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Length of ICU stay for chronic obstructive pulmonary disease varies among large community hospitals

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Abstract *Objective:* To determine whether differences exist among large community hospitals in length of Intensive Care Unit (ICU) stay, hospital stay or hospital mortality for patients admitted to ICU and whose most responsible diagnosis was chronic obstructive pulmonary disease (COPD). *Design:* Retrospective cohort study. *Setting:* All seven large community hospitals in British Columbia, Canada. *Patients:* All 296 patients who were admitted to ICUs and whose most responsible diagnosis was COPD during the 3 fiscal years 1994–1997. *Interventions:* None. *Measurements and main results:* After adjusting for age, gender, case-mix group, and co-morbidity, we found a significant difference in length of ICU stay for these patients among hospitals (P <0.03). No differences were found in hospital mortality or length of hospital stay for the same patients among the same hospitals. *Conclusions:* There is significant variation in length of ICU stay for patients who are admitted to ICU and whose most responsible diagnosis is COPD, among large community hospitals. These small area variations may point to opportunities to improve efficiency of care. Further prospective, detailed data collection is required to validate these observations and to identify factors responsible for any differences found.

Keywords Intensive care · Critical care unit · Benchmarking · Chronic obstructive pulmonary disease · Mortality · Length of ICU stay · Efficiency · Effectiveness

Introduction

Increasing demand for health services arising from both an expanding and aging population, coupled with a consistent influx of new technologies to care for patients, has created a fiscal crisis within most health care systems. While there are a number of ways to respond to this dilemma, one approach is to focus efforts on increasing efficiency. As efficiency encompasses both the effectiveness and the associated costs of health care processes, increasing efficiency may allow the delivery of a greater number of services with currently available resources. The greatest potential savings can be realized by improving efficiency of high-cost services, such as those found in Intensive Care Units (ICUs).

One approach to improving the efficiency of a healthcare system is to use knowledge gained from understanding variation in outcomes to identify opportunities for improvement. Although patient survival is an outcome of great interest, lengths of ICU stay and hospital stay are also meaningful outcomes. Increased length of stay, especially in the ICU, translates directly into increased healthcare costs. Small area variation in patient outcomes has been observed in a variety of patient populations [1, 2, 3, 4, 5, 6]. If variation in outcomes is observed, further study of the processes of care may identify factors associated with best practice. This process is called benchmarking [7, 8]. If such factors can be identified and universally adopted, quality of care across healthcare systems may be improved.

Chronic obstructive pulmonary disease (COPD) patients have been cared for in the critical care setting for many years [9]. While the relative proportion of patients admitted to the ICU due to an exacerbation of COPD is less than that in the past, these patients may require long stays. The objective of this study was to determine whether there is variation in length of ICU and hospital stay, and hospital mortality for patients who are admitted to ICU and whose most responsible diagnosis is COPD, among the seven large community hospitals in British Columbia (B.C.), Canada.

Materials and methods

Databases

We used two administrative databases of the Province of B.C. after permission was obtained from the B.C. Ministry of Health and Ministry Responsible for Seniors. These databases were linked by encrypted personal health number and prepared by the Centre for Health Services and Policy Research at the University of British Columbia using generalized linkage software created by the project staff [10]. The Hospital Separations File includes data on demographics, postal code, case-mix group (CMG), major clinical category, discharge diagnoses, procedures performed, use of physiotherapy or occupational therapy, length of hospital stay, length of stay in ICU and/or cardiac care units (sum of all ICU and/or cardiac care unit stays during a given hospital encounter), transfer to and from other hospitals, and hospital outcome (mortality) for each hospital encounter. The Vital Statistics Death File includes dates and causes of deaths occurring in B.C. In addition to these two files, we used one other information source and linked it locally to the above two files: Hospital Peer Group (designated by the Ministry of Health) codes all hospitals as follows: 00, non-Health Information Management System hospitals; 01, large teaching hospitals; 02–07, regional (large community) or local (smaller community) hospitals in descending order of size; 08 diagnostic and treatment centers; 09, free-standing extended care; and 10, specialty hospitals.

