Site of Hospital Readmission and Mortality

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Abstract (249 words)

Background: Unplanned hospital readmission is a complex process, particularly if the patient is readmitted to an acute-care institution other than their original hospital. This study tested the hypothesis that alternate-hospital readmission is associated with increased patient mortality compared to original-hospital readmission.

Methods: We performed a population-based retrospective cohort analysis set between 1995 and 2010 within all 21 acute-care adult general hospitals of the Greater Toronto and Hamilton Area. Participants were consecutive adults (>=18 years) emergently readmitted within 30 days of hospital discharge. The primary outcome measure was all-cause mortality within 30 days of readmission.

Results: A total of 198,149 patients were included, of whom 38,134 (19%) died within 30 days of readmission. Patients undergoing alternate-hospital readmission were more likely to be older, reside in a chronic care facility and arrive by ambulance. Alternate-hospital readmission was associated with a higher risk of death within 30 days (22% versus 19%; p<0.001; odds ratio 1.26; 95% confidence interval 1.23 - 1.30). The increased risk attenuated substantially after adjustment for patient- and hospital-level covariates (adjusted odds ratio 1.06; 95% confidence interval 1.02 – 1.10). Unadjusted Kaplan-Meier survival curves separated early and the absolute difference in mortality continued throughout the entire one-year follow-up period yet no difference between groups was observed on adjusted survival analyses.

Interpretation: Among patients readmitted within 30 days of discharge, alternate-hospital readmission was associated with a higher risk of death than original-hospital readmission. The increased mortality might be explained by a greater underlying severity of disease among patients undergoing alternate-hospital readmission**.**

Introduction

Each year about 4.5 million Americans and about 0.2 million Canadians undergo unplanned hospital readmission within 30 days of hospital discharge[1,2]. Unplanned readmissions are costly, challenging to predict, difficult to avoid, and associated with increased mortality[3,4,5,6,7,8,9]. Although the majority of readmitted patients return to their original hospital, about one fifth spend their initial ("primary") and subsequent ("secondary") admissions in different hospitals[10]. Clinical experience suggests that unfamiliar patients can pose unique challenges, yet one study found no large difference in mortality between alternate-hospital readmissions and original-hospital readmissions[11].

Patients undergoing alternate-hospital readmission might be disadvantaged by limited access to primary admission medical records, delayed treatments, discontinuity of care, and exposure to the nosocomial pathogens of multiple institutions[12,13,14,15,16,17,18]. On the other hand, alternate-hospital clinicians might be less likely to replicate errors committed during the primary hospitalization, less influenced by previously affixed diagnostic labels, and less dispirited by a patient's return to hospital[19]. Additionally, alternate-hospital procedures and protocols might intercept problems arising from the original hospital and facilitate rectification of prior medical errors[20]. These multiple countervailing forces have an uncertain aggregate influence on patient outcomes.

Whether a patient undergoes original-hospital readmission or alternate-hospital readmission is determined by factors that include hospital proximity, specialist availability, ambulance referral patterns, local traffic conditions, anticipated emergency department delays, institutional reputation, and patient preference[21,22,23,24]. The complexity and heterogeneity of these factors would make a prospective randomized trial logistically challenging and ethically

dubious. We therefore performed a population-based retrospective cohort analysis using linked administrative databases to test whether alternate-hospital readmissions were followed by a higher risk of death than original-hospital readmissions.

Methods

Setting

We focused on a large metropolitan area, reasoning that alternate-hospital readmissions in rural regions would be uncommon, difficult to modify, and confounded by referrals for urban subspecialty care. We selected Ontario's Greater Toronto and Hamilton Area (GTHA) because it is Canada's largest contiguous urban region[25]. The GTHA had a land area of 8,241 square kilometers and a population of 5.6 million residents at the midpoint of the study (2002)[26]. Throughout the study interval, Ontario residents had universal health insurance that provided access to medical care that was widely available, publically funded, and free at the point of service[27]. The healthcare system within the GTHA provided a full array of primary, secondary, tertiary, and quaternary care with no major changes to hospital financing during the study.

Hospitals

We performed an individual-level analysis of patients whose primary and secondary hospitalizations both occurred within the GTHA. This approach minimized confounding by excluding patients referred from rural regions for subspecialty readmission. We first identified all acute-care hospitals operating in the GTHA between 1995 and 2010. Individual inpatient acute-care sites sharing the same facility identification number were classified as a multi-site hospital because the shared data information systems, personnel, protocols, and governance

made such multi-site hospitals the smallest meaningful functional unit for analysis. Individual inpatient acute-care sites that had no sister sites were classified as single-site hospitals. We excluded hospitals without adult inpatient acute-care beds and hospitals restricted to pediatric, elective surgical, rehabilitative, respite, or palliative care. Inpatient acute-care sites that joined a multi-site hospital during the study period were included following the merger date.

Patients

We identified adult patients aged 18 years or older who had one or more eligible hospital readmissions during the study interval. A readmission was eligible if: (1) the patient was readmitted to hospital through the emergency department between 1 January 1995 and 31 December 2010; (2) the elapsed time between initial hospital discharge and subsequent hospital readmission was >=1 day and <= 30 days; and, (3) both the primary and secondary hospitalizations occurred in qualifying GTHA hospitals. A readmission was ineligible if the most responsible diagnosis for the primary or secondary hospitalization was related to pregnancy (ICD-9 630-676, ICD-10-CA O00-O99) or major psychiatric disorder (ICD-9 295-300, ICD-10-CA F20-F48). Same-day readmissions were excluded to avoid misidentifying hospital-to-hospital transfers as readmissions. Patients with multiple readmissions were analyzed according to the most recent eligible readmission, so that each individual contributed only once to analyses.

Variables

The primary study outcome was all-cause mortality within 30 days of the date of hospital readmission, as ascertained from the official government vital statistics record for Ontario (eFigure 1). Secondary outcomes examined in-hospital case-fatality and all-cause mortality at 90, 180, and 365 days of readmission. The principal predictor was the site of hospital readmission, categorized in a dichotomous manner as original-hospital readmission or alternate-hospital

readmission. Original-hospital readmissions were defined as those where both the primary and secondary hospitalizations occurred at the same hospital. Alternate-hospital readmissions were defined as those where the primary and secondary hospitalizations occurred at different hospitals.

Additional predictors were derived based on prior research and included patient demographics, average neighborhood household income (quintiles), rural residence (yes, no), year of readmission, Charlson co-morbidity score (integer), primary hospitalization length of stay (days), most responsible diagnosis for secondary hospitalization, arrival by ambulance at the time of secondary hospitalization (yes, no), and total number of hospitalizations in the year prior to readmission (integer), and total number of physician clinic visits in the year prior to readmission (integer)[5,28]. We included the hospital-free interval, defined as the number of days between hospital discharge and readmission. On the basis of prior literature we also examined secondary hospital annual case volume (integer) and secondary hospital sector (designated as academic sector or community sector by system-level hospital reports)[29,30,31,32,33]. Variables were modeled as continuous values unless otherwise indicated above but are displayed in categorical format to facilitate interpretation.

In the Canadian setting, the condition most responsible for the length of a patient's hospital stay is reported as the most responsible diagnosis[34]. In our study, the most responsible diagnosis for each admission was coded according to the International Classification of Diseases, using the Ninth Revision (ICD-9) prior to 1 April 2002 and the Tenth Revision, Canada (ICD-10-CA) after 1 April 2002[35,36]. We adapted the 285 single-level diagnostic categories in the Agency for Healthcare Research and Quality's Clinical Classifications Software to cluster

individual diagnostic codes into 30 mutually exclusive, clinically meaningful diagnostic categories (eTable 1)[37].

Databases

Encrypted patient-level data were obtained through validated, population-based, linked administrative databases used extensively in prior research[17,38,39]. Information on outpatient clinic visits and hospitalizations was obtained from the Ontario Health Insurance Plan database and the Canadian Institutes for Health Information database, respectively[40,41]. Demographics, vital status, and date of death were obtained from official government records[42]. Socioeconomic status was estimated using average household income at the census tract level using the 2006 Canadian census[43]. Hospital structural and operational data (including designation as an academic or community sector hospital) were obtained from reports published at or near the study midpoint[29,44,45,46]. The study interval extended from 1995 to 2010 to include the most recent year for which data was available and to reflect an interval with no major changes in hospital financing.

Missing Data

Where data for average neighborhood household income and rural residence were absent they were coded as missing and retained for analysis (less than 0.1% of patients). Patient-level data were otherwise complete. The research ethics board of the Sunnybrook Research Institute approved the study including a waived requirement for individual consent.

Statistical Analysis

The primary analysis compared 30-day patient mortality following alternate-hospital readmission to 30-day patient mortality following original-hospital readmission. Unadjusted risks were compared using a chi-squared test and then adjusted for patient- and hospital-level

covariates through a logistic regression model that applied general estimating equations (GEE) with an exchangeable correlation structure to account for clustering of individuals within hospitals[47]. A subsequent analysis stratified patients by secondary hospital, calculated hospital-specific unadjusted odds ratios, and then calculated hospital-specific adjusted odds ratios by fitting separate logistic regression models to each hospital to account for individual patient characteristics. Further models stratified the pooled cohort on patient characteristics and performed unadjusted univariate GEE analyses to explore potential effect modification.

Kaplan-Meier survival curves were generated for unadjusted survival up to one year and tested using the log-rank test. An adjusted survival analysis was performed using a Cox proportional hazards analysis. In-hospital case-fatality and death by 90, 180, and 365 days was examined using the multivariate GEE logistic regression model developed for the primary outcome. One sensitivity analysis retained only the first (rather than most recent) eligible readmission for each patient. A second sensitivity analysis examined the influence of analyzing according to primary (rather than secondary) hospital. A third sensitivity analysis defined all patients readmitted within 48 hours as hospital-to-hospital transfers and excluded these patients from analysis. A post hoc exploratory analysis examined the relative influence of distinct hospital sector transitions (Appendix). All analyses used two-sided statistical tests performed at the 5% level of significance using SAS, version 9.2 (SAS Institute Inc., Cary, NC).

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or interpretation of the data; and in the preparation, review, or approval of the manuscript for publication.

