Title: Patient characteristics, resource utilization, and outcomes associated with general internal medicine hospital care – The General Medicine Inpatient Initiative Study (GEMINI)

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Abstract

Background: The purpose of this study was to describe hospitalized general internal medicine (GIM) patients and their care at 7 hospital sites in the Greater Toronto Area, Canada.

Methods: This was a retrospective study involving all patients who were admitted to or discharged from GIM at study sites between April 1, 2010 and March 31, 2015. Clinical data from hospital electronic information systems were linked to administrative data from each hospital. We examined patient demographics, medical conditions, outcomes, and resource utilization.

Results: There were 136,208 hospitalizations to GIM, accounting for 38.8% of all admissions from the emergency department and 23.7% of all hospital bed-days. Over the five-year study period, the number of GIM hospitalizations per year increased by 32.4% with no meaningful change in the average length-of-stay or cost per hospitalization. The median age was 73 years (IQR 57-84) and the median number of comorbidities was 6 (IQR 3-9). The median acute length-of-stay was 4.6 days (IQR 2.5-8.6) and median total cost per hospitalization was $5,850 (IQR $3,915-10,061). Patients received at least one CT scan in 52.2% of hospitalizations. The most common primary discharge diagnoses were pneumonia (5.0%), heart failure (4.7%), chronic obstructive pulmonary disease (4.1%), urinary tract infection (4.0%), and stroke (3.6%). The ten most common diagnoses accounted for only 33.0% of all hospitalizations and the remainder included 439 different conditions.

Interpretation: GIM hospital patients represent a large, heterogeneous, resource-intensive, and growing population. Understanding and improving GIM care is essential to promote a high quality and sustainable healthcare system.

Introduction

Hospital care accounts for 30% of healthcare expenditure in Canada, making it the largest contributor to healthcare costs.(1) There has been a well-described growth in inpatient medical care by hospitalist physicians,(2) the majority of whom are not subspecialists but general internists and family physicians.(3) This care is often organized and delivered under a general internal medicine (GIM) service. An aging population, a growing number of patients with multiple chronic conditions,(4,5) and patients presenting with undifferentiated problems has resulted in more hospital patients whose care falls outside of clearly delineated subspecialty areas. Thus, better understanding GIM hospital patients is increasingly important.

Relatively little research has focused on the characteristics of GIM hospital patients or the quality of care that they receive. The proportion of hospital resources devoted to GIM patients in Canada has not been reported. Studies examining medical care in hospital typically include all medical admissions regardless of whether patients are cared for by a general or subspecialty service(6,7) or include only patients with specific diseases, such as heart failure, myocardial infarction, and pneumonia.(8)

Thus, the precise scope of GIM hospital care remains poorly quantified. Given that GIM services likely care for a large and growing inpatient population, the purpose of this study was to characterize GIM inpatients with respect to demographics, medical conditions, health outcomes, and resource utilization at 7 hospital sites in the Greater Toronto Area, Ontario, Canada. This is an essential first step toward improving the quality and sustainability of GIM care, which is relevant for health systems caring for aging populations around the world.(5)

Methods

Design and Setting

The General Medicine Inpatient Initiative Study (GEMINI) is a retrospective study involving 7 large hospital sites at 5 healthcare organizations affiliated with the University of Toronto serving adults in the Greater Toronto Area. Participating sites are St. Michael's Hospital, Sinai Health System (Mount Sinai Hospital), Sunnybrook Health Sciences Centre, Trillium Health Partners (Credit Valley and Mississauga sites), and the University Health Network (Toronto General Hospital and Toronto Western Hospital).

Trillium Health Partners is a large community teaching hospital serving the neighbouring city of Mississauga (population 756,000).(9) The remaining GEMINI hospitals are academic health centres in the city of Toronto (population 2,790,000).(10) Each healthcare organization participating in GEMINI is independent with distinct governance, funding, administration, staff, and information technology systems. Medical students and residents from the University of Toronto rotate between the different GEMINI hospitals.

Participants

The GEMINI cohort included all patients who were admitted to or discharged from the GIM service over a 5-year period between April 1, 2010 and March 31, 2015 (further details described in Appendix Methods 1). Based on these inclusion criteria, patients who were transiently cared for by the GIM service but were admitted and discharged by another hospital service were not included in the cohort. There were no exclusion criteria.

The GIM service includes hospitalist services as well as clinical teaching units that are approved by the Royal College of Physicians and Surgeons of Canada and involve undergraduate and post-graduate medical trainees as described in Appendix Methods 2. Across the participating sites, there were 283 attending physicians in GIM, 92.6% of whom were general internists or internal medicine subspecialists and 7.4% were family physicians.

Data Collection

At the individual patient level, we linked standardized administrative health data with clinical data that was extracted from hospital information systems (Appendix Figure 1). Data were collected locally at each hospital, deidentified, and transferred to St. Michael's Hospital, where they are stored securely on firewall-protected hospital servers. A secure hash algorithm using patient health insurance number was used to track deidentified patients across sites.(11,12) There were 1,678 hospitalizations with no health insurance number. They could not be tracked across sites and each was considered a unique patient.

Administrative Health Data

We collected patient-level characteristics including demographics, diagnoses, interventions, discharge destination, and resource utilization as reported by participating hospitals to the CIHI Discharge Abstract Database (DAD) and National Ambulatory Care Reporting System (NACRS). The CIHI DAD and NACRS contain these data for all hospital discharges and emergency department encounters, respectively. Data regarding diagnoses and interventions are coded manually by hospital-based chart abstractors using the enhanced Canadian version of the 10th revision of the

International Statistical Classification of Diseases and Related Health Problems (ICD-10-CA) and the Canadian Classification of Health Interventions (CCI). Data from CIHI have formed the basis for a substantial body of clinical and health services research.(13–15) We also obtained data about overall hospital patient volumes and bed utilization from the decision support department of each hospital.

Electronic Clinical Data

We collected data from the electronic information systems at each hospital about in-hospital patient room transfers, laboratory (biochemistry, hematology, and microbiology) test results, blood transfusions, radiology test results, electrocardiograms and echocardiography, in-hospital medications, dietary orders, vital signs and routine clinical monitoring. Appendix Table 1 describes which data elements could be extracted from each site.

