

Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

Calculating Person-Level Costs Using Health Administrative Databases in Ontario

Health Care Costs: Developing Unit Costs

Costing Data Sources

The following is an excerpt from Guidelines on Person-Level Costing Using Administrative Databases in Ontario that describes the costing methodology for acute inpatient hospitalizations, emergency visits (ED), and physician services, based on Ontario healthcare utilization data.¹

Total costs (direct costs and overheads) for acute care and ED are available from the Ontario Ministry of Health and Long-Term Care (MOHLTC) Health Data Branch and are based on Ontario Cost Distribution Methodology (OCDM). Fees associated with physician visits are available directly from the Ontario Health Insurance Plan (OHIP) Schedule of Claims and Benefits while fees paid to physicians are tracked in the OHIP physician billing database.

Unit Costs: Hospital-Specific vs. Provincial-Average

To determine person-level case costs, we start with unit-level costs. For services with relatively short episodes of care, such as acute hospital care, the unit cost is a cost per weighted case (CPWC). Unit costs for physician visits depend on the nature of the visit and type of provider and are measured as a cost per visit.

Costs per unit reported by the MOHLTC are either on a *provincial-average* or *hospital-specific* scale. Average patient costs can vary across hospitals, not only due to differences in efficiency but also because of fixed costs associated with different activities in the hospital (e.g. teaching) or with geographic location (e.g. small rural hospitals) as well as the heterogeneity of the patient mix admitted to each hospital. Costing based on Case Mix methodology assigns each patient a weight that is reflective of the clinical condition complexity and treatment intensity. Once cost per unit is determined, one derives the case cost for all individuals in the cohort, by multiplying the unit cost by the weight corresponding to the person's stay and/or the number of units of service (days, number of visits).

Utilization Intensity and Case-Mix Adjustment

Even among persons with the same diagnosis, there is variability in terms of their health care status and disease severity. Hence, persons with the same clinical diagnosis can have very different resource utilization profiles, and as a result very different direct cost to the health care system. Some of these differences can be explained by a range of factors such as age, sex, co-morbid conditions, physical and cognitive functioning and past medical history. Therefore, when trying to estimate a case-cost, it is important to know not only the type of services that a person used but also the usage intensity.

In acute care hospitals, such a measure of resource utilization intensity is known as Resource Intensity Weights (RIWs). RIW is assigned to each hospital inpatient and represents the amount of hospital resources used relative to the average patient. These weights were developed by Canadian Institute for Health Information (CIHI) and are part of *Case Mix methodology* for acute care that classifies patients with similar resource use patterns into statistically and clinically homogeneous groups based on their clinical and administrative data. Currently, in Ontario, case mix methodology has been adopted in acute hospital and emergency (ED) care. In these settings, a unit cost is referred to as a *weighted* unit cost, where *weighted* indicates the cost was adjusted to reflect intensity of resource utilization or case-mix of patients in a given hospital.

Deriving Unit Costs

Unit costs must be derived for hospital services and physician costs. The dominant approach in Ontario is the CIHI RIW system because it is generally representative, it applies to other jurisdictions and it includes complexity weights associated with additional comorbidities.

To derive unit costs for hospital settings, the costing data must match the utilization data. The OCDM allocates hospital costs to inpatient acute care associated with utilization in the CIHI Discharge Abstract Database (DAD), and emergency departments associated with National Ambulatory Care Reporting System (NACRS) database. Provincial average costs per weighted case are obtained by first summing up each hospital's total costs for the applicable cost centre and dividing by the total provincial case-weights from the respective utilization database. For example,

the total cost per weighted case for acute care would be the total net direct and indirect costs for acute and newborn care divided by the total RIW in the DAD.

Physician costs for capitation and shadow billing payments in primary care and for physician services paid for under alternative payment plans (particularly emergency department, medical and radiation oncology) are not recorded as a fee paid in the OHIP billing database. Shadow billing costs may be ascribed for visits according to the payment schedule.