Results

Hospital Overview

A total of 43 inpatient acute-care sites representing 28 distinct hospitals were active within the GTHA during the study period. Seven single-site hospitals provided highly restricted sub-specialty care and were excluded from analysis (3 provided only elective surgical services, 3 provided only palliative care, and 1 provided only pediatric care), leaving 21 qualifying acute-care hospitals (eFigure 2). Hospital characteristics at the midpoint of the study appear in the on-line only material (eTable 2 & eTable 3).

Patient Characteristics

We identified 2,448,759 patients with one or more admissions to qualifying acute-care hospitals in the GTHA during the 16-year study period, of which 198,228 (8.1%) were eligible for study inclusion due to a subsequent readmission within the GTHA. We excluded 79 patients who had a date of death erroneously recorded as occurring prior to readmission date, resulting in a cohort of 198,149 individual patients (Figure 1). 58,460 (29.5%) patients had more than one eligible readmission, but only the most recent readmission episode for each patient was retained in the primary analysis (eFigure 3). Less than 0.003% of data were missing for age, sex, average neighborhood household income, prior physician visits, prior hospitalizations, or most responsible diagnoses for primary and secondary hospitalization.

(***Figure 1: Patient Flow Diagram about here***)

Of the 198,149 patients in our cohort, a total of 161,974 (82%) underwent original-hospital readmission and 36,175 (18%) underwent alternate-hospital readmission. Compared to patients undergoing original-hospital readmission, patients undergoing alternate-hospital readmission were more likely to be older, male, a resident of a chronic care facility, burdened by more comorbidity (as measured by Charlson comorbidity score and by hospital admissions and clinic visits in the previous year), and brought to hospital by ambulance for readmission (Table 1). Compared to original-hospital readmissions, alternate-hospital readmissions were somewhat more likely to occur at community hospitals or at those with a lower annual case volume (eTable 6).

(***Table 1: Patient Characteristics about here***)

Short-term Mortality

Compared to patients undergoing original-hospital readmission, patients undergoing alternate-hospital readmission were significantly more likely to die within 30 days (8,072 of 36,175 patients [22%] versus 30,062 of 161,974 patients [19%]; Chi-squared p-value <0.001). This difference was equivalent to an unadjusted odds ratio of 1.26 (95% confidence interval 1.23 – 1.30; p-value <0.001). Adjustment for patient and hospital factors substantially attenuated this association (adjusted odds ratio 1.06; 95% confidence interval 1.02 – 1.10; p-value, 0.003). Additional independent predictors of death appear in Table 2. In our final model, the relative increase in risk of 30-day mortality attributable to alternate-hospital readmission was generally smaller than the risk associated with either sepsis or pneumonia (Table 2). The within-hospital correlation coefficient from our primary analysis was 0.12.

(***Table 2: Additional Predictors of 30-day Mortality about here***)

Stratification by Individual Hospital

Alternate-hospital readmission was associated with a significant increase in the adjusted odds of 30-day mortality for four of six academic secondary hospitals. All other secondary hospitals demonstrated no significant difference in the adjusted risk of mortality between alternate-hospital readmissions and original-hospital readmissions (Figure 2; eTable 7). Post hoc stratification of the multivariate GEE model by secondary hospital sector demonstrated a significant association between alternate-hospital readmission and 30-day mortality for academic sector hospitals (adjusted odds ratio, 1.17, 95% confidence interval 1.15 – 1.19, p-value <0.0001), but not for community sector hospitals (adjusted odds ratio, 1.00, 95% confidence interval 0.97 – 1.04, p-value 0.81). Results of an exploratory analysis examining specific hospital sector transitions yielded similar findings (eTable 9).

(***Figure 2: Odds Ratio for 30-day Mortality, Stratified… about here***)

Patient Subgroups

The unadjusted association between alternate-hospital readmission and increased mortality was present among patients of all age groups, all neighborhood household income quintiles, and both sexes (Table 3). The relative increase in risk was accentuated among women and among patients with less comorbidity, fewer hospitalizations, and a residence other than a chronic care facility. The increased risk was particularly significant among patients with a secondary hospitalization diagnosis of injury, diverticular disease, or intestinal obstruction. A most responsible diagnosis of chronic ischemic heart disease was the only subgroup in which alternate-hospital readmission was associated with a significant reduction in mortality on univariate analysis (eTable 10).

(***Table 3: Unadjusted Primary Outcome Stratified … about here***)

Delayed Mortality

Unadjusted survival analysis demonstrates that the risk associated with alternate-hospital readmission equated to an absolute difference in mortality of 4% that was sustained throughout the one year follow-up period (Figure 3; log rank test p-value < 0.001). In contrast, adjusted survival analysis found no difference between the groups (hazard ratio 1.01; 95% confidence interval 0.99 – 1.02; p-value = 0.44). Adjusted analyses at specific time points found that the adjusted odds of subsequent death at 90, 180, or 365 days following readmission was no different between the alternate- and original-hospital readmissions (eTable 11).

(***Figure 3: Kaplan-Meier Survival Curve about here***)

Sensitivity Analyses

Retaining only the first rather than the most recent readmission for each patient resulted in a similar primary outcome summary effect estimate: 20,571 [13%] of 161,955 patients undergoing original-hospital readmission died while 5,780 [16%] of 36,194 patients undergoing alternate-hospital readmission died (unadjusted odds ratio 1.30, 95% confidence interval 1.27 – 1.35; adjusted odds ratio 1.08, 95% confidence interval 1.04 – 1.12). Analyzing by primary rather than secondary hospital had little effect on the summary effect measure generated by the multivariate GEE model (adjusted odds ratio 1.08, 95% confidence interval 1.01 – 1.16) despite more pronounced influences on the unadjusted hospital-specific effect estimates (eFigure 4). Extending the definition of hospital-to-hospital transfer to exclude patients readmitted within 48 hours resulted in a smaller cohort (n = 187,446) but did not influence the primary outcome

summary effect measure (adjusted odds ratio 1.05, 95% confidence interval 1.02 – 1.09, p = 0.003).

Interpretation

Alternate-hospital readmission was associated with increased patient mortality in this population-based observational cohort study. Unadjusted analyses suggest that the increase in mortality was immediate (with increased in-hospital case-fatality), substantial (corresponding to a 4% absolute increase in mortality), and sustained (persisting over the one-year follow-up period). Most of the observed association could be explained by patient age and comorbidities. Regardless of causal mechanism, these findings suggest that alternate-hospital readmission has an ominous prognostic significance.

One interpretation of these findings is that alternate-hospital readmission can compromise patient safety, in accord with past studies examining discontinuous care[48,49,50]. An alternate interpretation is that increased patient mortality reflects residual confounding by unmeasured covariates that are imbalanced between the original- and alternate-hospital patients in our cohort (eTable 12). This interpretation acknowledges that conditions with relatively poor prognoses also predispose patients to alternate-hospital readmission, and that system factors promoting alternate-hospital readmission (such as ambulance diversion or prolonged emergency department wait times) also delay care and adversely impact patient outcomes[51,52]. Given the potential importance for patient outcomes, further examination of the association between alternate-hospital readmission and mortality is warranted.

Our exploratory analyses found that the association between alternate-hospital readmission and mortality was present in academic sector readmitting hospitals but within community sector readmitting hospitals. Exploratory comparisons of specific hospital sector transitions also suggested that hospital sector influences the association between alternate-hospital readmission and mortality (eTable 9). One explanation for this finding is that academic hospitals care for highly complex patients who might be particularly vulnerable to discontinuities in care[31]. A second explanation points to the confounding that might be introduced if patients with severe or unusual illnesses were directed to subspecialty academic centers for readmission. A third explanation focuses on differences in organizational culture between academic and community hospitals[52]. Further research, including organizational network analysis, may help clarify this finding[53,54].

Several features distinguish our study from past research[11]. We defined alternate-hospital versus original-hospital readmission in advance as the primary predictor of interest. Our patient cohort was population-based, universally insured, selected over an extended interval, and substantial in size. We focused on a large contiguous metropolitan area and excluded rural hospitals with potentially idiosyncratic readmission patterns. Each hospital in our study contributed a large number of patients (average of 9455 per hospital), allowing analyses to account for actual readmission site. Finally, a high proportion of our cohort died within 30 days of readmission, suggesting our patients had a substantial burden of comorbidity, a high acuity of presenting illness, or some combination of both.

Our study has several limitations inherent to an observational design. Detailed information such as clinical history, physical exam findings, laboratory data, patient preferences, cause of death, and indicators of hospital performance were not available. We had no

information on the factors motivating alternate-hospital readmission (e.g. dissatisfaction with prior care, geographic proximity when illness recurred, specialist availability) and could not assess the modifiability of the readmission patterns. Information about features that might both independently influence a patient's emergency department selection and their health outcomes (such as homelessness, the frequency of motor vehicle travel, or awareness of institutional expertise) was not available. Our focus on a single region also limits the generalizability of results. The mechanism by which alternate-hospital readmission might increase the risk of death remains a matter of conjecture.

Despite these limitations, our study has several implications for patients, clinicians, and policymakers. Prior to discharge, patients should be informed of the potential advantages of returning to their original hospital should they relapse and require emergency care[39,55]. Primary care clinicians and pre-hospital medical service providers should inquire about recent admissions and direct patients back to their original hospital where feasible. Health care financing policies that partially pay hospitals based on observed readmission rates need to consider the large numbers of patients readmitted to alternate hospitals and the distinctly high burden of illness associated with such alternate hospital readmissions. In the interim, the data suggest that alternate-hospital readmissions are worrisome and merit attention.

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All authors contributed equally to the design and conduct of the study. D Thiruchelvam and JA Staples had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors contributed to data interpretation. The initial draft of the manuscript was prepared by JA Staples. All authors revised the manuscript and provide their approval for submission.