Data were extracted at each hospital into comma-separated values (CSV) files. To allow for site-specific differences in data extraction and results formats, an ideal data format and table structure was provided to each hospital to populate. Where possible, standardized data elements were used, such as Drug Identification Number (DIN) for pharmacy data. Where existing standards were not uniformly applied, for example with laboratory data, the available data were extracted at each site and centrally mapped to a common format.

Research Ethics Board approval was obtained from all participating hospitals. Waivers of informed consent were obtained because this was a large retrospective study with minimal risk.

Measures and Statistical Analysis

We described demographics, coexisting medical conditions, patient outcomes, and resource utilization among all GIM hospitalizations and for each of the most prevalent discharge diagnoses. To examine coexisting conditions, we used 3-character ICD-10-CA codes from the CIHI DAD Database for each hospitalization. We calculated both a simple count of all coexisting conditions and the revised Charlson comorbidity score.(16) To describe patient outcomes, we reported utilization of the intensive care unit (ICU), in-hospital death, and readmission to GIM at one of the GEMINI hospitals within 30 days of discharge.

Acute inpatient length-of-stay was calculated by subtracting the number of days spent at an 'Alternate Level of Care' (ALC) from total hospital length-of-stay. ALC is a designation given in Canadian hospitals for patients who no longer require acute care but are awaiting transfer to a different care level, such as a rehabilitation facility. We also considered transfer to inpatient palliative care within the same facility as discharge from acute care.

In order to estimate hospitalization costs such that they could be compared across study sites and years, we used the CIHI Resource Intensity Weight for each admission using the 2015 grouping methodology and multiplied this by the annual cost per weighted case for acute inpatient cases that was reported for each hospital using the Ontario Cost Distribution Methodology.(17) This approach estimates the average amount of hospital resources used for each hospitalization, including costs related to administration, staff, supplies, technology, and equipment. It does not include fee-for-service physician billing costs. To determine the proportion of hospital costs attributable

to GIM patients, standardized data about overall hospital costs were obtained from the Ontario Ministry of Health and Long-Term Care Health Data Branch.

We used electronic clinical data to describe the proportion of patients receiving at least one of each imaging test (X-ray, CT scan, ultrasonography, or MRI) and at least one red blood cell transfusion. We used CCI codes to describe the number of patients receiving dialysis, endoscopy, or bronchoscopy.

To determine the proportion of hospital resources that were used by GIM patients, we compared the number of hospitalizations, admissions to hospital from the emergency department (which we refer to as 'emergency admissions'), and total bed-days for patients in the GEMINI cohort to overall hospital values (Appendix Methods 3).

We identified the most prevalent primary discharge diagnoses in GIM using 2015 CIHI case mix groups (CMGs). Every acute inpatient discharge is classified into a single CMG through the CIHI CMG+ methodology, which is based on the most responsible diagnosis and interventions received in hospital.(18) Because there are different methods of categorizing ICD-10-CA codes into clinically similar conditions, we tested the validity of our findings by comparing the sensitivity and specificity of the CIHI CMGs against existing validated cohort definitions for the five most prevalent conditions.(19–24)

We described changes in resource utilization in GIM over the five-year study period by examining the annual number of hospitalizations, the GIM proportion of total hospitalizations, median cost, median acute length-of-stay, rate of 30-day readmission to GIM within the GEMINI hospitals, and use of advanced imaging (the proportion of patients receiving at least one CT, MRI, or ultrasound test). We also described changes

in basic patient characteristics during this time: age, sex, comorbidity score, and number of coexisting medical conditions.

Simple descriptive statistics were presented for all findings because we made no pre-specified hypotheses. All analyses were performed using 'R' version 3.3.2.

Results

Demographics and Coexisting Medical Coniditions

There were 136,208 hospitalizations to GIM services involving 88,121 unique patients between April 1, 2010 and March 31, 2015 (Table 1). The study population was 50.6% women and the median age was 73 (IQR 57-84). Patients under 60 years accounted for 28.6% of hospitalizations and patients older than 80 years accounted for 37.6% (Appendix Figure 2).

On average, patients had 6 (IQR 3-9) coexisting conditions per hospitalization, 42.1% of patients had a high degree of comorbidity (Charlson Comorbidity Index score of 2 or greater), and 42.8% of patients had low comorbidity (Charlson score of 0). Hypertension (37.6%) and type 2 diabetes mellitus (33.3%) were the most prevalent comorbid conditions (Table 1).

Patient Outcomes and Resource Utilization

Among all GIM hospitalizations, 9.9% involved admission to ICU, 6.5% resulted in death in hospital, and 10.9% resulted in readmission to GIM within 30 days of discharge (Table 2). The median total cost per hospitalization was $5,850 (IQR $3,915-10,061, Table 3). The median acute length-of-stay was 4.6 days (IQR 2.5-8.6). Patients were designated ALC in 12.4% of hospitalizations and ALC days represented 22.0% of all

GIM bed-days. At hospital discharge, 70.8% of patients returned home whereas 18.9% were transferred to a nursing home or rehabilitation facility.

Patients received at least one CT scan in 52.2% of hospitalizations, ultrasonography in 29.9%, MRI in 11.7%, an interventional radiology procedure in 10.0%, at least one red blood cell transfusion in 9.2%, endoscopy or bronchoscopy in 10.2%, and dialysis in 1.8% (Table 4).

Hospitalizations to GIM accounted for 17.4% of all hospital admissions, 38.8% of all emergency admissions, and 23.7% of all hospital bed-days.

Time Trends in Resource Utilization and Patient Characteristics in GIM

The number of GIM hospitalizations increased annually from 23,475 to 31,078, representing a 32.4% increase over a five-year period (Figure 1). Over this time, the proportion of all hospital patients cared for by GIM increased by between 10.4% and 28.7% at every hospital except for one, where the GIM proportion decreased by 19.9%. There was no meaningful change over time in the median length-of-stay (4.6 days in both the first and last study year) or median cost ($5,808 to $5,813). There was a small increase in 30-day readmission to GIM from 10.5% to 11.3% and there was a 3.6% reduction in the proportion of patients receiving at least one advanced imaging test (66.9% to 63.3%). There was no meaningful change in patient age, sex, comorbidity score, or number of coexisting medical conditions over the study duration (Appendix Table 2).