Patients

The file provided by the Ministry of Health was created upon request to be comprised of all patients admitted to a hospital-designated ICU in British Columbia during any of the three fiscal years beginning 1 April 1994 and ending 31 March 31 1997. Patients admitted with COPD were defined as those patients assigned CMG number 136 or 148: chronic obstructive pulmonary disease or chronic bronchitis (CMG 136) and asthma age >70 with complications (CMG 148); or those patients over 50 years of age assigned CMGs 146 and 147: bronchitis and asthma age <70 without complications (CMG 146) or bronchitis and asthma age <70 with complications or age >70 without complications (CMG 147). We elected to include all these CMGs due to the fact that variation in coding practices among and within institutions [11] can lead to similar patients being assigned to any of these CMGs. While patients have ICD-9 codes recorded for a number of diagnoses, the CMG is the diagnosis that is considered ‘most responsible’ for the patient’s hospital admission.

To select a group that would have a similar severity of illness, we restricted our focus to patients who had COPD and who were admitted to ICUs in the seven large community hospitals (hospital peer group 2) of B.C. In the absence of severity of illness scores in these administrative databases, we assumed that these hospitals, which are recognized as similar sized by the Ministry of Health, admit patients of similar illness severity to their respective ICUs. We elected to study this group of hospitals because there are more hospitals in this group than in the group of larger hospitals, and more patients are admitted to these hospitals than to smaller hospitals. The first feature increased our potential to find differences among hospitals, and the second feature increased our power to demonstrate statistical significance for any differences found.

These large community hospitals range in size from 230 to 400 acute care beds and all have mixed medical-surgical ICUs with 8–12 beds and ability to provide mechanical ventilation for 5–11 patients. All have ICU directors, although not all are trained intensivists. While three have formally ‘closed’ ICUs, most have a restricted attending staff. All ICUs have similar nurse:patient ratios, 24-h in-house respiratory therapist coverage, and the ability to monitor patients with pulmonary and systemic arterial catheters. While actual occupancy rates are not available, in general all ICUs run close to, or at, full capacity at all times. None of these hospitals has a high dependency unit (intermediate care area) that allows noninvasive ventilation. Noninvasive ventilation, if available, is permitted only in the ICU or emergency room.

Analysis

First, the databases were carefully reviewed for missing or invalid data. Any invalid data were deleted. For those patients who had more than one hospital admission during the 3-year period, only the initial admission was used for this analysis.

Characteristics of patients admitted with COPD to the seven large community hospital ICUs were compared to determine whether differences existed in age distribution, gender, co-morbidity score, and specific CMG distribution. The latter was assessed because there may be a difference in severity of illness among specific CMGs within the CMG cluster describing COPD. This univariable analysis was conducted using Pearson’s chi-square test for categorical variables and the Kruskal-Wallis H-test for continuous variables. To control for potential differences in co-morbid illness among patients and ICUs we used the clinical co-morbidity index proposed by Romano and coworkers [12]. This co-morbidity index was adapted from the Charlson index [13] for use with ICD-9 administrative databases. All ICD-9 diagnoses recorded for the index admission, except the most responsible diagnosis, were used to develop this co-morbidity index. In order to express co-morbidity as a summary score we applied the weighted score for each co-morbid diagnosis (range from 1 to 6) as described by D’Hoore and colleagues [14] and added these weighted scores. Both the Charlson and the D’Hoore indices have been shown to correlate with mortality [13, 14].

To compare crude hospital mortality among the hospitals we used Pearson's chi-square test. To adjust for gender, age, co-morbidity and specific CMG, we developed a logistic regression model in which hospital survival was the dependent variable and age, gender, co-morbidity score, CMG, and hospital were independent variables. In a similar fashion, we compared length of ICU and hospital stay among hospitals using the Kruskal-Wallis H-test.

