

ABSTRACT

Objective: The average per person direct cost of illness of cardiorespiratory disease episodes was estimated based on a prospective study of emergency department visits.

Methods: Economic modelling of health care costs using prospectively collected resource utilization data (9/1/94 to 8/31/95) from hospital emergency department visitors assigned a diagnosis of asthma, chronic obstructive pulmonary disease (COPD), respiratory infections or cardiac conditions.

Results: The total direct costs (1997 CDN\$) [95% C.I.] per patient were \$1,043.55 [\$922.65, \$1,164.47] for asthma, \$1,690.11 [\$1,276.92, \$2,103.30] for COPD, \$676.50 [\$574.46, \$778.54] for respiratory infections, and \$3,318.74 [\$2,937.72, \$3,699.76] for cardiac conditions.

Conclusions: This study showed that on average, patients diagnosed with a cardiac condition had the highest total direct cost. Hospitalization cost was the largest component of costs for all diagnoses except asthma, for which medications were the single largest component of direct costs.

ABRÉGÉ

Objectif : Le coût direct moyen par personne des épisodes de maladies cardiorespiratoires a été évalué en fonction d'une étude prospective des visites au service des urgences.

Méthodes : Établissement de modèles économiques des coûts relatifs aux soins médicaux d'après des données sur l'utilisation des ressources recueillies prospectivement (du 1er septembre 1994 au 31 août 1995) de services des urgences d'hôpitaux au sujet de patients ayant les diagnostics suivants : asthme, bronchopneumopathie chronique obstructive (BCO), infections respiratoires ou maladies cardiaques.

Résultats : Les coûts directs totaux (\$CAN 1997) [IC de 95 %] par patient étaient de 1 043,55 \$ [922,65 \$, 1 164,47 \$] pour l'asthme, de 1 690,11 \$ [1 276,92 \$, 2 103,30 \$] pour les cas de BCO, de 676,50 \$ [574,46 \$, 778,54 \$] pour les infections respiratoires, et de 3 318,74 \$ [2 937,72 \$, 3 699,76 \$] pour les maladies cardiaques.

Conclusions : Cette étude montre qu'en moyenne, les coûts directs totaux sont plus élevés pour les patients atteints d'une maladie cardiaque. Les coûts d'hospitalisation représentaient la principale part des coûts directs pour tous les diagnostics à l'exception de l'asthme où le coût des médicaments était le plus important.

The Costs of Cardiorespiratory Disease Episodes in a Study of Emergency Department Use

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The first point of contact for individuals with urgent health problems is often the emergency department (ED). We recently completed a study of ED use due to cardiorespiratory conditions as part of a larger study on the health effects of air quality¹ which was motivated by the recent public health concerns over this issue.²⁻⁶ Several studies have documented an association between air quality and ED visits for respiratory diseases.⁷⁻¹⁶ Thus the emergency department served as a useful reference point from which to capture the potential health costs of cardiorespiratory disease episodes. In this paper, we describe the cost methodology used to estimate the average per person direct cost of illness for four cardiorespiratory conditions and discuss the results.

METHODS

Data collection

The study design and data collection are described in detail in the companion paper.¹ Briefly, data were collected prospectively between September 1, 1994 and August 31, 1995 at the two hospital emergency departments in Saint John, New Brunswick for emergency visits that were assigned a diagnosis of asthma,

chronic obstructive pulmonary disease (COPD), respiratory infections, or cardiac conditions. Follow-up was conducted using a structured telephone interview in which consenting patients were asked about the occurrence of various outcomes from the onset of their earliest symptoms until the follow-up interview. Estimates of out-of-hospital costs were based on these data.

Estimates of costs for hospitalization episodes were based on inpatient utilization data abstracted from clinical records for a sample of 393 patients. These inpatient records were selected randomly after stratification for the four diagnosis groups considered. Types of utilization data captured in the record abstracts included medication, procedures, investigations, physician care and length of stay.

Cost calculation

The direct cost of cardiorespiratory disease episodes included six cost categories: hospital utilization, emergency department visits, physicians visits, concomitant medication use, equipment and out-of-pocket expenses. The methodology used to calculate each cost category is as outlined below. All costs were deflated by the Price Index for all products¹⁷ and are in 1997 Canadian dollars.

Emergency Visits: The cost of emergency visits included the initial visit by the patient and any subsequent visits prior to the telephone interview. A fully allocated cost including that for all hospital-based resources and physician time was estimated.