Prevalent Discharge Diagnoses

The most common discharge CMGs were pneumonia (5.0%), heart failure (4.7%), chronic obstructive pulmonary disease (COPD, 4.1%), urinary tract infection (UTI,

4.0%), and stroke not including transient ischemic attack (3.6%). Compared with other validated cohort definitions. the specificity of the CIHI CMGs for all of these conditions was >99.9% and the sensitivity ranged from 80.4 to 99.2% (Appendix Table 3).

The ten most common CMGs accounted for only 33.0% of all hospitalizations to GIM and the remainder included 439 different CMGs (Figure 2).

Characteristics of Most Common Case Mix Groups

Patient characteristics, outcomes, and resource utilization for the most common conditions are presented in Tables 2, 3, and 4. There were high levels of multimorbidity among patients with all of the most prevalent diagnoses, ranging from a median of 5 to 7 coexisting conditions (IQR 3-10). ICU utilization and death-in-hospital was highest among patients with stroke (14.5% and 8.3%, respectively) and lowest among patients with UTI (5.3% and 2.7%, respectively). Patients with COPD had high levels of ICU utilization (12.6%) but relatively lower rates of death (5.3%).

Patients with stroke had the highest rates of being designated ALC (24.4%), the longest average acute length-of-stay (6.4 days, IQR 3.9-10.4), and the highest average cost per hospitalization ($6915, IQR 5,584-11,455). There was marked variation in patient age, comorbidity, length-of-stay, and cost among all diagnoses (Tables 2 and 3).

Interpretation

GEMINI is the largest study of GIM hospital care conducted in Canada. We described patient characteristics, resource utilization, and patient outcomes for more than 135,000 hospitalizations at 5 academic and 2 community hospital sites in the Greater Toronto Area. GIM hospitalizations accounted for 38.8% of emergency admissions and 23.7% of

all hospital bed days and the number of GIM hospitalizations grew by 32.4% between 2010 and 2015. Although the most prevalent conditions in GIM (COPD, pneumonia, heart failure, and stroke) are among the most costly causes of hospitalization in Canada,(25) the ten most common conditions accounted for fewer than one-third of all GIM hospitalizations. Our findings emphasize the importance of considering hospital GIM care as a whole for research and quality improvement efforts because disease-specific approaches will neglect the majority of patients. Broader metrics of quality and outcomes are urgently needed that can be applied across diseases, including patient-reported health and functional outcomes and other experience measures.(26)

Our findings are generally consistent with other studies that have been conducted in GIM patient populations. In 2 studies, each involving approximately 10,000 patients at 7 teaching hospitals in Alberta, the most prevalent discharge diagnoses were COPD, pneumonia, heart failure, UTI, and venous thromboembolism and in-hospital mortality ranged from 3.9-7.4% across hospitals.(27,28) The median length-of-stay in our study was 4.6 days, which is similar to studies in the US and Europe, in which the median length-of-stay in GIM patients was 4.0.(29,30) GIM hospital patients are often considered to be elderly and highly multimorbid(31) and in our study the median age was 73 years with 6 coexisting conditions on average. However, one of our most striking findings was the marked heterogeneity of this patient population. Nearly 30% of the population was under 60 years of age whereas nearly 40% were over 80. Approximately 40% had a low comorbidity score whereas nearly 45% had high comorbidity. There was dramatic variability in length-of-stay and resource utilization among hospitalizations for the same diagnosis. For example, the median length of stay

for patients with heart failure was 5.6 days but the 25th and 75th percentile were 3.1 and 9.7 days. Thus, GIM patients are highly variable in terms of individual characteristics, the conditions that lead to hospitalization, and resource utilization and outcomes within each condition. The reasons for variability should be a major focus of research for this patient population, which is poorly represented by “average” measures.

We highlight several interesting trends over time. Despite the substantially increased number of GIM hospitalizations, and an increase in the proportion of hospital patients cared for by GIM at most sites, there was no meaningful change in the average cost of hospitalization or length-of-stay. There was a small increase in 30-day readmissions to GIM and a reduction in the proportion of patients receiving imaging tests. It appears that GIM services have been able to accommodate increased volume without major changes in patient outcomes or resource utilization. There were no major changes in basic patient characteristics and thus further work is needed to understand the drivers of changes in resource utilization over time.

Our study has several strengths. We identified patients cared for by GIM services by collecting hospital-level data. Studies using centrally-collected administrative data often include patients cared for by both general medical services and subspecialists or they identify patients with specific diagnoses and are thus unable to capture the true scope of GIM. This is an important advantage of our study design as GIM wards are a functional unit for care delivery and represent an important target for quality improvement initiatives. The GEMINI study also demonstrates the feasibility of electronic data extraction across multiple hospitals, each with its own electronic medical record and information technology infrastructure. The marked heterogeneity of the GIM

patient population highlights the importance of comprehensively capturing a breadth of data about all patients and the importance of a large sample. This was made possible by extraction of electronic clinical data.

One limitation of this study is the use of ICD-10-CA discharge diagnoses to define disease states. The CIHI databases require a single disease to be listed as the most responsible diagnosis. This presents an important limitation in cases where conditions coexist or overlap, such as the comorbid complex of heart failure and pneumonia in patients presenting with dyspnea. Second, we used only the diagnoses coded for each hospitalization to calculate the Charlson comorbidity score, which could underestimate the degree of comorbidity. Third, our study was conducted in 7 teaching hospitals in Canada's largest metropolitan area. Our patient sample is broadly similar to other studies in GIM in Canada, the US, and Europe(27–30) and is likely generalizable to other urban and suburban academic health centres and large community hospitals, but may not be representative of patients or practices in other settings. Third, we were only able to capture readmission to GIM at hospitals within our network. We did not capture admissions to other medical services or hospitals outside the network. Finally, data collection was limited to those elements that were readily available in electronic clinical data and administrative data. Thus, we are unable to report important information such as patient socioeconomic factors, functional status and frailty, caregiver support, or advanced care planning. There is an opportunity for hospitals to standardize data collection around these important factors, given their importance in determining patient outcomes.

