with re-admissions. Utilization analysis helps target where the probability of potential change is greater because variation is greater. However, an overall provincial rate may still be uniformly too high or too low even though the variation may be small.

Our study had several limitations. Hospital discharges were greater in number in regional and rural hospitals and fewer in urban hospitals. Although community-acquired pneumonia incidence may vary geographically, we also noted that comorbidity increased from rural to urban hospitals. Urban hospitals may be more effective in triaging hospital admissions. Once admitted however, length of stay was greater in urban and regional hospitals compared to rural hospitals. In this study we constructed an episode of care by attributing re-admissions within the first 2 days of discharge back to the original index admission. As the date of re-admission becomes more remote from the actual discharge date, the influence of the first admission will be less. Although using the first 48 h re-admissions as a cut-off for constructing an episode of care was arbitrary, we were more confident that a shorter interval would more likely be related to the original hospital admission. Re-admissions after 2 days and within the first 10 days attributable to a pneumonia diagnosis occurred after 2·2% of hospital discharges. Even extending the cut-off to as long as 10 days post discharge would result in altering the length of stay in only about 2% of cases. As the cut-off time is extended we increase the probability that separate admissions have been inappropriately combined. Population based administrative database research is highly generalizable although limited in clinical details. We attempted to adjust for case severity (hypotension/shock, respiratory arrest/failure, ventilation, special

care unit admission, export to another region, transfer to another hospital) and case mix (comorbidity, transfer from nursing home, age, sex) but may not have captured all variation [35]. These variables are likely to be less reliable than a clinically derived pneumonia index [3]. Also, we have no index for family support which may have varied geographically and impacted upon length of stay. Data about regional variation in the use of influenza and pneumococcal vaccine was unavailable. In particular, influenza vaccine has been shown to reduce the hospitalization rate for pneumonia in the elderly [36].

We believe that a clinical pathway targeting appropriateness of hospital admission in rural hospitals and length of stay in urban hospitals would be beneficial. Either strategy may be applicable to health regions with a regional hospital. More generally, a targeted approach to quality improvement for any size hospital may diminish the costs of the initiative rather than attempting a broader, more comprehensive programme. The actual cost per patient for a community-acquired pneumonia clinical pathway in one Alberta study was small: about $95 [3]. Our study suggests the use of clinical pathway decision aids at the time of hospital admission may be reasonable even for smaller rural hospitals. The next suggested step for a hospital or health region wishing to initiate a community-acquired pneumonia clinical pathway is a retrospective review of the actual criteria used to admit or discharge patients with pneumonia in their facility.

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