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Table 1: Patient Characteristics

Characteristic	Original-hospital readmission (n = 161,974)	Alternate-hospital readmission (n = 36,175)
Age†		
<65 years	63,578 (39%)	13,064 (36%)
65-74 years	33,471 (21%)	7,602 (21%)
75-84 years	41,941 (26%)	9,650 (27%)
≥85 years	22,984 (14%)	5,859 (16%)
Female sex	80,941 (50%)	17,654 (49%)
Neighborhood household income*		
Highest quintile	29,375 (18%)	6,675 (19%)
Next highest quintile	29,277 (18%)	6,381 (18%)
Middle quintile	30,910 (19%)	6,609 (18%)
Next lowest quintile	35,262 (22%)	7,653 (21%)
Lowest quintile	36,696 (23%)	8,732 (24%)
Rural residence*	3,198 (2%)	465 (1%)
Additional hospitalizations in prior year	81,549 (50%)	19,428 (54%)
Seven or more physician clinic visits in prior year†	125,726 (78%)	28,540 (79%)
Charlson co-morbidity score >=2	84,955 (52%)	19,704 (55%)
Most responsible diagnosis for primary hospitalization‡		
Malignant neoplasm	19,590 (12%)	4,303 (12%)
Injury	10,666 (7%)	2,724 (8%)
Acute coronary syndrome	9,000 (6%)	2,115 (6%)
Heart failure	9,258 (6%)	1,856 (5%)
Pneumonia	6,696 (4%)	1,588 (4%)
Obstructive lung disease	6,742 (4%)	1,316 (4%)
Chronic ischemic heart disease	3,168 (2%)	2,440 (7%)
Cardiac arrhythmia	4,318 (3%)	824 (2%)
Cerebrovascular disease	3,708 (2%)	1,135 (3%)
Miscellaneous	49,237 (30%)	10,652 (29%)
Primary length of stay† **greater than cohort median**	92,533 (57%)	20,843 (58%)
Hospital-free interval† **greater than cohort median**	80,749 (50%)	20,321 (56%)
Resident of chronic care facility at readmission	16,479 (10%)	5,446 (15%)
Arrival by ambulance at readmission	70,523 (44%)	20,677 (57%)

* Missing data was coded as such and included in analyses. It was uncommon and is not presented here (<0.003% of cohort).
† Variable were analyzed as continuous data but are presented here in categorical format for interpretation.
‡ The ten most common diagnostic categories were selected for presentation here. For a full listing of primary and secondary hospitalization diagnostic categories and their frequency, see eTables 4 and 5.

Table 2: Additional Predictors of Death Within 30 Days of Hospital Readmission

Predictor	Adjusted Odds Ratio* (95% CI)
Age†	
<65 years	Reference
65-74 years	1.26 (1.23 – 1.30)
75-84 years	1.49 (1.43 – 1.55)
≥85 years	2.05 (1.90 – 2.21)
Sex	
Female	Reference
Male	1.15 (1.13 – 1.16)
Neighborhood household income‡	
Highest quintile	Reference
Next quintile	0.99 (0.96 – 1.03)
Middle quintile	1.01 (0.98 – 1.04)
Next quintile	1.03 (0.98 – 1.09)
Lowest quintile	1.01 (0.98 – 1.05)
Hospitalizations in prior year†	
1	Reference
>=2	1.11 (1.09 – 1.14)
Physician clinic visits in prior year†	
<=6	Reference
>=7	0.97 (0.94 – 1.00)
Charlson co-morbidity score†	
<=1	Reference
>=2	1.87 (1.80 – 1.94)
Primary length of stay† **longer than cohort median**	
No	Reference
Yes	1.20 (1.17 – 1.23)
Hospital-free interval† **longer than cohort median**	
No	Reference
Yes	1.03 (1.00 – 1.05)
Resident of chronic care facility at readmission	
No	Reference
Yes	1.31 (1.25 – 1.37)
Most responsible diagnosis for secondary hospitalization§	
Cardiac arrest	7.23 (5.70 – 9.18)
Malignant neoplasm	3.57 (3.16 – 4.03)
Sepsis	3.10 (2.72 – 3.53)
Liver disease	2.29 (2.03 – 2.59)
Pneumonia	1.87 (1.69 – 2.07)
Miscellaneous	Reference
Nephrolithiasis	0.44 (0.41 – 0.47)
Nonspecific abdominal pain	0.40 (0.36 – 0.43)
Nonspecific chest pain	0.26 (0.24 – 0.28)
Syncope and collapse	0.24 (0.22 – 0.27)
Prostatic hypertrophy	0.24 (0.20 – 0.29)
Arrival by ambulance at readmission	
No	Reference
Yes	1.95 (1.88 – 2.01)
Year of readmission†	
1994 – 1999	Reference
2000 – 2005	0.95 (0.92 – 0.99)
2006 – 2010	0.87 (0.83 – 0.92)
Sector of secondary hospital	
Community	Reference
Academic	0.70 (0.59 – 0.82)
Case volume of secondary hospital†	
Lower	Reference
Higher	1.04 (0.86 – 1.25)

* Adjusted for age, sex, neighborhood household income, hospitalizations in prior year, physician clinic visits in prior year, Charlson comorbidity score, chronic care facility residency at readmission, most responsible diagnosis at secondary hospitalization, arrival by ambulance at readmission, year of readmission, primary length of stay, hospital-free interval, and secondary hospital sector and case volume.
† Variables were analyzed as continuous data but are presented here in categorical format for interpretation.
‡ Missing data was coded as such and included in the analysis. It was uncommon (<0.003%) and is not presented here.
§ The five most dangerous and most protective diagnostic categories were selected for presentation here. For a full listing, see eTable 8.

Table 3: Unadjusted Comparison of the Odds of 30-day Mortality Following Alternate-Hospital Readmission to the Odds of 30-day Mortality Following Original-Hospital Readmission, Stratified on Patient Characteristics

Characteristic	Unadjusted Odds Ratio (95% CI)
Age	
<65 years	1.36 (1.27 – 1.46)
65-74 years	1.22 (1.11 – 1.33)
75-84 years	1.16 (1.09 – 1.23)
≥85 years	1.15 (1.07 – 1.23)
Sex	
Female	1.35 (1.26 – 1.45)
Male	1.16 (1.08 – 1.25)
Neighborhood household income	
Highest quintile	1.27 (1.14 – 1.42)
Next highest quintile	1.22 (1.11 – 1.33)
Middle quintile	1.23 (1.13 – 1.34)
Next lowest quintile	1.25 (1.17 – 1.34)
Lowest quintile	1.28 (1.19 – 1.37)
Charlson co-morbidity score	
<=1	1.42 (1.24 – 1.63)
>=2	1.17 (1.10 – 1.24)
Hospitalizations in prior year	
1	1.46 (1.35 – 1.58)
>=2	1.09 (1.01 – 1.18)
Physician clinic visits in prior year	
<=6	1.32 (1.21 – 1.43)
>=7	1.23 (1.15 – 1.32)
Most responsible diagnosis for secondary hospitalization*	
Injury	2.27 (1.72 – 2.99)
Diverticular disease	2.25 (1.43 – 3.55)
Intestinal obstruction	1.80 (1.32 – 2.45)
Abdominal pain	1.61 (0.61 – 4.23)
Infections of the skin	1.53 (1.00 – 2.35)
-	-
Acute coronary syndrome	0.93 (0.80 - 1.07)
Venous thromboembolism	0.89 (0.67 - 1.19)
Chest pain not otherwise specified	0.75 (0.29 - 1.90)
Syncope and collapse	0.64 (0.25 - 1.63)
Chronic ischemic heart disease	0.52 (0.35 - 0.76)
Primary hospitalization length of stay longer than cohort median	
No	1.26 (1.16 – 1.36)
Yes	1.25 (1.15 – 1.35)
Hospital-free interval longer than cohort median	
No	1.30 (1.19 – 1.42)
Yes	1.20 (1.13 – 1.27)
Resident of chronic care facility at readmission date	
No	1.25 (1.17 – 1.33)
Yes	0.99 (0.89 – 1.11)
Arrival by ambulance at readmission	
No	1.19 (1.07 – 1.31)
Yes	1.02 (0.96 – 1.08)

* The ten diagnostic groups with the most extreme effect (five with the greatest augmentation and the five with the greatest mitigation) on the unadjusted risk of 30-day mortality with alternate-hospital readmission were selected for presentation here. For a full listing of unadjusted results stratified by secondary hospitalization diagnosis, see eTable 10.

Figure 1: Patient Flow Diagram

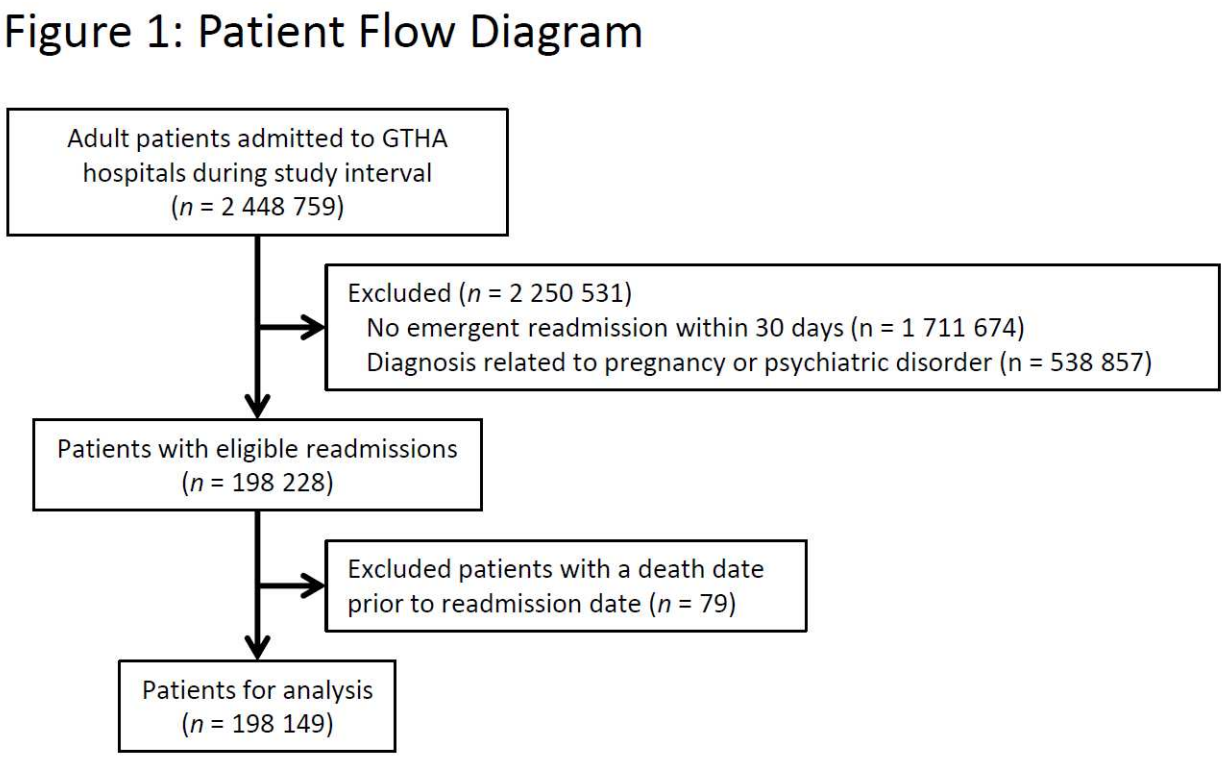


Figure 2: Odds Ratios for 30-day Mortality, Stratified by Secondary Hospital

Figure 2a: Unadjusted Odds Ratio for 30-day Mortality, Stratified by Secondary Hospital