Conclusion

GIM hospital patients represent a large and growing population that consumes substantial hospital resources. This population is characterized by marked heterogeneity and there are substantial opportunities to develop broad measures of quality care for this population, to study variations in care and outcomes, and to improve the quality of care. Electronic data collection and linkage can support multicentre research to study this complex population. Advancing our understanding of GIM patients is essential for promoting a high quality, sustainable healthcare system.

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Figure 1. Trends in resource utilization in GIM over time

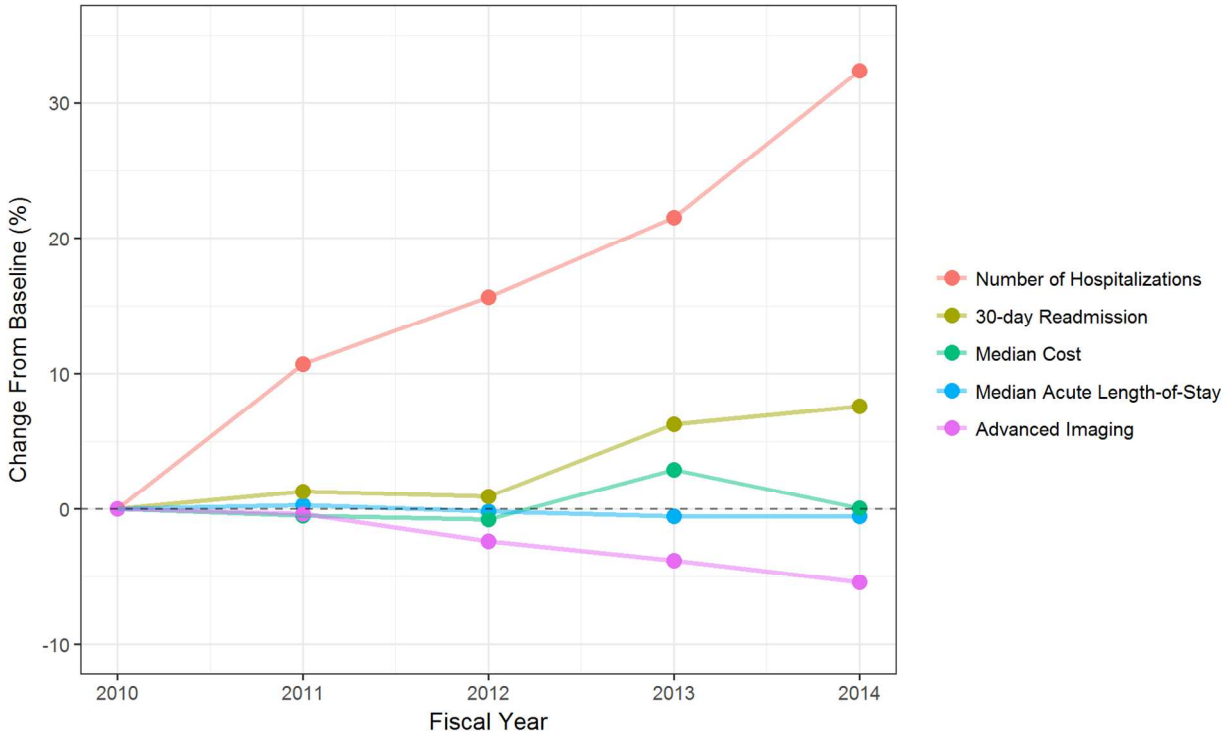


Figure 1 Legend: 30-day readmission represents readmission to GIM at one of the participating GEMINI hospitals within 30 days of discharge. 'Advanced Imaging' represents the proportion of patients receiving at least one ultrasound, CT scan, or MRI, as an indicator of the intensity of investigations patients receive.

Figure 2. Prevalence and cost of most common primary discharge conditions in GIM.