Physicians Visits: Each physician clinic visit was assumed to be a "minor assessment" and valued according to the allowed reimbursement rate as specified by BC Medical Services Agreement.

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Concomitant Medications: The per unit costs of medications was obtained from "Formulary & Medication Prescribing Policies" (St. Paul's Hospital 1996/97). For those drugs whose unit cost was not available from this source, the "Drug Benefit Formulary" for Ontario was used as a supplemental source. When the indicated strength could not be matched from either source, the maximum unit cost of the medication was used. The cost of medications equaled the per unit cost multiplied by the number of units consumed per patient. When the information on the amount consumed was incomplete, the maximum dosage allowed as specified in "Compendium of Pharmaceuticals and Specialties" (CPS), 1996 was applied.¹⁸

Equipment: The cost of equipment used outside the hospital was based on telephone interview responses. In instances where patients provided the type of equipment but not its cost, an average cost of equipment based on other patients' responses was applied.

Miscellaneous Expenses: The miscellaneous expenses included travel costs and homecare costs. In the case that patients did not provide the cost but did provide the type of expense, an average cost based on other patients' responses was used.

Hospitalization: Hospitalization cost can be broken down into fixed cost and variable cost. The fixed cost accounts for the hotel cost and the variable cost accounts for the costs associated with medication, therapy, procedures, laboratory tests and radiology tests. For each hospitalized patient, the length of stay by type of ward (non-critical care unit, intensive care unit and coronary care unit) was available based on patient responses to the follow-up interview. Using this information, the fixed cost was the length of stay in each type of ward multiplied by the unit costs per day for that ward. These unit costs included the fully allocated cost of nursing care, the cost of the bed and the cost of the physical space in the unit.¹⁹

The variable cost of each hospital admission was modelled according to the inpatient resource-utilization profiles of 393 randomly selected admissions of patients from the Saint John Regional Hospital with matching diagnoses. For each admis-

TABLE I
Age and Sex of Emergency Department Visitors in Saint John, New Brunswick Who Completed Follow-up Interviews, September 1, 1994 – August 31, 1995 by Diagnosis and Type of Hospital Stay

Discharge Diagnosis	N	(%)	Male %	Age	
				Mean	SD
Asthma	733	(100)	47	20.1	17.7
No Stay*	621	(86)	48	19.9	17.0
NCC†	63	(9)	39	28.0	22.4
CC‡	37	(5)	44	8.1	12.0
COPD	82	(100)	42	65.2	10.0
No Stay	44	(54)	40	63.9	11.2
NCC	37	(45)	43	67.8	7.8
CC	1	(1)	100	63.2	0.0
Respiratory Infections	687	(100)	45	24.1	22.7
No Stay	572	(84)	45	23.2	21.5
NCC	86	(12)	46	35.3	27.1
CC	24	(4)	50	3.3	10.9
Cardiac Conditions	270	(100)	52	63.4	13.1
No Stay	53	(20)	44	63.7	16.4
NCC	71	(27)	51	65.4	11.5
CC	138	(53)	56	62.4	12.5

* No hospital stays.
† Non-critical care stay.
‡ Critical care stay.

TABLE II
Hospital Days and Number of ED & Physician Visits for ED Visitors Who Completed Follow-up Interviews, September 1, 1994 – August 31, 1995 by Diagnosis and Type of Hospital Stay

Discharge Diagnosis	LOS		ED Visits		Physicians Visits	
	Mean	SD	Mean	SD	Mean	SD
Asthma	0.6	2.0	1.2	0.5	1.0	1.3
No Stay*	0.0	0.0	1.2	0.4	1.0	1.2
NCC†	4.8	3.1	1.5	0.8	1.5	1.5
CC‡	4.4	2.9	1.4	0.7	1.2	1.9
COPD	3.9	5.2	1.2	0.5	0.7	0.9
No Stay	0.0	0.0	1.1	0.3	0.9	0.9
NCC	8.2	4.3	1.3	0.7	0.6	0.8
CC	16	0.0	1.0	0.0	0.0	0.0
Respiratory Infections	0.9	2.5	1.2	0.5	0.8	0.9
No Stay	0.0	0.0	1.2	0.4	0.8	0.9
NCC	5.7	3.7	1.4	0.8	0.9	1.0
CC	4.5	3.1	1.7	0.8	1.2	1.1
Cardiac Conditions	4.9	3.9	1.1	0.4	0.7	0.8
No Stay	0.0	0.0	1.0	0.2	0.8	0.9
NCC	5.2	2.9	1.2	0.5	0.7	0.8
CC	6.6	3.5	1.2	0.4	0.6	0.8