Methodology

Once the two primary costing components, namely utilization and unit costs, are known, estimation of individual case-costs becomes relatively straightforward. For services that implement case-mix methodology and where the unit cost is per *weighted case* (acute hospitals, ED) a case-cost would be a product of the resource intensity weight (RIW) for the specific episode (which reflects intensity of service utilization and patient acuity) and the appropriate unit costs. For all remaining services that do not currently adjust for patient's case-mix, such as physician services, a case-cost is a product of quantity (visits) and cost (cost per visit).

Inpatient Hospitalizations

The number and type of hospitalizations can be determined from the DAD and hospitalization costs estimated using the Resource Intensity Weight (RIW) method.²⁻⁴ CIHI classifies all patients in the DAD according to a Case Mix Group (CMG), which was developed to categorize groups of patients with similar clinical and resource utilization patterns. Within each CMG, patients are further stratified into distinct age categories. In 2007, CIHI introduced new acute care inpatient grouping methodology known as CMG+. The main objective was redevelopment of the existing acute care inpatient grouping methodology and RIWs, using the WHO International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada (ICD-10-CA) and the Canadian Classification of Health Interventions (CCI) activity and cost data. CMGs are developed based on a patient's major diagnosis as well as procedures or interventions received. The base RIW is calculated by CIHI for each CMG + age group, and the base weight is adjusted on a case-by-case basis for five factors: age, length of stay, comorbidity level and interventions received. CMG+ makes use of 9 age groups, 14 flagged intervention groups, and five comorbidity levels. As a result, an RIW is assigned to each patient representing the level of resources used relative to the average

inpatient (RIW = 1.0). Overall, the higher a patient's RIW, the more hospital resources consumed during the hospital stay.

Costs

To estimate the specific case cost of patient i admitted to hospital j in a given year y , the hospital-specific cost per weighted case (CPWC) for Ontario is multiplied by patient's RIW for a given hospitalization (1.1). Depending on the research objectives, CPWC can be calculated at the hospital, regional, or provincial (1.2) level. Use of provincial costs better reflects the average costs in the province and ensures that case cost estimates reflect only service utilization and representative costs at the provincial level, not location-specific variation in costs.

$$\text{Case Cost}_{i(y)}^j = \text{RIW}_{i(y)} * \text{CPWC}^j(y) \quad (1.1)$$

$$\text{CPWC}^j(y) = \text{Total Acute Care Costs}^j(y) / \text{Total Weighted Cases}^j(y), \quad (1.2)$$

where Total Weighted Cases for all patients in the province $i=1...N$ are given by $\sum_{i=1}^N \text{RIW}_i$

Year-specific provincial average costs per weighted case can be obtained from the Canadian MIS Database Hospital Financial Performance Indicators report or from the MOHLTC Health Data Branch, calculated as the sum of all provincial inpatient costs divided by the sum of all provincial weighted cases, excluding outliers. Costs related to physician services provided in hospital are not included as part of the cost per weighted case.

Emergency Room

The NACRS database contains all data describing visits to the emergency room from the 2002-2003 fiscal years onwards. Individuals in NACRS are classified based on the Comprehensive Ambulatory Classification System (CACS) methodology that groups individuals based on their main symptom, interventions received, age and gender. The CACS groups are assigned an individual resource intensity weight (CACS RIW) that reflects the average resource utilization for the CACS group relative to the average case. Costing data for calculation of RIWs are calculated using data from a set of participating Case Costing hospitals in Ontario and Alberta. Although the NACRS database was created in 2003, CACS RIWs were first developed in 2006. For studies beginning in 2006 or later, there are year-specific RIWs. The standard CIHI NACRS database for 2003 through 2005 includes only CACS 2008 RIW and therefore, the 2008 RIW would be appropriate for studies that

include data from years prior to 2006. In the latter case, the 2008 RIW should be applied from the initial year of study through to 2008.