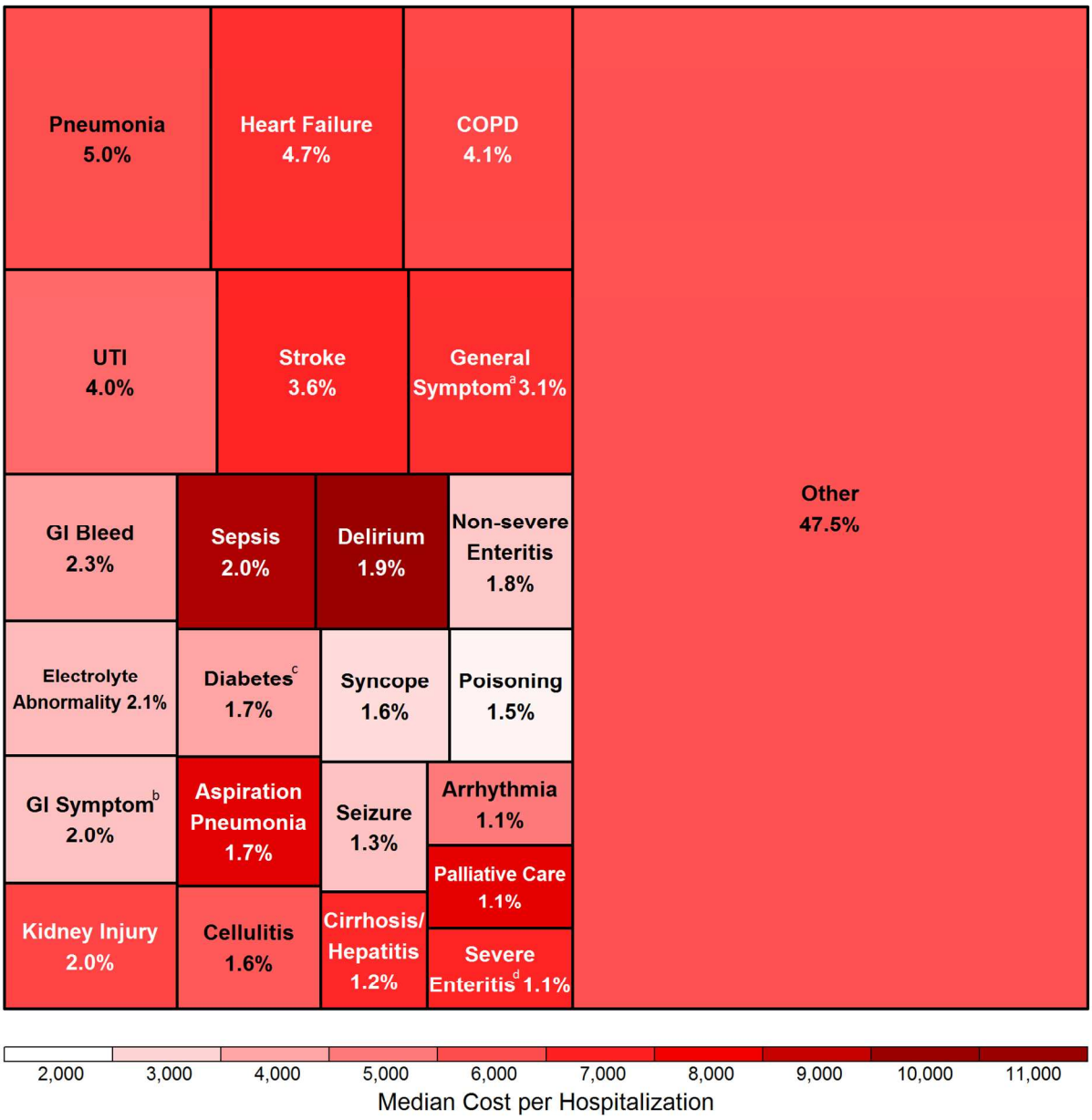


Figure 2 Legend: Primary discharge diagnosis was calculated using CIHI CMGs. Prevalence is denoted by the size of each box, and cost in Canadian dollars is denoted by colour. "Other" represents all remaining CMGs in general medicine, and is comprised of 426 additional diagnoses. For clarity of presentation in this figure, we simplified the description of certain CMGs: a) e.g. falls, cachexia, and fatigue; b) e.g. abdominal pain, constipation, vomiting; c) e.g. diabetic ketoacidosis, hyperglycemia, hypoglycemia; d) e.g C. *difficile*-associated diarrhea, ischemic bowel. GI: Gastrointestinal; COPD: Chronic Obstructive Pulmonary Disease; UTI: Urinary Tract Infection.

Table 1. Patient characteristics in the GEMINI study cohort.

Characteristic	GEMINI Cohort N=136,208
Age (years) - Median (IQR)	73 (57, 84)
Categories – N (%)	
< 60	39004 (28.6)
60-80	46039 (33.8)
>80	51165 (37.6)
Sex (female) – N (%)	68971 (50.6%)
Number comorbidities – Median (IQR)	6 (3, 9)
Charlson Index – N (%)	
0	58257 (42.8%)
1	20620 (15.1%)
2+	57331 (42.1%)
Most Common Comorbid Conditions – N (%)	
Hypertension	51204 (37.6)
Type 2 Diabetes Mellitus	45376 (33.3)
Atrial Fibrillation and Flutter	19947 (14.6)
Dyslipidemia	19518 (14.3)
Electrolyte Abnormality	19113 (14.0)
Heart Failure	18736 (13.8)
Discharge Disposition – N (%)	
Home	96414 (70.8)
Nursing Home or Rehabilitation	25804 (18.9)
Death	8916 (6.5)
Discharge Against Medical Advice	2543 (1.9)
Other Acute Care Hospital Other	1841 (1.4)
Other	690 (0.5)

Table 2. Patient characteristics and outcomes among most prevalent conditions in GIM.

	Total Cohort	Pneumonia	Heart Failure	COPD	UTI	Stroke
Total N (% of Total Cohort)	136,208 (100)	6,804 (5.0)	6,341 (4.7)	5,574 (4.1)	5,466 (4.0)	4,912 (3.6)
Age (median, IQR)	73 (57, 84)	80 (64, 87)	83 (75, 88)	77 (66, 84)	80 (69, 87)	76 (64, 84)
Comorbidities (median, IQR)	6 (3, 9)	5 (3, 8)	7 (5, 10)	6 (3, 8)	6 (4, 9)	5 (3, 7)
ICU Utilization* (N, %)	10,031 (9.9)	460 (8.6)	409 (8.0)	589 (12.6)	185 (5.3)	337 (14.5)
Death in Hospital (N, %)	8,916 (6.5)	534 (7.8)	491 (7.7)	293 (5.3)	150 (2.7)	410 (8.3)
30-day Readmission^ (N, %)	14,387 (10.9)	620 (9.4)	990 (16.1)	893 (16.5)	663 (12.4)	268 (5.7)

Table 2 Legend: The most prevalent conditions in GIM were identified using CIHI CMGs. *ICU utilization does not include 34,453 patients at Trillium Health Partners, for which data were not available at the time of submission. ^30-day readmission represents readmission to GIM at one of the participating GEMINI hospitals within 30 days of discharge. COPD: Chronic Obstructive Pulmonary Disease; UTI: Urinary Tract Infection; ICU: Intensive care or step-up unit.

Table 3. Resource utilization among most prevalent conditions in GIM.