To adjust for potential confounders, we developed a Poisson regression model in which length of ICU stay was the dependent variable and age, gender, co-morbidity score, CMG, and hospital were independent variables. We used a similar model to analyze length of hospital stay. To control for the effect of mortality on length of stay we repeated this analysis for each outcome in the hospital survivors alone. To adjust for the overall risk of death in each hospital, we repeated this analysis for hospital survivors with hospital mortality as an explanatory variable. The Poisson models were adjusted for over-dispersion by scaling the standard errors of parameter estimates by the square root of the deviance divided by the degrees of freedom. The deviance was used to assess the goodness of fit of the models. Diagnostic plots of residuals versus normal distribution percentiles were used to check for violations of model assumptions. The plots for each of the models were linear indicating no violation.

This study was approved by the University of British Columbia/Providence Health Care Research Ethics Board and no consent was required.

Results

During the 3-year period, 296 patients whose most responsible diagnosis was COPD were admitted to ICUs in large community hospitals in B.C. (29–97 patients per ICU). The proportion of patients who were male ranged from 48.3% to 54.6% and mean age ranged from 66.0±14.2 years to 71.4±9.2 years, but there were no significant differences in these variables among hospitals (Table 1). The mean co-morbidity score ranged from 0.74 to 1.59 and the median scores were 1 in all hospitals but one (Table 1). The majority of patients with COPD were represented by the CMG 136 [202/296 (68%)], with lesser numbers in CMG 146 [8/296 (3%)], 147 [51/296 (17%)], and 148 [35/296 (12%)]. Hospital mortality ranged from 10.8% to 29.0% but was not significantly different among hospitals in univariable analysis (P =0.200) or after adjusting for age, gender, and co-morbidity score (P =0.213).

Univariable analysis showed that length of ICU stay differed among hospitals (P =0.029) but length of hospital stay did not (P =0.219). In multivariable analyses that adjusted for age, gender, co-morbidity score and CMG, length of ICU stay continued to differ significantly among hospitals for all patients and for hospital survivors alone (Table 2). When we included hospital mortality in the model for hospital survivors, we found that this variable was not a significant predictor of length of ICU stay (P =0.233) and that it did not change the significant relationship between hospital site and length of ICU stay (P =0.003). No other factors were associated with length

Table 1 Demographics and outcomes of COPD patients admitted to ICUs in large community hospitals

	n	Gender (% male)	Age (mean, SD)	Co-morbidity index (median, range)	Hospital mortality (%)	Length of ICU stay (median, range)	Length of hospital stay (median, range)
Hospital A	29	48.3	71.2 (9.2)	1 (0,4)	13.8	3.0 (1,18)	9.0 (2,30)
Hospital B	31	48.4	70.7 (9.4)	1 (0,12)	29.0	2.0 (1,8)	13.0 (1,116)
Hospital C	35	51.4	69.1 (9.3)	0 (0,3)	20.0	2.0 (1,8)	10.0 (1,59)
Hospital D	35	51.4	70.6 (9.3)	1 (0,4)	28.6	3.0 (1,14)	10.0 (3,66)
Hospital E	37	51.4	66.6 (13.2)	1 (0,8)	10.8	1.0 (1,7)	8.0 (0,59)
Hospital F	97	54.6	70.2 (8.7)	1 (0,13)	13.4	2.0 (1,18)	8.0 (0,83)
Hospital G	32	53.1	66.0 (14.2)	1 (0,9)	21.9	2.5 (1,10)	8.0 (1,76)
P value		0.996	0.2116	0.2335	0.200	0.0286	0.2185