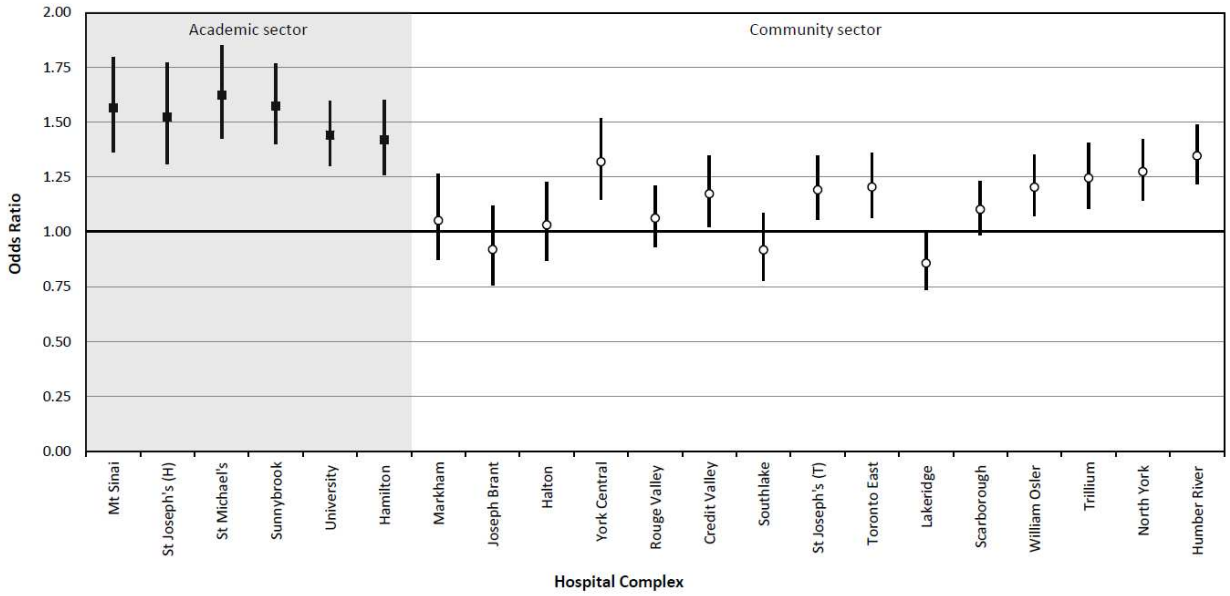
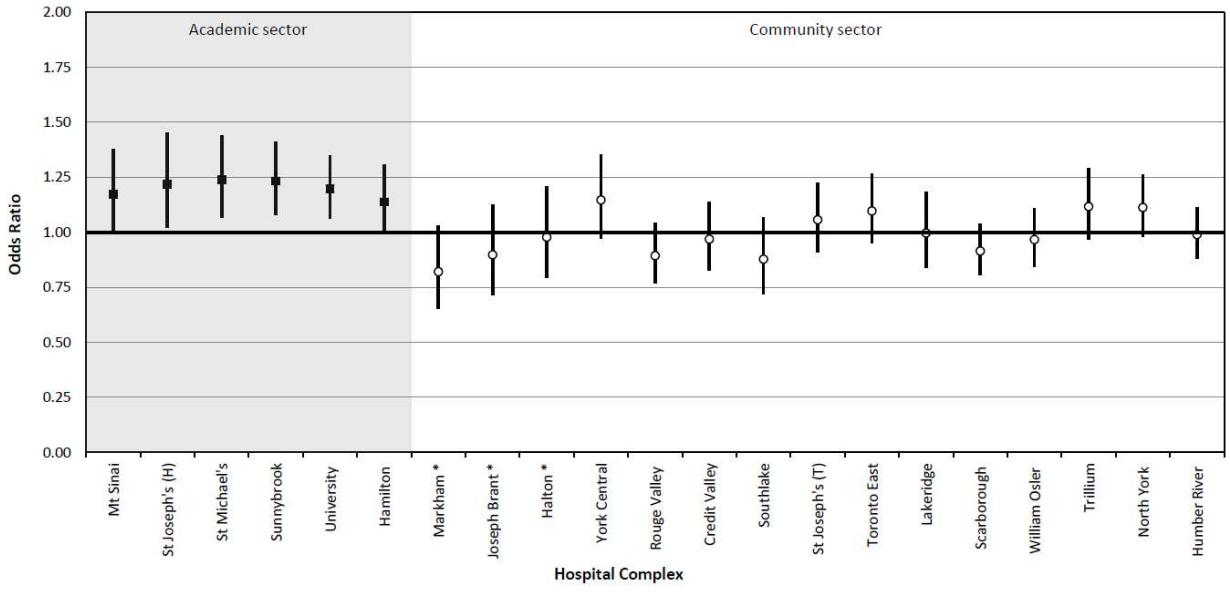
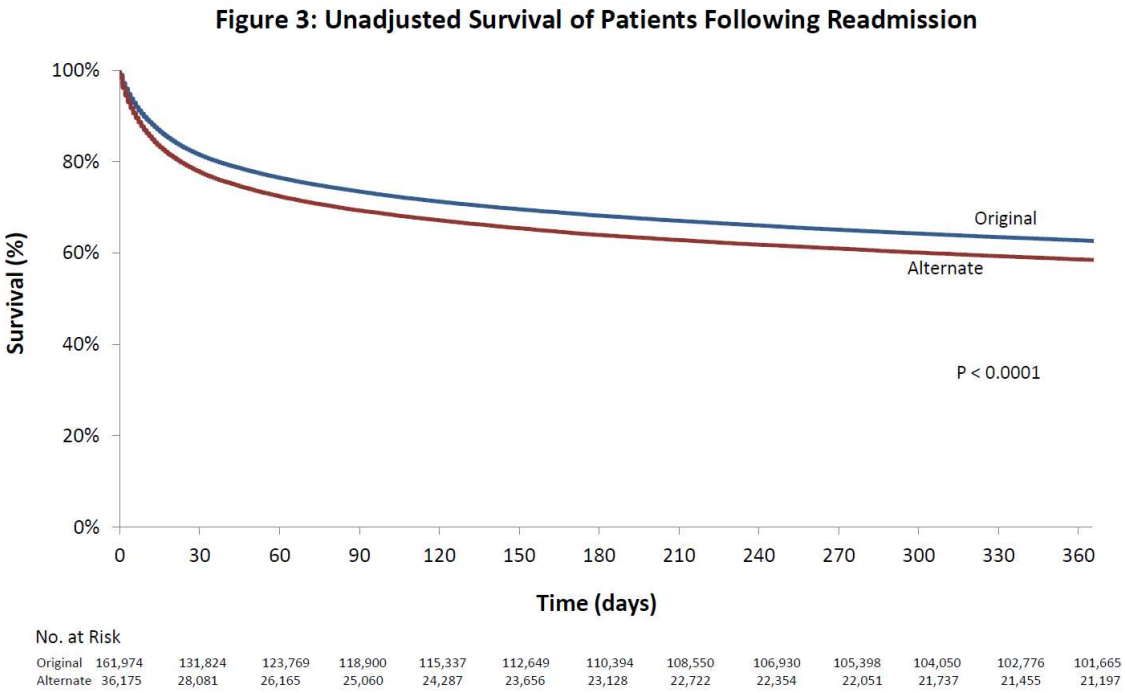


Figure 2b: Adjusted Odds Ratio for 30-day Mortality, Stratified by Secondary Hospital



Legend: Data points represent the hospital-specific odds ratio comparing the odds of death within 30 days of alternate-hospital readmission to the odds of death within 30 days of original-hospital readmission. For this stratification, patients were assigned to their secondary (ie readmission) hospital. Black square data points indicate academic sector hospitals. White circle data points indicate community sector hospitals. Vertical lines represent the 95% confidence interval for the associated data point. Multivariate logistic regression produces unstable estimates due to nonconvergence for the hospitals marked with asterisks.

Figure 3: Unadjusted Survival of Patients Following Readmission



Site of Hospital Readmission and Mortality:

On-Line Only Material

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eTable 1: Diagnostic Categories

Category	Clinical Classifications Software (CCS)[37] Components
Nonspecific abdominal pain	Abdominal pain
Acute coronary syndrome	Acute myocardial infarction
Acute renal failure	Acute and unspecified renal failure
Appendicitis	Appendicitis and other appendiceal conditions
Cardiac dysrhythmias	Conduction disorders Cardiac dysrhythmias
Biliary tract disease	Biliary tract disease
Cardiac arrest	Cardiac arrest and ventricular fibrillation
Cerebrovascular disease	Acute cerebrovascular disease Occlusion or stenosis of precerebral arteries Other and ill-defined cerebrovascular disease Transient cerebral ischemia Late effects of cerebrovascular disease
Nonspecific chest pain	Nonspecific chest pain
Chronic ischemic heart disease	Coronary atherosclerosis and other heart disease
Diabetes	Diabetes mellitus without complication Diabetes mellitus with complications
Diverticular disease	Diverticulosis and diverticulitis
Fluid and electrolyte imbalance	Fluid and electrolyte disorders
Gastrointestinal hemorrhage	Gastrointestinal hemorrhage Gastroduodenal ulcer (except hemorrhage)
Heart failure	Congestive heart failure; nonhypertensive
Infections of the skin	Skin and subcutaneous tissue infections
Inflammatory bowel disease	Regional enteritis and ulcerative colitis

eTable 1: Diagnostic Categories (continued)