	Total Cohort	Pneumonia	Heart Failure	COPD	UTI	Stroke
Cost* (CAD, median, IQR)	5,850 (3,915, 10,061)	5,935 (4,343, 8,068)	6,706 (4,956, 9,403)	6,148 (4,459, 8,741)	5,391 (3,981, 7,140)	6,915 (5,584, 11,455)
Length-of-stay (days, median, IQR)	4.6 (2.5, 8.6)	4.5 (2.5, 7.7)	5.6 (3.1, 9.7)	4.4 (2.5, 7.5)	4.4 (2.7, 6.9)	6.4 (3.9, 10.4)
Bed-Days (N, % of total cohort)	1,310,717 (100.0)	50,059 (3.8)	56,799 (4.3)	39,159 (3.0)	39,552 (3.0)	64,550 (4.9)
ALC Designation (N, %)	16,868 (12.4)	567 (8.3)	614 (9.7)	434 (7.8)	609 (11.1)	1,197 (24.4)
ALC Days (N, % of total ALC days)	288,250 (100.0)	6,713 (2.3)	7,585 (2.6)	4,949 (1.7)	7,531 (2.6)	19,075 (6.6)

Table 3 Legend: The most prevalent conditions in GIM were identified using CIHI CMGs. *48 hospitalizations with missing cost data were excluded. ALC: Alternate Level of Care; COPD: Chronic Obstructive Pulmonary Disease; UTI: Urinary Tract Infection.

Table 4. Use of diagnostic and therapeutic services among most prevalent conditions in GIM.

Diagnosis	Total Cohort	Pneumonia	Heart Failure	COPD	UTI	Stroke
X-ray (N, %)	84,481 (83.0)	5,918 (98.6)	5,557 (99.0)	4,999 (98.5)	3,750 (87.3)	1,946 (65.7)
CT (N, %)	53,125 (52.2)	2,608 (43.4)	1,629 (29.0)	1,709 (33.7)	2,007 (46.7)	2,879 (97.3)
Ultrasound (N, %)	34,577 (29.9)	1,172 (19.5)	1,821 (32.4)	879 (17.3)	1,637 (38.1)	1,354 (45.7)
MRI (N, %)	13,481 (11.7)	132 (2.2)	79 (1.4)	57 (1.1)	142 (3.3)	1,885 (63.7)
Interventional Radiology (N, %)	11,577 (10.0)	270 (4.5)	214 (3.8)	143 (2.8)	335 (7.8)	170 (5.7)
Red Blood Cell Transfusion (N, %)	9,325 (9.2)	213 (4.0)	243 (4.8)	105 (2.3)	114 (3.3)	55 (2.4)
Endoscopy or Bronchoscopy (N, %)	13,832 (10.2)	360 (5.3)	169 (2.7)	182 (3.3)	101 (1.8)	139 (2.8)
Dialysis (N, %)	2,448 (1.8)	130 (1.9)	91 (1.4)	44 (0.8)	41 (0.8)	36 (0.7)

Table 4 Legend: The most prevalent conditions in GIM were identified using CIHI CMGs. N = number of hospitalizations with at least one of this test or treatment. Radiology data were not available from 20,693 patients at Trillium Health Partners and transfusion data were not available for 34,453 patients at Trillium Health Partners. COPD: Chronic Obstructive Pulmonary Disease; CT: Computed Tomography; MRI: Magnetic Resonance Imaging; UTI: Urinary Tract Infection.

Appendix Methods 1. Identifying patients cared for by GIM.

We identified patients cared for by GIM based on their admitting service as documented at each hospital except Trillium Health Partners where admitting service was not recorded by the hospital. At Trillium Health Partners, patients were included in the cohort if a physician who attends on the GIM service was their 'most responsible physician', which is defined by the Canadian Institute for Health Information (CIHI) as, the "physician who is responsible for the care and treatment of the patient for the majority of the visit".[14] To address possible inaccuracies in the admitting service codes, we manually reviewed the list of physicians and included only patients who were admitted or discharged by a physician who attends on the GIM service.

Appendix Methods 2. Structure of General Internal Medicine Services at GEMINI hospitals

St. Michael's Hospital

- Clinical Teaching Unit – 4 Teams
- Hospitalist Service – 1 Team
- General Internists are the attending physicians on all teams

University Health Network - Toronto General Hospital

- Clinical Teaching Unit – 4 Teams
- Hospitalist Service – 1 Team
- Internal Medicine Cancer Service – 1 Team (started in September 2014)
- General Internists and subspecialists in other areas of Internal Medicine are the attending physicians on all teams

University Health Network - Toronto Western Hospital

- Clinical Teaching Unit – 4 Teams
- Hospitalist Service – 1 Team
- Family Medicine Hospitalist Service – 1 Team
- General Internists and subspecialists in other areas of Internal Medicine are the attending physicians on all teams except for the family medicine hospitalist service, which is run by family physicians.

Sinai Health System

- Clinical Teaching Unit – 4 Teams
- General Internists, subspecialists in other areas of Internal Medicine, and one family physician-hospitalist are the attending physicians on all teams

Sunnybrook Health Sciences Centre

- Clinical Teaching Unit – 4 Teams
- Short Stay Unit – 1 Team
- Hospitalist Service – 1 Team
- General Internists and subspecialists in other areas of Internal Medicine are the attending physicians on all teams

Trillium Health Partners - Credit Valley Hospital

- Clinical Teaching Unit – 2 Teams
- Hospitalist Service (GIM) – 3 additional teams
- Hospitalist Service (Family Medicine) – 4 teams
- Clinical Teaching Unit and Hospitalist Service (GIM) teams are staffed by general internists and subspecialists in other areas of Internal Medicine. Hospitalist

(family medicine) teams are staffed by family medicine hospitalist physicians and include the Family Medicine Teaching Unit.