* No hospital stays.
† Non-critical care stays.
‡ Critical care stays.

sion, a hospital resource profile including various components listed above for the variable cost was obtained from the hospital chart. A total variable cost for each admission was calculated by applying the unit costs derived from the Saint Paul's Hospital Cost Model to the utilization data. This cost model provides fully allocated unit costs for all services within the hospital. The allocation methodology was one of simultaneous allocation.²⁰ The resulting fully allocated unit costs are

according to the appropriate output for each department which was often a Work Load Measurement Unit (WMS), a standardized output reporting mechanism implemented by Statistics Canada. The costs included a 5% depreciation rate for capital equipment and fixed assets.

Regression analysis on variable costs for these 393 admissions was performed to estimate the coefficient for variable costs associated with diagnosis, age, length of stay in a non-critical care unit, and length

TABLE III
Summary of Cost Components by Diagnostic Group for ED Visitors Who Completed Follow-up Interviews, September 1, 1994 – August 31, 1995: Average Cost (SE)

Component	Asthma	COPD	Respiratory Infections	Cardiac Conditions
Emergency Visits	\$164.04	\$160.26	\$168.80	\$155.13
Physicians Visits	\$24.99	\$19.37	\$20.01	\$16.53
Medication	\$492.87	\$460.68	\$99.52	\$33.70
Equipment	\$10.02	\$3.95	\$4.03	\$0.27
Miscellaneous	\$8.35	\$4.03	\$10.52	\$25.84
Hospitalization	\$343.29	\$1,041.82	\$373.62	\$3,087.27
TOTAL	\$1,043.55 (61.69)	\$1,690.11 (210.81)	\$676.50 (52.06)	\$3,318.74 (194.40)

TABLE IV
Estimation of the Multiple Regression Model for Total Direct Cost

Variables	Estimated Coefficient	SE	p-value
Constant	1478.78	256.23	0.0001
Age	3.25	1.94	0.09
Asthma	-501.03	241.53	0.04
Respiratory Infections	-880.21	280.53	0.0002
Cardiac Conditions	1634.38	237.40	0.0001

of stay in a coronary or intensive care unit. We then calculated the variable cost for each of the 1,772 patients who were admitted to the hospital by applying the estimated coefficients from above to their reported utilization pattern.

Summing up the six cost components yielded the total direct cost for each patient.

Statistical analysis

Descriptive analyses were conducted of the various characteristics of ED visitors including gender, age, length of stay, number of ED visits and number of physician visits. Multiple regression analysis was performed to investigate the effect of diagnosis adjusted for demographic factors on total direct cost.

RESULTS

The characteristics and descriptive statistics of all 1,772 ED visitors who completed follow-up interviews including gender, age and type of hospital stays are summarized in Tables I and II. The majority of discharge diagnoses were either asthma or respiratory infections (about 40% each), versus about 15% for a cardiac condition and only about 5% for COPD. Those with cardiac conditions or COPD diagnoses were older than those with asthma or respiratory infections. Bed days were also more

frequently reported among those with a cardiac condition or COPD. The number of ED visits was comparable across the diagnoses. With respect to the number of physician visits, patients with asthma appeared to consult their physicians more frequently.

About 80% of cardiac patients were admitted to the hospital and more than 65% of these inpatients stayed in a critical care unit. In contrast, only a minority of patients with discharge diagnoses of asthma or respiratory infections was admitted to the hospital; moreover, most of those admitted to a critical care unit were younger. The hospitalization rate for COPD was moderate (46%) but only one of these inpatients had stayed in the critical care unit.

From the 393 inpatients' clinical records with approximately an equal number of patients for each diagnosis, we found that the average hospitalization cost for asthma, COPD, respiratory infections and cardiac conditions was \$1,614.09, \$4,473.59, \$2,687.68, and \$4,392.96 respectively. For each diagnosis, approximately 80% of the hospitalization costs were fixed costs. The estimated hotel cost per day (unit cost) of non-critical care unit (NCC), coronary care unit (CCU) and intensive care unit (ICU) was \$289.85, \$746.59 and \$1,543.60 respectively. From the fitted regression model for variable cost for each