Category	Clinical Classifications Software (CCS)[37] Components
Injury	Joint disorders and dislocations; trauma-related
	Fracture of neck of femur (hip)
	Spinal cord injury
	Skull and face fractures
	Fracture of upper limb
	Fracture of lower limb
	Other fractures
	Sprains and strains
	Intracranial injury
	Crushing injury or internal injury
	Open wounds of head; neck; and trunk
	Open wounds of extremities
	Complication of device; implant or graft
	Complications of surgical procedures or medical care
	Superficial injury; contusion
	Burns
	Poisoning by psychotropic agents
	Poisoning by other medications and drugs
	Poisoning by nonmedicinal substances
	Suicide and intentional self-inflicted injury [ICD-9CM CCS only]
	Other injuries and conditions due to external causes
	E Codes: All (external causes of injury and poisoning)
	E Codes: Cut/pierceb
	E Codes: Drowning/submersion
	E Codes: Fall
	E Codes: Fire/burn
	E Codes: Firearm
	E Codes: Machinery
	E Codes: Motor vehicle traffic (MVT)
	E Codes: Pedal cyclist; not MVT
	E Codes: Pedestrian; not MVT
	E Codes: Transport; not MVT
	E Codes: Natural/environment
	E Codes: Overexertion
	E Codes: Poisoning
	E Codes: Struck by; against
	E Codes: Suffocation
	E Codes: Adverse effects of medical care
	E Codes: Adverse effects of medical drugs
	E Codes: Other specified and classifiable
	E Codes: Other specified; NEC [ICD-9CM CCS only]
	E Codes: Unspecified [ICD-9CM CCS only]
	E Codes: Place of occurrence [ICD-9CM CCS only]

eTable 1: Diagnostic Categories (continued)

Category	Clinical Classifications Software (CCS)[37] Components
Intestinal obstruction	Intestinal obstruction without hernia Abdominal hernia [only those codes that specify intestinal obstruction]
Liver disease	Liver disease; alcohol-related Other liver diseases Hepatitis
Nephrolithiasis	Calculus of urinary tract
Obstructive lung disease	Chronic obstructive pulmonary disease and bronchiectasis Asthma
Pneumonia	Pneumonia (except that caused by tuberculosis or sexually transmitted disease) Influenza Aspiration pneumonitis; food/vomitus
Prostatic hypertrophy	Hyperplasia of prostate
Sepsis	Septicemia (except in labor)
Syncope	Syncope
Urinary tract infection	Urinary tract infections
Venous thromboembolism	Phlebitis; thrombophlebitis and thromboembolism
Malignant neoplasm	Cancer of head and neck Cancer of esophagus Cancer of stomach Cancer of colon Cancer of rectum and anus Cancer of liver and intrahepatic bile duct Cancer of pancreas Cancer of other GI organs; peritoneum Cancer of bronchus; lung Cancer; other respiratory and intrathoracic Cancer of bone and connective tissue Melanomas of skin Cancer of breast Cancer of uterus Cancer of cervix Cancer of ovary Cancer of other female genital organs Cancer of prostate Cancer of testis Cancer of other male genital organs Cancer of bladder Cancer of kidney and renal pelvis Cancer of other urinary organs Cancer of brain and nervous system

eTable 1: Diagnostic Categories (continued)

Category	Clinical Classifications Software (CCS)[37] Components
Malignant neoplasm (continued)	Cancer of thyroid
	Hodgkin`s disease
	Non-Hodgkin`s lymphoma
	Leukemias
	Multiple myeloma
	Cancer; other and unspecified primary
	Secondary malignancies
	Malignant neoplasm without specification of site
	Neoplasms of unspecified nature or uncertain behavior
	Maintenance chemotherapy; radiotherapy
Miscellaneous	Overall
	No diagnosis
	Invalid diagnosis
	Tuberculosis
	Bacterial infection; unspecified site
	Mycoses
	HIV infection
	Viral infection
	Other infections; including parasitic
	Sexually transmitted infections (not HIV or hepatitis)
	Immunizations and screening for infectious disease
	Thyroid disorders
	Benign neoplasm of uterus
	Other and unspecified benign neoplasm
	Other endocrine disorders
	Nutritional deficiencies
	Disorders of lipid metabolism
	Gout and other crystal arthropathies
	Cystic fibrosis
	Immunity disorders
	Other nutritional; endocrine; and metabolic disorders
	Deficiency and other anemia
	Acute posthemorrhagic anemia
	Sickle cell anemia
	Coagulation and hemorrhagic disorders
	Diseases of white blood cells
	Other hematologic conditions

eTable 1: Diagnostic Categories (continued)

Category	Clinical Classifications Software (CCS)[37] Components
Miscellaneous (continued)	Adjustment disorders [ICD-9CM CCS only] Anxiety disorders [ICD-9CM CCS only] Anxiety; somatoform; dissociative; and personality disorders [ICD-10-CM CCS only] Attention-deficit, conduct, and disruptive behavior disorders [ICD-9CM CCS only] Delirium, dementia, and amnestic and other cognitive disorders [ICD-9CM CCS only] Senility and organic mental disorders [ICD-10-CM CCS only] Developmental disorders [ICD-9CM CCS only] Mental retardation [ICD-10-CM CCS only] Disorders usually diagnosed in infancy, childhood, or adolescence [ICD-9CM CCS only] Preadult disorders [ICD-10-CM CCS only] Impulse control disorders, NEC [ICD-9CM CCS only] Mood disorders [ICD-9CM CCS only] Affective disorders [ICD-10-CM CCS only] Personality disorders [ICD-9CM CCS only] Schizophrenia and other psychotic disorders [ICD-9CM CCS only] Schizophrenia and related disorders [ICD-10-CM CCS only] Other psychoses [ICD-10-CM CCS only] Alcohol-related disorders [ICD-9CM CCS only] Alcohol-related mental disorders [ICD-10-CM CCS only] Substance-related disorders [ICD-9CM CCS only] Substance-related mental disorders [ICD-10-CM CCS only] Screening and history of mental health and substance abuse codes [ICD-9CM CCS only] Other mental conditions [ICD-10-CM CCS only] Personal history of mental disorder; mental and behavioral problems; observation and screening for mental condition [ICD-10-CM CCS only] Miscellaneous disorders [ICD-9CM CCS only] Meningitis (except that caused by tuberculosis or sexually transmitted disease) Encephalitis (except that caused by tuberculosis or sexually transmitted disease) Other CNS infection and poliomyelitis Parkinson`s disease Multiple sclerosis Other hereditary and degenerative nervous system conditions Paralysis Epilepsy; convulsions Headache; including migraine Coma; stupor; and brain damage

eTable 1: Diagnostic Categories (continued)

Category	Clinical Classifications Software (CCS)[37] Components
Miscellaneous (continued)	Cataract
	Retinal detachments; defects; vascular occlusion; and retinopathy
	Glaucoma
	Blindness and vision defects
	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)
	Other eye disorders
	Otitis media and related conditions
	Conditions associated with dizziness or vertigo
	Other ear and sense organ disorders
	Other nervous system disorders
	Heart valve disorders
	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease)
	Essential hypertension
	Hypertension with complications and secondary hypertension
	Pulmonary heart disease
	Other and ill-defined heart disease
	Peripheral and visceral atherosclerosis
	Aortic; peripheral; and visceral artery aneurysms
	Aortic and peripheral arterial embolism or thrombosis
	Other circulatory disease
	Varicose veins of lower extremity
	Hemorrhoids
	Other diseases of veins and lymphatics
	Acute and chronic tonsillitis
	Acute bronchitis
	Other upper respiratory infections
	Pleurisy; pneumothorax; pulmonary collapse
	Respiratory failure; insufficiency; arrest (adult)
	Lung disease due to external agents
	Other lower respiratory disease
	Other upper respiratory disease
	Intestinal infection
	Disorders of teeth and jaw
	Diseases of mouth; excluding dental
	Esophageal disorders
	Gastritis and duodenitis
	Other disorders of stomach and duodenum
	Anal and rectal conditions
	Peritonitis and intestinal abscess

eTable 1: Diagnostic Categories (continued)

Category	Clinical Classifications Software (CCS)[37] Components
Miscellaneous (continued)	Pancreatic disorders (not diabetes) Noninfectious gastroenteritis Other gastrointestinal disorders Nephritis; nephrosis; renal sclerosis Chronic renal failure Other diseases of kidney and ureters Other diseases of bladder and urethra Genitourinary symptoms and ill-defined conditions Inflammatory conditions of male genital organs Other male genital disorders Nonmalignant breast conditions Inflammatory diseases of female pelvic organs Endometriosis Prolapse of female genital organs Menstrual disorders Ovarian cyst Menopausal disorders Female infertility Other female genital disorders Contraceptive and procreative management Spontaneous abortion Induced abortion Postabortion complications Ectopic pregnancy Other complications of pregnancy Hemorrhage during pregnancy; abruptio placenta; placenta previa Hypertension complicating pregnancy; childbirth and the puerperium Early or threatened labor Prolonged pregnancy Diabetes or abnormal glucose tolerance complicating pregnancy; childbirth; or the puerperium Malposition; malpresentation Fetopelvic disproportion; obstruction Previous C-section Fetal distress and abnormal forces of labor Polyhydramnios and other problems of amniotic cavity Umbilical cord complication OB-related trauma to perineum and vulva Forceps delivery

eTable 1: Diagnostic Categories (continued)

Category	Clinical Classifications Software (CCS)[37] Components
Miscellaneous (continued)	Other complications of birth; puerperium affecting management of mother Normal pregnancy and/or delivery Other inflammatory condition of skin Chronic ulcer of skin Other skin disorders Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease) Rheumatoid arthritis and related disease Osteoarthritis Other non-traumatic joint disorders Spondylosis; intervertebral disc disorders; other back problems Osteoporosis Pathological fracture Acquired foot deformities Other acquired deformities Systemic lupus erythematosus and connective tissue disorders Other connective tissue disease Other bone disease and musculoskeletal deformities Cardiac and circulatory congenital anomalies Digestive congenital anomalies Genitourinary congenital anomalies Nervous system congenital anomalies Other congenital anomalies Liveborn Short gestation; low birth weight; and fetal growth retardation Intrauterine hypoxia and birth asphyxia Respiratory distress syndrome Hemolytic jaundice and perinatal jaundice Birth trauma Other perinatal conditions Fever of unknown origin Lymphadenitis Gangrene Shock Nausea and vomiting Malaise and fatigue Allergic reactions Rehabilitation care; fitting of prostheses; and adjustment of devices Administrative/social admission Medical examination/evaluation Other aftercare Other screening for suspected conditions (not mental disorders or infectious disease) Residual codes; unclassified

eTable 2: Hospital Characteristics for Analysis[29,44,45,46,56]