Trillium Health Partners - Mississauga Hospital

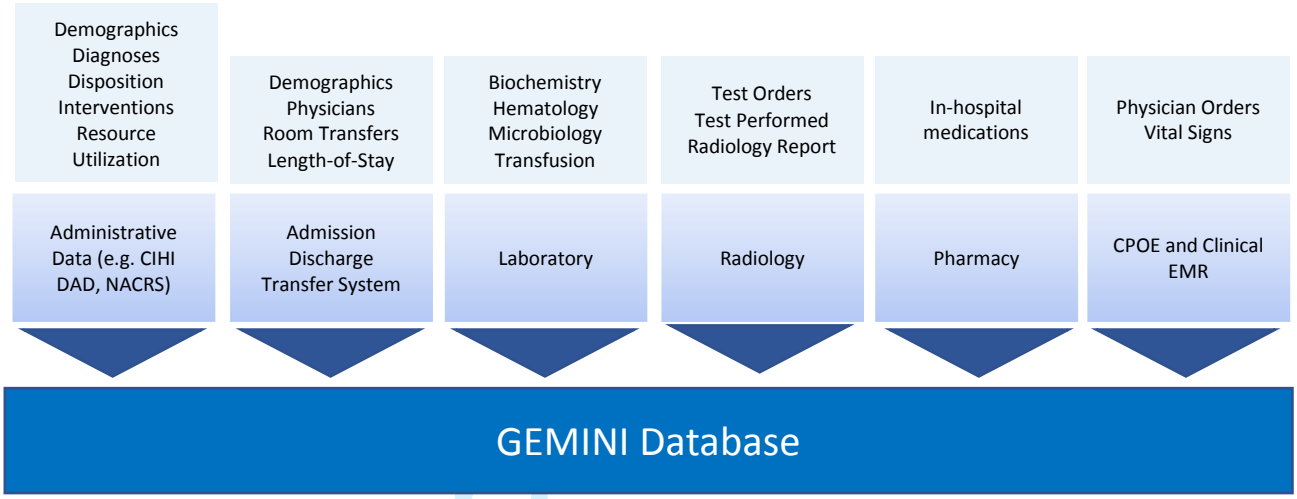
- Clinical Teaching Unit – 2 Teams
- Hospitalist Service (GIM) – variable (2 intake teams per week with other teams continuing to care for admitted patients; maximum of 16 teams in operation at a time)
- General Internists attend on both Clinical Teaching Unit and Hospitalist teams. A small number of Internal Medicine subspecialists attend on Clinical Teaching Unit teams. Data for GEMINI was collected only for General Internists because for subspecialists it was not possible to distinguish between their patients cared for on subspecialty services and general medicine services.

Appendix Methods 3. Determining the proportion of hospital resources used by GIM.

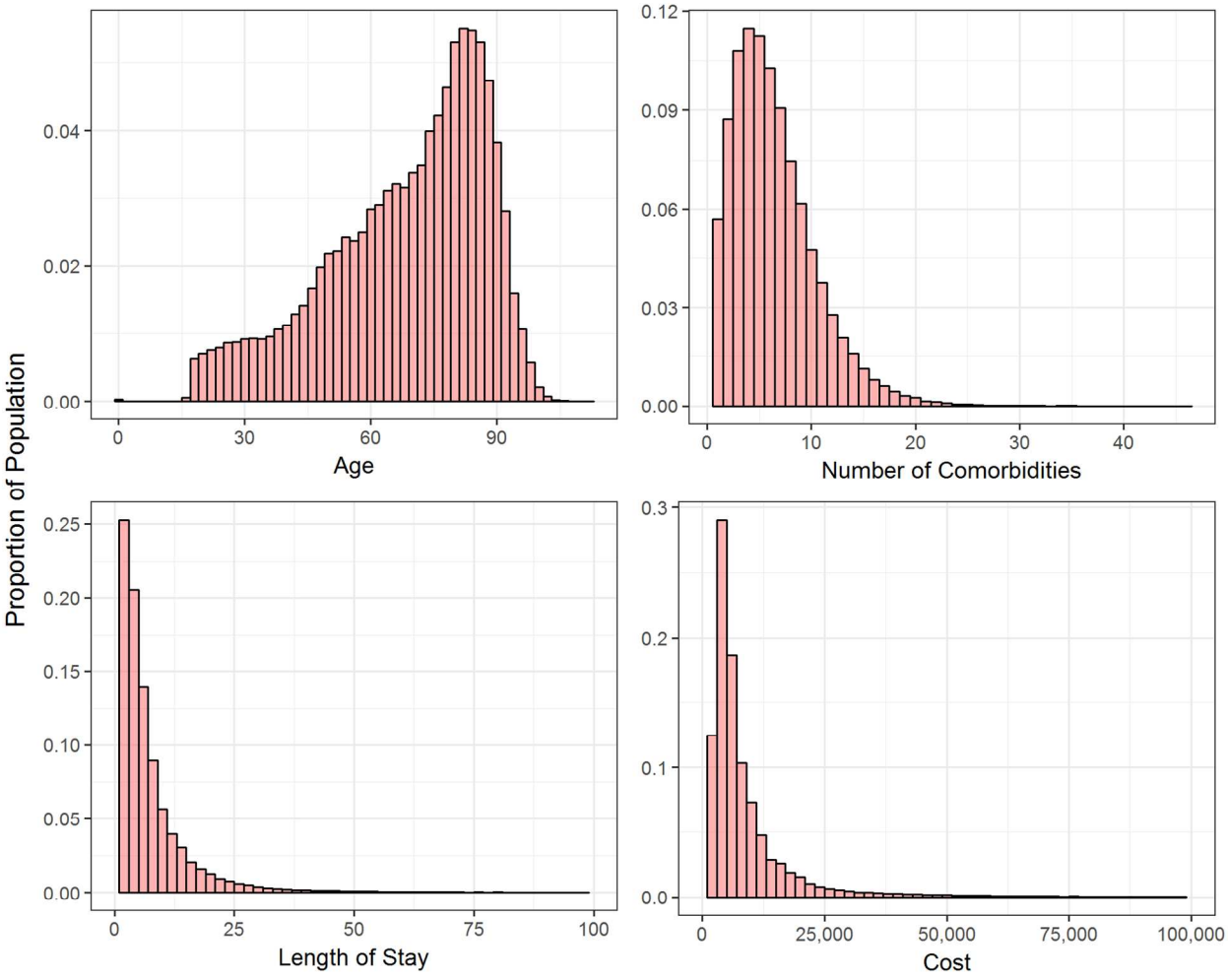
To determine the proportion of hospital resources that were used by GIM patients, we compared the number of hospitalizations, admissions to hospital from the emergency department (which we refer to as 'emergency admissions'), and total bed-days for patients in the GEMINI cohort to overall hospital values.