Table 2 Multivariable analysis for length of ICU stay in COPD patients

Parameter	All patients			Hospital survivors		
	Beta	Standard error	P value	Beta	Standard error	P value
Age	−0.0030	0.0048	0.5314	−0.0049	0.0050	0.3203
Male gender	0.0342	0.0955	0.7204	0.0936	0.1053	0.3740
Hospital A[a]	0.8824	0.2159	0.0001	0.8025	0.2271	0.0004
Hospital B	0.3154	0.2347	0.1789	0.4277	0.2497	0.0867
Hospital C	0.6044	0.2138	0.0047	0.7183	0.2209	0.0011
Hospital D	0.5914	0.2157	0.0061	0.3119	0.2475	0.2076
Hospital F	0.4690	0.1903	0.0137	0.3976	0.1973	0.0439
Hospital G	0.3179	0.2291	0.1652	0.2901	0.2435	0.2334
Co-morbidity	−0.0091	0.0314	0.7722	0.0127	0.0372	0.7319
CMG 136	0.0757	0.1066	0.4778	0.0288	0.1142	0.8006

[a] Estimates for each hospital are compared to hospital E, the hospital with the shortest length of ICU stay

Table 3 Multivariable analysis for length of hospital stay in COPD patients

Parameter	All patients			Hospital survivors		
	Beta	Standard error	P value	Beta	Standard error	P value
Age	0.0057	0.0054	0.2893	0.0048	0.0056	0.3866
Male Gender	0.0394	0.1013	0.6972	0.0564	0.1107	0.6101
Hospital A[a]	0.1637	0.2378	0.4912	0.0974	0.2446	0.6904
Hospital B	0.5486	0.2073	0.0082	0.4754	0.2261	0.0354
Hospital C	0.3504	0.2093	0.0941	0.3862	0.213	0.0697
Hospital D	0.3088	0.2124	0.1459	0.1514	0.2318	0.5136
Hospital F	0.0892	0.1842	0.6283	0.0279	0.1834	0.879
Hospital G	0.2063	0.2169	0.3414	0.0556	0.23	0.8091
Co-morbidity	0.0398	0.027	0.1406	0.0559	0.0332	0.0921
CMG 136	0.367	0.1216	0.0025	0.3927	0.1287	0.0023

[a] Estimates for each hospital are compared to hospital E, the hospital with the shortest length of ICU stay

of ICU stay. Similar multivariable analyses for length of hospital stay showed that only hospital B differed from hospital E, the reference hospital, and the only other factor that was significantly associated with hospital length of stay was CMG 136 (Table 3).

Discussion

After controlling for age, gender, co-morbidity, and diagnostic group, we found significant differences in the length of ICU stay for patients whose most responsible diagnosis is COPD and who are admitted to ICUs in large community hospitals in British Columbia. Only one hospital differed from the reference hospital in length of hospital stay. We believe that this is the first study to demonstrate variation in length of ICU stay for COPD patients admitted to peer institutions.

Shorter length of ICU stay with no difference in hospital survival may indicate greater efficiency of care, a goal desirable for all ICUs. While this difference in length of ICU stay may be confounded by patient-specific factors, such as differing severity of illness or proportion of patients receiving mechanical ventilation, we believe that this is unlikely for the following reasons. First, the B.C. Ministry of Health considers these hospitals to be peers, treating similar patients. We found that hospital mortality was similar across all institutions (in both univariate and multivariate analyses) for this patient group. Second, we adjusted for co-morbidity score which correlates independently with mortality [13, 14]. Third, we identified inter-hospital differences in length of stay even when we considered only the hospital survivors. Finally, we still found interhospital differences in length of ICU stay after we adjusted for overall hospital mortality at each hospital (a surrogate for average severity of illness at that hospital). If this difference in length of stay reflects differences in practice among hospitals that are amenable to change, we have identified an important area for further study. If process factors associated with shorter length of stay and equal morbidity and mortality can be identified through careful prospective study and applied across the healthcare system, improved efficiency could be realized.