Hospital	Inpatient Acute-care Sites	Size* (beds)	Case Volume† (discharges/y)
Academic Sector			
Mt Sinai	Mount Sinai Hospital	222	24,738
St Joseph's (H)	St Joseph's Health Care System (Hamilton)	256	19,881
St Michael's	St Michael's Hospital	402	24,954
Sunnybrook	Sunnybrook Health Sciences Centre	438	29,049
University	University Health Network: Princess Margaret, Toronto General, and Toronto Western sites	639	29,072
Hamilton	Hamilton Health Sciences Corporation: General, Juravinski, and McMaster sites	559	39,849
Community Sector			
Markham	Markham Stouffville Hospital	111	11,479
Joseph Brant	Joseph Brant Memorial Hospital	167	13,152
Halton	Halton Healthcare Services Corporation: Milton and Oakville sites	188	16,731
York Central	York Central Hospital	167	14,677
Rouge Valley	Rouge Valley Health System: Centenary and Ajax sites	259	24,697
Credit Valley	Credit Valley Hospital	208	21,186
Southlake	Southlake Regional Health Centre	164	16,080
St Joseph's (T)	St Joseph's Health Centre (Toronto)	259	17,681
Toronto East	Toronto East General Hospital	249	18,801
Lakeridge	Lakeridge Health Corporation: Bowmanville, Oshawa, Port Perry, and Uxbridge sites	329	25,374
Scarborough	Scarborough Hospital: General and Grace sites	453	34,570
William Osler	William Osler Health System: Brampton, Etobicoke, and Georgetown sites	343	40,856
Trillium	Trillium Health Centre (Mississauga)	328	30,693
North York	North York General Hospital: General and Branson sites	255	27,137
Humber River	Humber River Regional Hospital: Humber Memorial, Northwestern, and York-Finch sites	433	29,138

* Size reflects the number of medical and surgical adult acute care in-patient beds reported for the hospital in 2002.
† Case volume reflects the total number of separations reported for the hospital in 2002.

eTable 3: Hospital Characteristics for Description* [29,44,45,46]

Hospital	Established (year)	Religious Affiliation	Annual Budget (million $CAD)	Average Length of Stay (days)	Myocardial Infarction 28-day Readmission Rate* (%)	Use of Clinical Information Technology† (%)	Patient Assessment of Quality of Care† (%)
Academic Sector							
Mt Sinai	1923	Yes	184	6.0	5.9	60.1	89.8
St Joseph's (H)	1890	Yes	158	6.7	7.5	60.1	89.8
St Michael's	1892	Yes	370	7.0	5.9	47.6	87.6
Sunnybrook	1948	No	400	8.0	3.8	74.8	87.6
University	1829	No	650	7.5	3.8	74.8	87.6
Hamilton	1848	No	530	7.9	5.9	47.6	89.8
Community Sector							
Markham	1990	No	60	6.0	7.5	60.1	89.8
Joseph Brant	1961	No	73	6.6	5.9	25.0	87.6
Halton	1949	No	132	5.8	10.1	60.1	89.8
York Central	1963	No	77	6.5	7.5	60.1	82.0
Rouge Valley	1954	No	189	6.4	7.5	47.6	87.6
Credit Valley	1985	No	170	7.5	10.1	74.8	87.6
Southlake	1922	No	98	5.0	10.1	47.6	92.2
St Joseph's (T)	1921	Yes	142	5.8	7.5	47.6	87.6
Toronto East	1929	No	127	7.2	5.9	60.1	85.8
Lakeridge	1946	No	183	5.6	7.5	74.8	85.8
Scarborough	1956	Yes	231	6.6	10.1	60.1	82.0
William Osler	1961	No	165	3.5	5.9	74.8	82.0
Trillium	1958	No	194	6.0	3.8	74.8	82.0
North York	1957	No	254	5.0	3.8	60.1	87.6
Humber River	1948	No	141	6.6	5.9	47.6	82.0

* Data from study midpoint (2002 where possible, 2004 otherwise).
†Data reported as a range in the source rather than a point estimate. The midpoint of the reported range is presented here.

eTable 4: Diagnostic Category Frequency for Primary Hospitalization

Most Responsible Diagnosis for Primary Hospitalization	Original Hospital Readmission (n = 161,974)	Alternate Hospital Readmission (n = 36,175)
Miscellaneous	49,237 (30.4%)	10,652 (29.4%)
Malignant neoplasm	19,590 (12.1%)	4,303 (11.9%)
Injury	10,666 (6.6%)	2,724 (7.5%)
Acute coronary syndrome	9,000 (5.6%)	2,115 (5.8%)
Heart failure	9,258 (5.7%)	1,856 (5.1%)
Pneumonia	6,696 (4.1%)	1,588 (4.4%)
Obstructive lung disease	6,742 (4.2%)	1,316 (3.6%)
Chronic ischemic heart disease	3,168 (2.0%)	2,440 (6.7%)
Cardiac arrhythmia	4,318 (2.7%)	824 (2.3%)
Cerebrovascular disease	3,708 (2.3%)	1,135 (3.1%)
Biliary tract disease	4,172 (2.6%)	463 (1.3%)
Intestinal obstruction	3,709 (2.3%)	465 (1.3%)
Gastrointestinal hemorrhage	3,202 (2.0%)	597 (1.7%)
Urinary tract infection	2,905 (1.8%)	761 (2.1%)
Diabetes	2,844 (1.8%)	674 (1.9%)
Liver disease	2,560 (1.6%)	531 (1.5%)
Fluid and electrolyte imbalance	2,223 (1.4%)	565 (1.6%)
Nonspecific chest pain	2,013 (1.2%)	498 (1.4%)
Nonspecific abdominal pain	1,868 (1.2%)	360 (1.0%)
Acute renal failure	1,448 (0.9%)	373 (1.0%)
Infections of the skin	1,484 (0.9%)	310 (0.9%)
Sepsis	1,491 (0.9%)	285 (0.8%)
Appendicitis	1,633 (1.0%)	97 (0.3%)
Diverticular disease	1,480 (0.9%)	150 (0.4%)
Venous thromboembolism	1,335 (0.8%)	221 (0.6%)
Nephrolithiasis	1,419 (0.9%)	135 (0.4%)
Inflammatory bowel disease	1,381 (0.9%)	172 (0.5%)
Prostatic hypertrophy	1,225 (0.8%)	173 (0.5%)
Syncope and collapse	947 (0.6%)	290 (0.8%)
Cardiac arrest	252 (0.2%)	102 (0.3%)

eTable 5: Diagnostic Category Frequency for Secondary Hospitalization

Most Responsible Diagnosis for Secondary Hospitalization	Original Hospital Readmission (n = 161,974)	Alternate Hospital Readmission (n = 36,175)
Miscellaneous	47,116 (29.1%)	10,362 (28.6%)
Malignant neoplasm	13,085 (8.1%)	2,802 (7.7%)
Injury	20,194 (12.5%)	2,888 (8.0%)
Acute coronary syndrome	6,648 (4.1%)	1,933 (5.3%)
Heart failure	10,193 (6.3%)	2,452 (6.8%)
Pneumonia	7,584 (4.7%)	2,264 (6.3%)
Obstructive lung disease	5,855 (3.6%)	1,177 (3.3%)
Chronic ischemic heart disease	1,599 (1.0%)	404 (1.1%)
Cardiac arrhythmia	554 (0.3%)	203 (0.6%)
Cerebrovascular disease	4,008 (2.5%)	1,398 (3.9%)
Biliary tract disease	3,213 (2.0%)	511 (1.4%)
Intestinal obstruction	4,830 (3.0%)	648 (1.8%)
Gastrointestinal hemorrhage	3,624 (2.2%)	960 (2.7%)
Urinary tract infection	3,370 (2.1%)	866 (2.4%)
Diabetes	2,606 (1.6%)	679 (1.9%)
Liver disease	2,618 (1.6%)	595 (1.6%)
Fluid and electrolyte imbalance	2,799 (1.7%)	651 (1.8%)
Nonspecific chest pain	3,149 (1.9%)	1,094 (3.0%)
Nonspecific abdominal pain	2,306 (1.4%)	320 (0.9%)
Acute renal failure	1,853 (1.1%)	490 (1.4%)
Infections of the skin	1,399 (0.9%)	277 (0.8%)
Sepsis	2,805 (1.7%)	788 (2.2%)
Appendicitis	336 (0.2%)	61 (0.2%)
Diverticular disease	1,033 (0.6%)	149 (0.4%)
Venous thromboembolism	2,426 (1.5%)	605 (1.7%)
Nephrolithiasis	1,053 (0.7%)	110 (0.3%)
Inflammatory bowel disease	909 (0.6%)	150 (0.4%)
Prostatic hypertrophy	201 (0.1%)	17 (0.0%)
Syncope and collapse	988 (0.6%)	373 (1.0%)
Cardiac arrest	554 (0.3%)	203 (0.6%)

eTable 6: Secondary Hospital Characteristics

Characteristic*	Original Hospital Readmission (n = 161,974)	Alternate Hospital Readmission (n = 36,175)
For Analysis		
Academic sector (percent)	36	33
Average adult acute-care medical and surgical beds (count)	328	328
Average annual case volume (patient discharges per year)	27,196	26,160
For Description		
Average year of establishment (year)	1948	1948
Religious affiliation (percent)	21	24
Average annual budget (million $CAD)	183	183
Average length of stay (days)	7	7
Average 28-day readmission rate following discharge after acute myocardial infarction (rate per 100 patients)	5.9	5.9
Average use of clinical information technology (percent)	60	60
Average patient rating of global quality (percent)	88	88

* Data represent the distribution of characteristics within the population of readmissions, rather than the distribution of characteristics within all qualifying GTHA hospitals. Reported averages are medians.