REFERENCES

1. Bushmeneva K, Nikitovic M, McKillop I, et al. *Guidelines on Person-Level Costing Using Administrative Databases in Ontario*. Toronto: Health System Performance Research Network; 2011.
2. Johnson LM, Richards J, Pink GH, et al. *Case Mix Tools for Decision Making in Health Care*. Ottawa, ON: Canadian Institute for Health Information; 1998.
3. Canadian Institute for Health Information. *Acute Care Grouping Methodologies: From Diagnosis Related Groups to Case Mix Groups Redevelopment. Background Paper for the Redevelopment of the Acute Care Inpatient Grouping Methodology Using ICD-10-CA/CCI Classification Systems*. Ottawa: CIHI; February 2004.
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eTable 1. ICD-9 and ICD-10-CA Diagnosis Codes Used to Identify the Study Cohorts, and CCP and CCI Codes Used to Identify the Intervention Codes for the AMI Cohort

Admission Diagnosis	ICD-9 Codes	ICD-10-CA Codes
Acute myocardial infarction (AMI)	410.00-410.92 (excluding 410.x2)	I21.0-I21.9
Congestive heart failure	428.0, 428.1, 428.9	I50.0, I50.1, I50.9
Hip Fracture	820.xx	S720, S721, or S722
Colon Cancer (from Ontario Cancer Registry)	153.0, 153.1, 153.2, 153.3, 153.4, 153.6, 153.7, 153.8, 153.9	
AMI Procedures	CCP Codes	CCI Codes
Cardiac catheterization	489.2-489.8, 499.6, 499.7	2.HZ.28, 3.IP.10, 3.IS.10
Percutaneous coronary intervention	48.02, 48.03, 48.09	1.IJ.26, 1.IJ.50, 1.IJ.55, 1.IJ.57
Coronary Artery Bypass Graft	48.1-48.19, 48.2	1.IJ.76, 1.IJ.80
Colon Cancer Surgical Resection	CCP Codes	CCI Codes
	57.51, 57.52, 57.53, 57.54, 57.55, 57.56, 57.59, 57.6	1NM87DA, 1NM87DE, 1NM87DF, 1NM87DN, 1NM87DX, 1NM87DY, 1NM87LA, 1NM87RD, 1NM87RE, 1NM87RN, 1NM87TF, 1NM87TG, 1NM89DF, 1NM89DX, 1NM89RN, 1NM89TF, 1NM91DE, 1NM91DF, 1NM91DN, 1NM91DX, 1NM91DY, 1NM91RD, 1NM91RE, 1NM91RN, 1NM91TF, 1NM91TG

ICD refers to International Classification of Diseases; CCP refers to Canadian Classification of Procedures; CCI refers to Canadian Classification of Interventions.