Data regarding total hospital utilization were obtained from the decision support department at each hospital. For the two hospital sites at Trillium Health Partners, this data could only be obtained for April 1, 2012 to March 31, 2015 (excluding the first two years of the study) because the hospital underwent a merger at that time. For Mount Sinai Hospital, data were unavailable for the fourth quarter of fiscal year 2011. Therefore, we excluded all of 2011 data from Mount Sinai Hospital for this calculation.

Appendix Figure 1. GEMINI cohort study data collection schematic.



Appendix Figure 2. Distribution of age, number of comorbidities, length-of-stay, and cost in the GEMINI cohort.



Appendix Figure 2 Legend: Age is expressed in years, length-of-stay in days, and cost in Canadian dollars. The length-of-stay and cost figures have had the x-axis truncated. For length-of-stay, 276 cases had a length-of-stay between 100 and 1,653 days. For cost, 1,240 cases had a cost between $100,000 and $2,443,417.

Appendix Table 1. Data availability for each GEMINI site.

Data Source	SMH	UHN – TGH/TWH	MSH	SBK	THP – CVH/M
CIHI DAD/NACRS	Available	Available	Available	Available	Available
In-Hospital Transfers	Available	Available	Available	Available	Not Available
Case Cost	Available	Available	Available	Available	Available
Cardiology ECG and Echo	Available	Partially Available	Partially Available	Available	Partially Available
Microbiology	Available	Available	Available	Available	Available
Biochemistry/Hematology	Available	Available	Available	Available	Available
Blood Transfusions	Available	Available	Available	Available	Available
Pharmacy	Available	Available	Available	Available	Available
Radiology	Available	Available	Available	Available	Available
Vital Signs	Available	Not Available	Available	Not Available	Available
Clinical Documentation (Diet Orders, Confusion Assessment Method Score, Pain Score, Weight)	Available	Not Available	Available	Not Available	Partially Available

Appendix Table 2. Overall trends in GIM by fiscal year.

	2010-11	2011-12	2012-13	2013-14	2014-15
Number of hospitalizations	23,475	25,988	27,140	28,527	31,078
Length-of-stay (days – median, 25%, 75%)	4.6 (2.5, 8.6)	4.7 (2.5, 8.8)	4.6 (2.5, 8.6)	4.6 (2.5, 8.6)	4.6 (2.5, 8.5)
30-day Readmission* (N, %)	2,440 (10.5)	2,739 (10.7)	2,856 (10.6)	3,160 (11.2)	3,192 (11.3)
Cost (median, 25%, 75%)	5,808 (3,888, 10,128)	5,779 (3,857, 10,095)	5,762 (3,898, 10,039)	5,977 (4,027, 10,255)	5,813 (3,914, 9,824)
Patients receiving at least 1 of: Ultrasound, CT scan, or MRI (N, %)	12,573 (66.9)	13,257 (66.7)	13,213 (65.3)	13,407 (64.4)	13,942 (63.3)
Patients receiving at least 1 Ultrasound (N,%)	5,791 (30.8)	6,053 (30.4)	5,707 (28.2)	5,706 (27.4)	5,636 (25.6)
Patients receiving at least 1 CT scan (N, %)	10,103 (53.8)	10,540 (53.0)	10,566 (52.2)	10,679 (51.3)	11,237 (51.0)
Patients receiving at least 1 MRI (N, %)	2,357 (12.5)	2,398 (12.1)	2,221 (11.0)	2,254 (10.8)	2,419 (11.0)
Age (years)	68.8	68.7	68.6	68.5	69.0
Sex Female (N, %)	50.2	51.0	50.7	50.2	51.0
High Comorbidity^ (N, %)	9,759 (41.6)	10,766 (41.4)	11,408 (42.0)	12,323 (43.2)	13,075 (42.1)
Number of Coexisting Conditions (N)	6.4	6.3	6.5	6.6	6.4

Appendix Table 2 Legend: *30-day readmission represents readmission to GIM at one of the participating GEMINI hospitals within 30 days of discharge. ^High comorbidity was defined as a Charlson score of 2 or greater. There were 48 hospitalizations with missing cost data and they were excluded from the analysis of cost. Radiology data were unavailable for 20,693 patients from Trillium Health Partners at the time of submission.

Appendix Table 3: Comparison of CIHI Case Mix Groups with validated cohort definitions using combinations of ICD-10-CA codes.

Cohort	CMG Group	Number of Hospitalizations	Validated Cohort Definition ICD-10-CA Codes	Number Of Hospitalizations	Sensitivity (%)	Specificity (%)
COPD	139	5574	J41-44[1]	5588	99.23	99.98
Pneumonia	138	6804	J10-18[2]	7229	93.17	99.95
Heart Failure	196	6341	I50, I25.5., I40-I43, I11+I50, I13+I50[3]	6677	94.64	99.98
Stroke	26	4912	I63, I64, H34[4]	5535	88.74	100.00
UTI	487	5466	N10, N12, N151, N300, N308, N309, N410, N412, N413, N510[5]	6794	80.38	100.00

Legend: Sensitivity and Specificity of CIHI CMG compared with validated cohort definitions. 48 hospitalizations had missing CMG designation and were excluded from this table. CMG: Case-Mix Group. COPD: Chronic Obstructive Pulmonary Disease; UTI: Urinary Tract Infection.

Appendix References

1 Health Quality Ontario; Ministry of Health and Long-Term Care. Quality-Based Procedures: Clinical Handbook for Chronic Obstructive Pulmonary Disease. 2013; : 60.

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4 Hall R, Mondor L, Porter J, Fang J, Kapral MK. Accuracy of Administrative Data for the Coding of Acute Stroke and TIAs. *Can J Neurol Sci* 2016; : 1–9.

5 Kwong, J.C, Crowcroft, N.S., Campitelli, M.A.; Ratnasingham, S.; Daneman, N.; Deeks, S.L.; Manuel DG. OB of IDSG. Ontario Burden of Infectious Disease Study (ONBOIDS): An OAHPP/ICES Report. Toronto, Ontario, 2010 DOI:http://www.oahpp.ca/resources/documents/reports/onboid/ONBoID_ICES_Report_ma18.pdf.