eTable 7: Primary Outcome Stratified by Secondary Hospital

Hospital	Sample Size (count)	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio* (95% CI)
Academic Sector			
Mt Sinai	6,535	1.57 (1.36 – 1.80)	1.17 (1.00 – 1.38)
St Joseph's (H)	7,726	1.52 (1.31 – 1.77)	1.22 (1.02 – 1.45)
St Michael's	9,744	1.63 (1.43 – 1.85)	1.24 (1.07 – 1.44)
Sunnybrook	10,110	1.57 (1.40 – 1.77)	1.23 (1.08 – 1.41)
University	15,335	1.44 (1.30 – 1.60)	1.20 (1.07 – 1.35)
Hamilton	19,758	1.42 (1.26 – 1.60)	1.14 (0.99 – 1.31)
Community Sector			
Markham†	3,723	1.05 (0.88 – 1.27)	0.82 (0.66 – 1.03)
Joseph Brant†	6,397	0.92 (0.76 – 1.12)	0.90 (0.72 -1.13)
Halton†	6,736	1.03 (0.87 – 1.23)	0.98 (0.79 – 1.21)
York Central	6,913	1.32 (1.15 – 1.52)	1.15 (0.97 – 1.35)
Rouge Valley	7,096	1.06 (0.93 – 1.21)	0.89 (0.77 – 1.04)
Credit Valley	7,371	1.17 (1.02 – 1.35)	0.97 (0.83 – 1.14)
Southlake	8,405	0.92 (0.78 – 1.09)	0.88 (0.72 – 1.07)
St Joseph's (T)	9,057	1.19 (1.06 – 1.35)	1.06 (0.91 – 1.22)
Toronto East	9,455	1.21 (1.07 – 1.36)	1.10 (0.95 – 1.27)
Lakeridge	9,472	0.86 (0.74 – 1.00)	1.00 (0.84 – 1.18)
Scarborough	10,072	1.10 (0.99 – 1.23)	0.92 (0.81 – 1.04)
William Osler	10,534	1.20 (1.07 – 1.35)	0.97 (0.84 – 1.11)
Trillium	10,770	1.25 (1.11 – 1.41)	1.12 (0.97 – 1.29)
North York	10,965	1.28 (1.14 – 1.42)	1.11 (0.98 – 1.26)
Humber River	11,975	1.35 (1.22 – 1.49)	0.99 (0.88 – 1.11)
Overall	**198,149**	**1.26 (1.23 – 1.30)**	**-**

* Adjusted odds ratios for hospital-specific strata were generated using multivariate logistic regression.
†Multivariate logistic regression produced unstable adjusted odds ratios for these hospitals due to model nonconvergence.

eTable 8: Diagnosis as Predictor of 30-day Mortality

Most Responsible Diagnosis for Secondary Hospitalization	Adjusted Odds Ratio* (95% CI)
Miscellaneous	Reference
Malignant neoplasm	3.57 (3.16 – 4.03)
Injury	0.45 (0.41 – 0.48)
Acute coronary syndrome	1.05 (0.94 – 1.16)
Heart failure	0.91 (0.83 – 1.01)
Pneumonia	1.87 (1.69 – 2.07)
Obstructive lung disease	0.93 (0.85 – 1.02)
Chronic ischemic heart disease	0.67 (0.59 – 0.76)
Cardiac arrhythmia	0.45 (0.41 – 0.50)
Cerebrovascular disease	1.27 (1.13 – 1.42)
Biliary tract disease	0.53 (0.49 – 0.58)
Intestinal obstruction	0.60 (0.55 – 0.65)
Gastrointestinal hemorrhage	0.76 (0.70 – 0.82)
Urinary tract infection	0.57 (0.52 – 0.62)
Diabetes	0.52 (0.47 – 0.58)
Liver disease	2.29 (2.03 – 2.59)
Fluid and electrolyte imbalance	0.81 (0.73 – 0.90)
Nonspecific chest pain	0.26 (0.24 – 0.28)
Nonspecific abdominal pain	0.40 (0.36 – 0.43)
Acute renal failure	1.40 (1.24 – 1.58)
Infections of the skin	0.43 (0.40 – 0.46)
Sepsis	3.10 (2.72 – 3.53)
Appendicitis	0.54 (0.46 – 0.63)
Diverticular disease	0.61 (0.55 – 0.68)
Venous thromboembolism	0.76 (0.69 – 0.85)
Nephrolithiasis	0.44 (0.41 – 0.47)
Inflammatory bowel disease	0.50 (0.46 – 0.55)
Prostatic hypertrophy	0.24 (0.20 – 0.29)
Syncope and collapse	0.24 (0.22 – 0.27)
Cardiac arrest	7.23 (5.70 – 9.18)

*As with Table 2, adjusted odds ratios presented here were generated by the model that treated continuous variables as categorical.

eTable 9: Analysis of Sector Transitions and the Comparative Odds of 30-day Mortality Following Readmission

Hospital Sector Transition Comparison	Adjusted Odds Ratio (95% CI)
Relatively Simple Comparisons	
AA(alternate) vs AA(original)[a]	1.19 (1.12 – 1.26)
CC(alternate) vs CC(original)[b]	1.04 (1.00 – 1.07)
More Complicated Comparisons	
AC(alternate) vs AA(original)[c]	1.52 (1.31 – 1.75)
CA(alternate) vs CC(original)[d]	0.74 (0.63 – 0.86)
AA(original) vs CC(original)[e]	0.64 (0.55 – 0.75)

In the notation used here to express sector transitions, the first letter represents the sector of the primary hospital (A = Academic; C = Community), the second letter represents the sector of the secondary hospital, and the subscript indicates alternate- or original-hospital readmission. To perform the exploratory sector transition analysis, we created a six-level categorical term describing all possible sector transitions [i.e. AA(original), AA(alternate), AC(alternate), CA(alternate), CC(alternate), CC(original)]. The multivariate logistic regression model with generalized estimating equations used for the primary analysis was modified by removing the term for hospital sector and replacing the alternate-hospital readmission term used for the primary outcome with the categorical term for sector transition. The odds ratios listed for each comparison express the relative risk of 30-day mortality.

Within the academic sector ([a]) alternate-hospital readmission is associated with an increased risk of death, but within the community sector ([b]) the effect is only marginally significant. This finding is similar to the results of the analysis that stratified on secondary hospital sector (see page 10 of manuscript) and suggests that the association between alternate-hospital readmission and death is modified by hospital sector.

The remainder of the results listed above can be interpreted as follows: For patients initially admitted to an academic sector hospital, readmission to an alternate academic ([a]) or community hospital ([c]) is associated with an increased risk of death compared to readmission to the original academic hospital. For patients initially admitted to a community sector hospital, readmission to an alternate community hospital is associated with a risk of death that is not significantly different than the risk associated with readmission to the original hospital ([b]), yet readmission to academic hospital is associated with lower risk than returning to the original hospital ([d]). Original hospital readmissions within the academic sector are associated with a lower risk of death than original hospital readmissions within the community sector ([e]).

eTable 10: Unadjusted Comparison of the Odds of 30-day Mortality Following Alternate-Hospital Readmission to the Odds of 30-day Mortality Following Original-Hospital Readmission, Stratified on Diagnosis

Most Responsible Diagnosis for Secondary Hospitalization	Unadjusted Odds Ratio (95% CI)
Miscellaneous	1.26 (1.19 - 1.33)
Malignant neoplasm	1.22 (1.10 - 1.36)
Injury	2.27 (1.72 - 2.99)
Acute coronary syndrome	0.93 (0.80 - 1.07)
Heart failure	0.96 (0.87 - 1.06)
Pneumonia	1.08 (0.97 - 1.19)
Obstructive lung disease	1.03 (0.87 - 1.22)
Chronic ischemic heart disease	0.52 (0.35 - 0.76)
Cardiac arrhythmia	0.97 (0.76 - 1.24)
Cerebrovascular disease	1.20 (1.01 - 1.43)
Biliary tract disease	1.00 (0.61 - 1.64)
Intestinal obstruction	1.80 (1.32 - 2.45)
Gastrointestinal hemorrhage	1.03 (0.79 - 1.33)
Urinary tract infection	1.38 (1.14 - 1.67)
Diabetes	0.93 (0.70 - 1.24)
Liver disease	1.12 (0.91 - 1.37)
Fluid and electrolyte imbalance	1.12 (0.91 - 1.38)
Nonspecific chest pain	0.75 (0.29 - 1.90)
Nonspecific abdominal pain	1.61 (0.61 - 4.23)
Acute renal failure	1.32 (1.08 - 1.60)
Infections of the skin	1.53 (1.00 - 2.35)
Sepsis	1.21 (1.02 - 1.43)
Appendicitis *	-
Diverticular disease	2.25 (1.43 - 3.55)
Venous thromboembolism	0.89 (0.67 - 1.19)
Nephrolithiasis *	-
Inflammatory bowel disease *	-
Prostatic hypertrophy *	-
Syncope and collapse	0.64 (0.25 - 1.63)
Cardiac arrest	1.12 (0.78 - 1.6)

* Effect estimates for these diagnoses could not be calculated as there were no deaths in the alternate-hospital group.

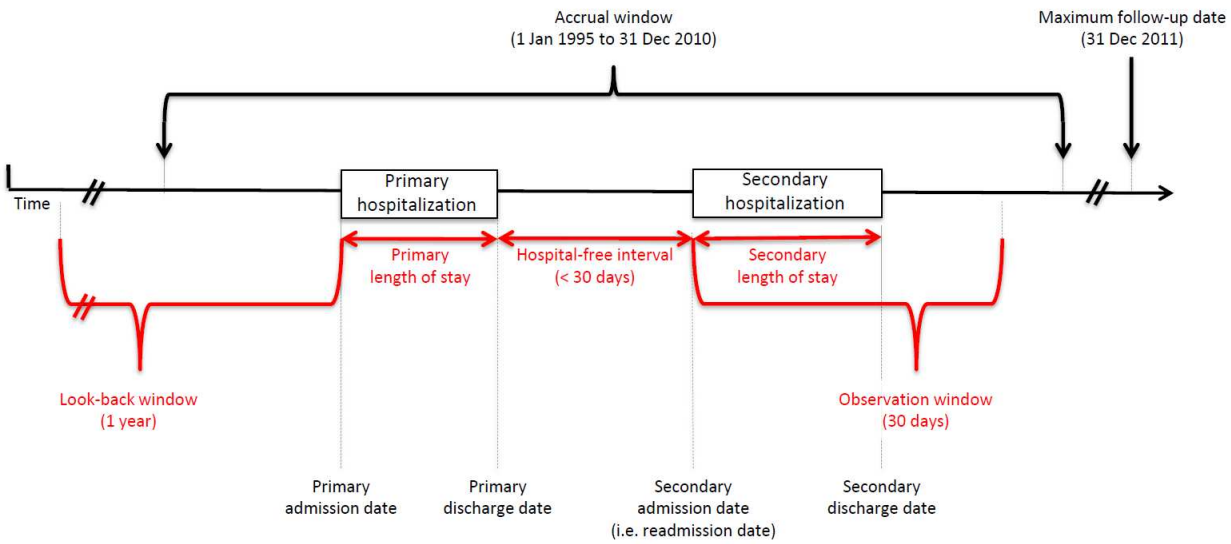
eTable 11: Adjusted Comparison of the Odds of Mortality Following Alternate-Hospital Readmission to the Odds of Mortality Following Original-Hospital Readmission at Additional Time Points