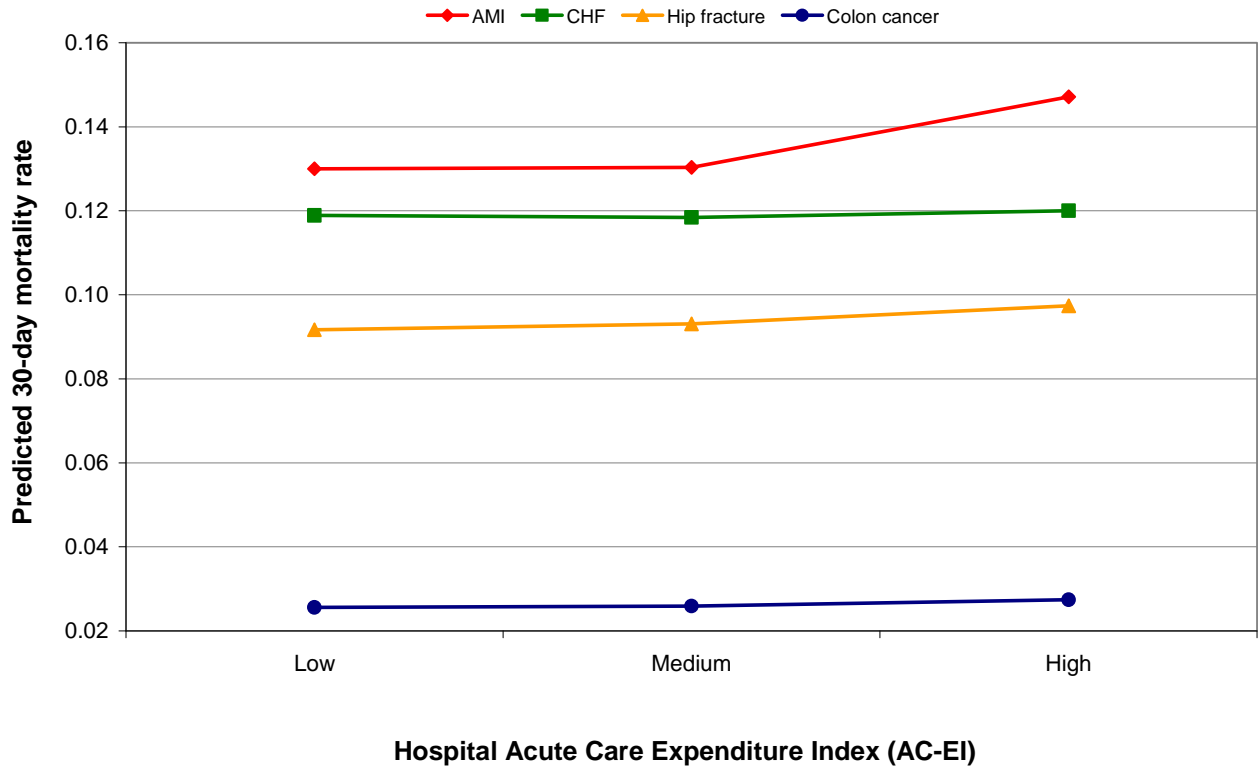
CHF Cohort Comorbidities

CHF Severity Conditions at Index Admission: ICD-9 and 10 codes for ischemic heart disease, other cardiovascular diseases, and other comorbidities		
Diagnosis	ICD-9 codes	ICD-10 codes
Ischemic heart disease	410-414	I20-I25
Other cardiovascular disease		
Myo-/peri-/endo-cardial disease	420-423, 425	I30-I33, I40-I43, I51.4
Pulmonary vascular disease	415-417	I26-I28
Rheumatic heart disease	390-398	I00-I02, I05-I09
Syncope, Sudden death	780.2, 798.1	R55, R96.0
Valvular heart disease	424	I34-I39
Other cardiac	429, 458	I51, I52, I95, I97
Shock	785.5	R57
Peripheral vascular disease PVD	440-448, 451-453, 785.4	I70-I74, I77-I82, R02
Arrhythmia	426,427	I44-I49
Cerebrovascular disease CVD	430-438	I60-I69
Hypertensive disease	401-405	I10-I13, I15
COPD	490-493, 496	J20, J40-J45
Dementia	290	F00-F03
Angina	411, 413	I20

CHF Procedure Codes: (CIHI/SDS)		
Description	CCP	CCI
Implantable cardiac defibrillator (ICD)	4974	1HZ53GRFS, 1HZ53LAFS
Permanent pacemaker (PPM)	4971	1HZ53GRNM, 1HZ53LANM, 1HZ53GRNK, 1HZ53LANK, 1HZ53GRNL, 1HZ53LANL, 1HZ53GRFR, 1HZ53LAFR

eFigure 1. Baseline Patient Severity, Measured as Predicted 30-Day Mortality Rate, Against Hospital Expenditure Index Group for the 4 Cohorts

AMI, indicates acute myocardial infarction; CHF, congestive heart failure.