of the diagnoses considered, the estimated coefficient associated with each variable is summarized as follows. As there is a positive association between age and variable cost for patients with asthma or respiratory infections, the estimated coefficient with each additional year of age was \$3.89 and \$7.35 respectively. On the other hand, for diagnoses of COPD and cardiac conditions, since a number of older patients have much lower variable costs than younger patients, the estimated coefficient associated with each additional year of age for COPD and cardiac conditions was -\$3.11 and -\$9.44 respectively. The coefficients for per day of stay in a non-critical care unit and that in a coronary or intensive care unit were estimated to be: \$91.27 and \$76.10 for asthma, \$41.44 and \$206.63 for COPD, \$19.76 and \$84.34 for respiratory infections, and \$38.20 and \$181.72 for cardiac conditions. The estimated constant was -\$122.88, \$610.76, \$66.50 and \$1,182.33 respectively. The estimated cost of emergency and physician visit was \$96.32 and \$25.10 per visit respectively. The equipment items most frequently rented or purchased by patients were aerochambers, humidifiers and aerosol machines and the average costs were \$37.48, \$48.77 and \$180.00 respectively. With respect to miscellaneous expenses, the most frequently reported were (average cost): travel/parking (\$16.87), taxi (\$30.79), ambulance (\$102.00), and childcare (\$171.96).

Table III summarizes the average direct costs per patient by cost component and by diagnosis. The estimated total direct cost per patient [standard error] was: \$3,318.74 [\$194.40] for cardiac conditions, \$1,690.11 [\$210.81] for COPD, \$1,043.55 [\$61.69] for asthma and \$676.50 [\$52.06] for respiratory infections. The variability of cost components among the diagnoses was quite large due to the diversity of patients' characteristics, with exceptions of ED visits and physicians visits.

The fitted regression model is presented in Table IV. Due to missing values, only 1,658 out of 1,772 patients were included in the analysis. All the diagnoses were significantly associated with total direct cost (all *p*-values < 0.0005 with an exception of

the diagnosis of asthma whose p -value is < 0.04). With the diagnosis of COPD taken to be the reference diagnosis, its cost is reflected by the estimated coefficient of the constant, \$1,478.78. The estimated coefficients for the diagnosis of asthma, cardiac conditions and respiratory infections are the estimated difference between the effect of COPD adjusted for age and that of the indicated diagnosis. Thus the cost of cardiac conditions was estimated to be \$1,634.38 higher than COPD while the costs of asthma and respiratory infections were estimated to be \$501.03 and \$880.21 lower than COPD. Age was positively but not significantly associated with total direct cost (p -value=0.09). Total direct costs were not related to gender. Univariate analysis to compare the 1,658 patients who were included in the regression analysis and the remaining 114 patients showed that there were no significant differences with respect to age, gender and hospital stay.

DISCUSSION

This analysis based on a prospective cohort of patients presenting at EDs with cardiorespiratory diagnoses showed that the associated health care costs are substantial and include a number of costs that occur after the original ED encounter. These costs were found to differ significantly across the four diagnostic categories considered (all two-tailed p -values < 0.003). On average, patients diagnosed with a cardiac condition had the highest total direct cost.

Hospitalization costs were the largest component of costs for all diagnoses, with the exception of asthma (30%). For cardiac conditions, hospitalization cost, on average, accounted for more than 90% of the total cost. The largest cost component for asthma was the cost of medications, which was estimated to be \$492.87 (50%). The average medication cost for COPD was also quite substantial at \$460.68. For respiratory infections and cardiac conditions, the average medication costs were lower at \$99.52 and \$33.70 respectively. The costs of ED visits and physicians visits were

comparable across the diagnosis categories. The contribution of physicians visits, equipment and out-of-pocket expenses to total cost was minor.

With respect to study limitations, reliance on patient recall as the source of information on the number and type of hospital admissions and length of stay, medication, equipment and miscellaneous expenses may result in incomplete or inaccurate data, which affects our ability to calculate the corresponding costs. This problem was most frequently observed in the medication cost component because patients were often unfamiliar with the full name of the medication, its presentation or the dosage. To deal with missing data, we employed several extrapolation methods described above.

Because of the potential data censoring that occurs as only individuals visiting the ED were captured in this study, the total costs identified represent a conservative estimate of the total direct cost of cardiorespiratory disease episodes for the respective population at risk in the Saint John, New Brunswick catchment area.

It should be noted that a complete assessment of the costs of ED visitors with cardiorespiratory disease would also need to include data on the value of lost productivity and of pain and suffering. Our future work will focus on this issue. In addition, future statistical analysis is planned to determine the association between air pollution and cardiorespiratory ED visits and we will then be able to estimate health care costs attributable directly to air pollution.

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