Variation in the delivery of health care services appears to be the norm rather than the exception [1, 2, 3, 4, 5, 6]. Differences in outcomes and processes of care have been demonstrated among peer hospitals [1, 2, 3, 4, 5, 6], between teaching and community hospitals [15, 16], between 'best hospitals' and others [17], and within hospitals by level of specialization [18, 19]. These differences may be explained by differences in patient factors such as severity of illness or co-morbid disease. In addition to patient factors, differences in outcome may be due to variations in practice patterns. These may arise as a result of clinical uncertainty and the absence of compelling evidence, or variation in the application of evidence into practice. Regardless, variation in practice that exceeds variation due to patient factors represents an opportunity to improve patient care and clinical outcomes.

The movement of evidence-based medicine outlines a methodical approach to practicing medicine in a fashion that maximizes benefit and minimizes harm. This approach includes formulating an appropriate clinical question, searching and appraising relevant evidence in a systematic fashion, using best evidence and considering of individual and societal values to make the best decisions for the individual patient, and then evaluating the result [20]. A complimentary approach to improving patient care is benchmarking [7, 8]. Benchmarking involves the systematic comparison of processes or outcomes among similar providers to identify the practices that are associated with best outcomes. If differences in outcomes are found, improvement strategies can be used to adopt 'best practices' across participating centers so that overall outcomes will improve.

Are there other factors that may account for the differences in ICU length of stay that we observed? Care for patients with COPD admitted to an ICU has undergone a major change in the last decade and variation in the adoption and implementation of new technologies may explain differences in length of ICU stay. For example, the introduction of noninvasive ventilation for acute exacerbations of COPD has been demonstrated to improve hospital survival and length of stay [21, 22, 23, 24, 25, 26, 27, 28, 29], most likely as a result of avoiding the harmful effects of endotracheal intubation, including ventilator-associated pneumonia [24]. Unfortunately, our databases did not capture information on the use of noninvasive ventilation. In addition, the use of high dependency units (intermediate care areas) has been associated with decreased mortality after discharge from ICU [30] and may be associated with fewer readmissions to ICU; therefore, use of high dependency units may influence length of ICU stay. However, none of the hospitals in this study have a high dependency unit. While one may speculate that physician training may affect outcome, Regueiro and colleagues found no difference in survival or resource utilization between COPD patients cared for by respirologists or by generalists [18]. It is possible that other organizational features, such as staffing by intensivists [31] and use of protocols [32], may influence length of ICU stay. We have no data about these variables in the hospitals in this study.

The strengths of our study include the absence of a sampling bias by including all patients admitted to the ICUs of interest over a 3-year period. We also have tried to avoid comparing patient populations of differing severity of illness by studying peer hospitals. The mortality rates for COPD among the hospitals in our study range from 11% to 29% and are comparable to those reported by others [33, 34, 35, 36, 37], suggesting that our population of COPD patients is similar in severity to those admitted to other ICUs. In addition, we adjusted for co-morbidity by using an accepted index. Despite these strengths, there are also important limitations to this study design. Given the retrospective design, we relied on CMGs to create our diagnostic group of interest. The CMG describes the diagnosis most responsible for the hospital encounter but it is not necessarily the reason for admission to ICU. Diagnoses responsible for ICU admission are not identified in the hospital separation file. Similarly, severity of illness is not recorded in these files and therefore we were not able to adjust for this important variable. In addition, we have no measure of the stage of COPD for the patients we considered. While these ICUs may be similar in their admission policies and patient profiles (all being large community hospitals), it remains possible that differences among COPD patients admitted to these ICUs account, in part, for the differences seen in length of ICU and hospital stay.

In conclusion, we have found a significant difference in length of ICU stay for patients with COPD, among the large community hospitals in B.C. after adjusting for age, gender, co-morbidity score, and specific CMG. This difference may be due to differences in processes of care but may also be due to differences in patient factors that we were unable to measure. Nevertheless, these findings justify further prospective study to determine if this difference is sustained over time and if it persists after adjustment for severity of illness. If so, then the next step will be to identify processes of care that are associated with length of ICU stay and to implement changes in these processes so that overall outcomes will be improved.

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