eTable 2. Selected hospital and physician characteristics, according to Acute Care Hospital Expenditure Index (AC-EI)

Cohort Characteristics	AC-EI		
	Low	Medium	High
Acute Myocardial Infarction (AMI), N	60,900	68,631	49,608
Hospital characteristics, %			
High-volume teaching hospital (>200 AMI patients per year)	0.0	12.6	32.4
High-volume community hospital (>200 AMI patients per year)	44.6	62.4	44.5
Onsite cardiac catheterization laboratory	8.4	35.2	35.1
Onsite CABG surgery capacity	2.3	24.3	27.5
Attending physician characteristics, %			
Cardiology	11.0	43.8	50.0
Annual AMI volume >24 patients	34.1	53.4	36.5
Congestive Heart Failure (CHF), N	33,323	33,568	25,486
Hospital characteristics, %			
High-volume teaching hospital (>200 CHF patients per year)	0.0	9.9	31.7
High-volume community hospital (>200 CHF patients per year)	27.0	54.5	38.8
Attending physician characteristics, %			
Cardiology	6.7	23.8	25.7
General internal medicine	32.7	30.3	46.2
Annual CHF volume >13 patients	32.8	38.2	43.7
Hip Fracture, N	28,203	35,450	26,393
Hospital characteristics, %			
High-volume teaching hospital (>150 hip fracture patients per year)	0.0	14.0	37.0
High-volume community hospital (>150 hip fracture patients per year)	22.3	44.5	27.4
Operating surgeon characteristics, %			
Orthopedic surgeon	83.0	85.7	89.8
Annual hip fracture repair >18 patients	22.3	31.5	42.5
Colon Cancer (CCA), N	7,943	10,155	8,097
Hospital characteristics, %			
High-volume teaching hospital (>135 CCA patients per year)	0.0	13.4	54.9
High-volume community hospital (>135 CCA patients per year)	38.2	56.7	30.4
Associated with regional cancer centre	13.9	31.6	44.5
Operating surgeon characteristics, %			
Annual CCA resection volume >35 patients	34.2	47.2	54.6
Hospital Characteristics Among Combined Cohorts, N	130,369	147,804	109,584
Onsite CT scanner, %	66.5	86.2	92.4
Onsite MRI scanner, %	9.6	71.6	61.2
Onsite Critical Care Response Team (2007 forward), %	7.4	55.9	61.4
Inpatient nursing hours per weighted patient day, mean (SD)	7.98 (1.39)	8.95 (1.56)	10.17 (2.18)
Inpatient nursing hours per acute care bed, mean (SD)	2,463 (568)	2,919 (653)	3,293 (817)

eTable 3. Selected Therapies and Procedures, According to Acute Care Hospital Expenditure Index (AC-EI), Averaged Over the 10-Year Period

Cohort Characteristics	AC-EI		
	Low	Medium	High
Acute Myocardial Infarction, N	60,900	68,631	49,608
Selected inpatient care during index episode			
Index episode length of stay, median days (IQR)	7 (5-11)	7 (5-12)	8 (6-13)
Inpatient medical specialist consults, median (IQR)	4 (1-6)	4 (2-8)	5 (3-10)
ICU admission during index episode (year 2002 forward), %	75.2	67.0	67.8
Interventional cardiac therapies, %			
Cardiac catheterization within 30 days	34.0	44.9	44.6
CABG surgery or PCI within 30 days	21.8	30.0	30.9
PCI same day	1.4	5.8	7.8
Discharge drug prescriptions within 30 days			
Patients aged ≥65, alive 4 weeks post-discharge, N	31,661	34,288	25,875
ACEI/ARB, %	63.1	64.5	67.4
Statins, %	49.3	53.2	58.2
Post-discharge ambulatory care, %			
Patients alive 30 days post-discharge, N	52,468	59,513	42,325
Visit to primary care (PC) physician within 4 weeks	72.9	75.8	68.4
Visit to cardiologist within 4 weeks	7.4	11.3	12.6
Visit to PC and cardiologist within 4 weeks	9.9	14.4	17.9
Visit to cardiologist within 1 year	37.6	53.0	57.1
Congestive Heart Failure, N	33,323	33,568	25,486
Selected inpatient care during index episode			
Index episode length of stay, median days (IQR)	7 (4-11)	7 (4-12)	7 (4-13)
Inpatient medical specialist consults, median (IQR)	2 (0-5)	3 (1-7)	5 (2-10)
ICU admission during index episode (year 2002 forward), %	29.2	19.9	19.3
Inpatient echocardiogram, %	9.5	10.7	11.2
Discharge drug prescriptions within 30 days, %			
Patients aged ≥65, alive 4 weeks post-discharge, N	23,940	24,217	18,068
ACEI/ARB	62.3	61.3	62.3
Beta blockers	32.2	35.7	40.5
Statins	18.8	23.2	26.9
NSAIDS/CLASS1 AAD within 1 year (contraindicated)	18.8	17.9	15.5
Post-discharge ambulatory care, %			
Patients alive 30 days post-discharge, N	28,712	29,319	22,239
Visit to primary care physician (PCP) within 4 weeks	67.2	69.9	63.4
Visit to cardiologist within 4 weeks	6.3	12.8	15.7
Visit to PC and cardiologist within 4 weeks	4.5	9.7	10.9
Visit to cardiologist within 1 year	20.3	36.1	40.7

eTable 3 (Continued)

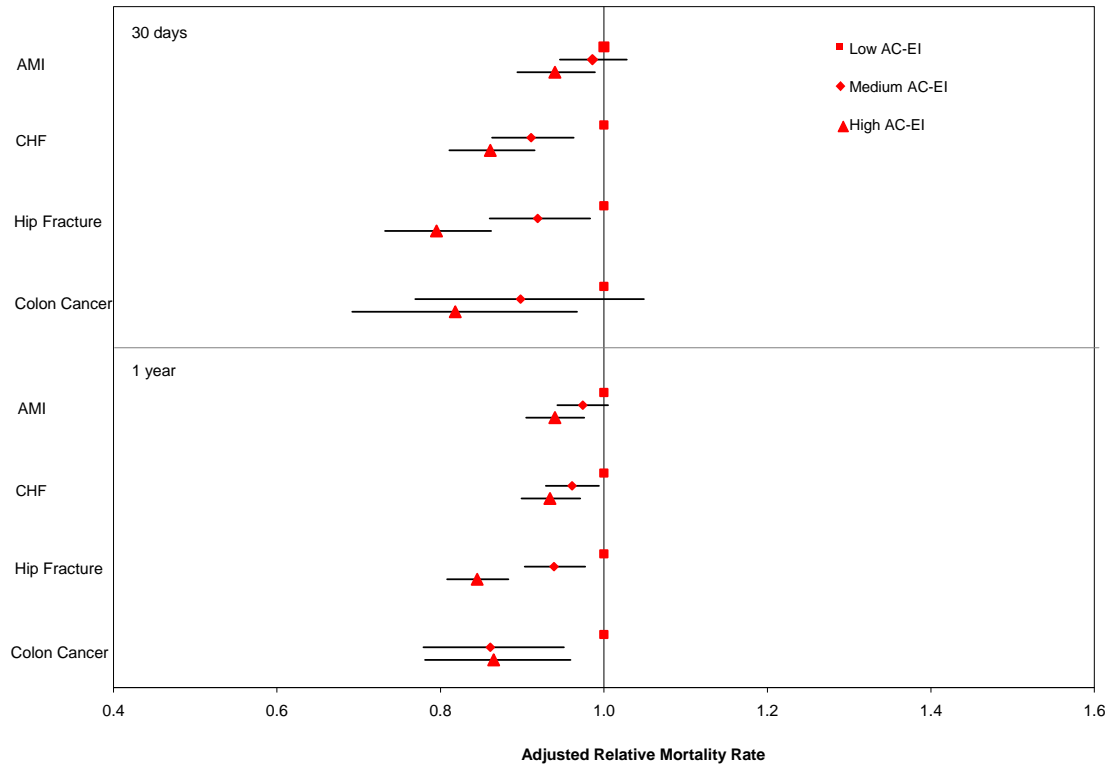
Cohort Characteristics	AC-EI		
	Low	Medium	High
Hip Fracture, N	28,203	35,450	26,393
Selected inpatient care during index episode			
Surgery ≤2 days after admission, %	79.1	83.4	81.0
Index episode length of stay, median days (IQR)	11 (8-18)	11 (7-19)	13 (8-23)
Inpatient medical specialist consults, median (IQR)	1 (0-4)	1 (0-4)	3 (0-8)
ICU admission during index episode (year 2002 forward), %	8.9	7.8	9.2
Inpatient rehabilitation, %	19.5	32.4	36.3
Colon Cancer, N	7,943	10,155	8,097
Selected pre-operative specialty care, %			
Pre-operative consult with anesthesiologist, within 4 weeks	21.6	28.5	34.7
Pre-operative consult with surgeon, within 6 weeks	43.4	44.2	50.4
CT scan prior to surgery for pre-operative staging	31.7	35.0	46.5
Selected inpatient care during index episode			
Index episode length of stay, median days (IQR)	10 (8-14)	9 (7-14)	9 (7-14)
Inpatient medical specialist consults, median (IQR)	0 (0-2)	0 (0-2)	0 (0-2)
ICU admission during index episode (year 2002 forward), %	33.8	29.8	20.6

eTable 4. Age- and Sex-Adjusted Outcomes According to Acute Care Hospital Expenditure Index (AC-EI), Averaged Over the 10-Year Period

Cohort Outcomes	AC-EI		
	Low	Medium	High
Acute Myocardial Infarction, N	60,900	68,631	49,608
Death within 30 days of admission, %	12.8	12.6	12.9
Death within 1 year of admission, %	22.3	21.8	22.8
Major cardiac event within 30 days of admission, %	18.4	17.7	17.7
Major cardiac event within 1 year of admission, %	37.1	35.5	36.8
Congestive Heart Failure, N	33,323	33,568	25,486
Death within 30 days of admission, %	12.1	10.8	10.4
Death within 1 year of admission, %	31.6	30.2	30.1
Major cardiac event within 30 days of admission, %	17.2	15.5	15.4
Major cardiac event within 1 year of admission, %	46.3	45.2	45.4
Hip Fracture, N	28,203	35,450	26,393
Death within 30 days of admission, %	9.3	8.6	7.7
Death within 1 year of admission, %	25.4	24.5	22.9
Readmission or death within 30 days of admission, %	14.2	13.6	12.1
Readmission or death within 1 year of admission, %	47.4	45.8	44.2
Colon Cancer, N	7,943	10,155	8,097
Death within 30 days of admission, %	3.7	3.5	3.4
Death within 1 year of admission, %	10.8	9.9	10.2
Readmission or death within 30 days of admission, %	13.1	11.4	10.6
Readmission or death within 1 year of admission, %	39.9	38.2	37.3

eFigure 2. Multivariate Adjusted Relative 30-Day and 1-Year Mortality Rates for Medium and High vs Low Hospital Expenditure Groups for the 4 Cohorts

AC-EI indicates acute care expenditure index; AMI, acute myocardial infarction; CHF, congestive heart failure.



eFigure 3. Multivariate Adjusted Relative 30-Day and 1-Year Readmission Rates for Medium and High vs Low Hospital Expenditure Groups for the 4 Cohorts

AC-EI indicates acute care expenditure index; AMI, acute myocardial infarction; CHF, congestive heart failure.