Outcome	Adjusted Odds Ratio (95%CI)
Death during secondary hospitalization	1.05 (1.02 – 1.09)
Death within 90 days	1.04 (0.99 – 1.10)
Death within 180 days	1.03 (0.97 – 1.09)
Death within one year	1.01 (0.95 – 1.07)

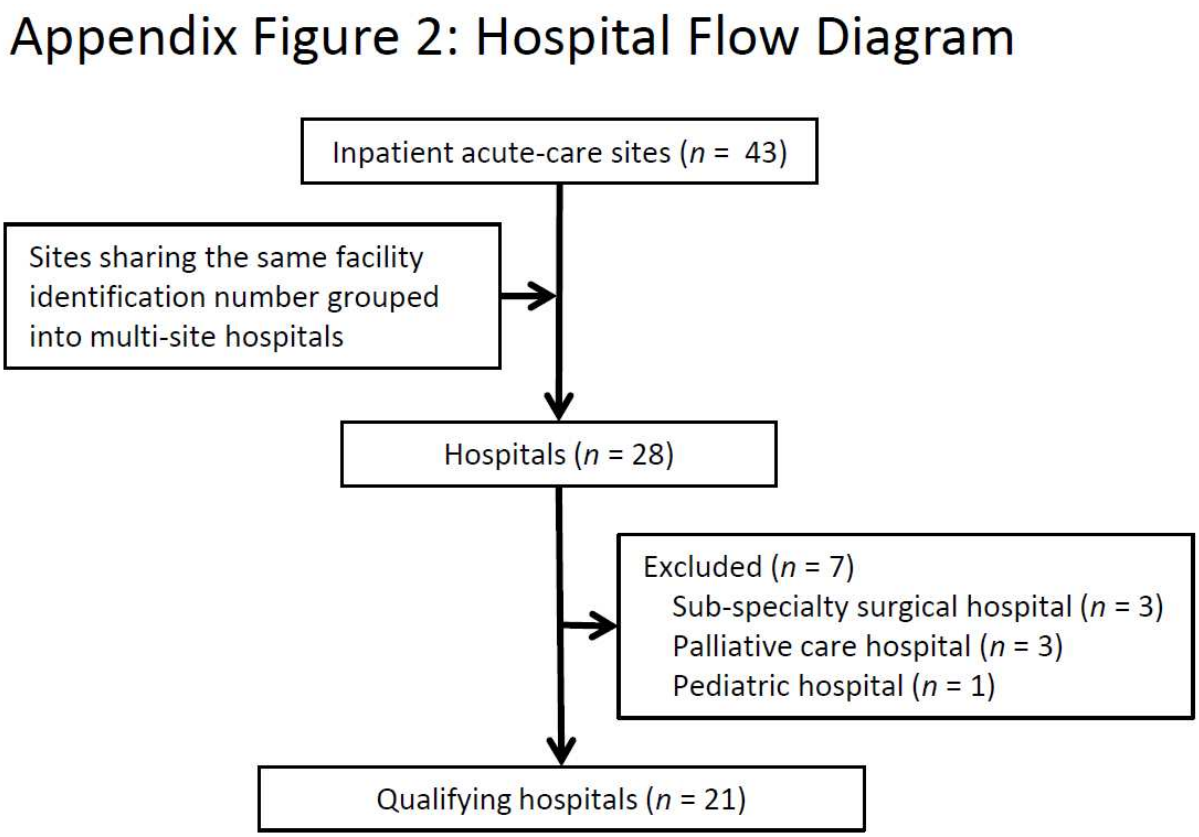
eTable 12: Odds Ratio for Death Within 30 Days of Readmission in the Presence of an Unmeasured Confounder With a Hazard Ratio of 2.0 for Death and Various Prevalence Levels of the Confounder, by Exposure Group

	Prevalence of Risk Factor in Original-Hospital Readmissions					
	0.0	0.1	0.2	0.3	0.4	0.5
Prevalence of Risk Factor in Alternate-Hospital Readmissions						
0.0	1.00	0.89	0.80	0.72	0.65	0.59
0.1	**1.13**	1.00	0.90	0.81	0.73	0.66
0.2	**1.26**	**1.12**	1.00	0.90	0.82	0.74
0.3	**1.40**	**1.24**	**1.11**	1.00	0.91	0.82
0.4	**1.54**	**1.37**	**1.23**	**1.10**	1.00	0.91
0.5	**1.69**	**1.50**	**1.35**	**1.21**	**1.10**	1.00
0.6	**1.85**	**1.65**	**1.47**	**1.33**	**1.20**	**1.09**
0.7	**2.02**	**1.80**	**1.61**	**1.45**	**1.31**	**1.19**
0.8	**2.20**	**1.96**	**1.75**	**1.58**	**1.43**	**1.30**
0.9	**2.39**	**2.12**	**1.90**	**1.71**	**1.55**	**1.41**
1.0	**2.59**	**2.30**	**2.06**	**1.86**	**1.68**	**1.53**

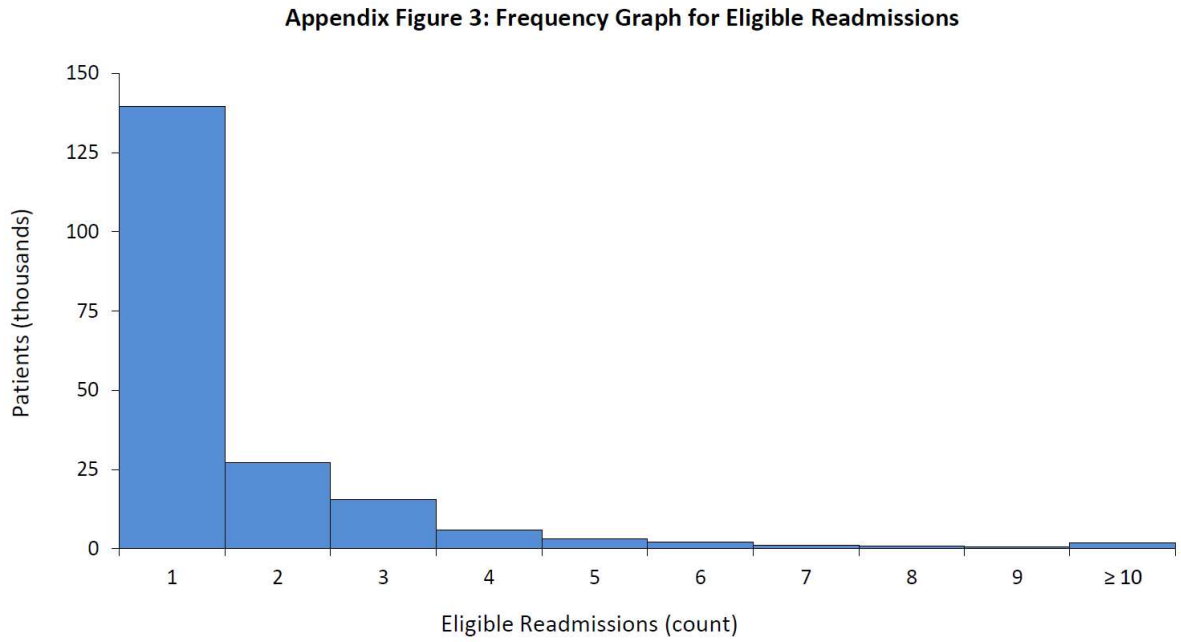
eFigure 1: Study Schematic



eFigure 2: Hospital Flow Diagram

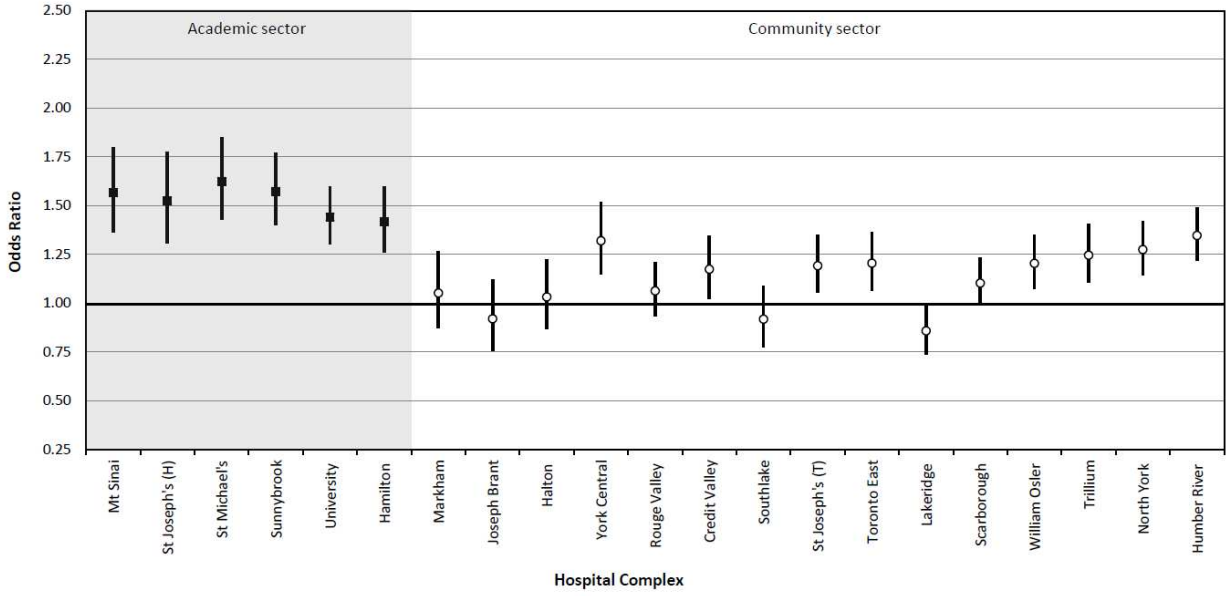


eFigure 3: Frequency Graph for Eligible Readmissions

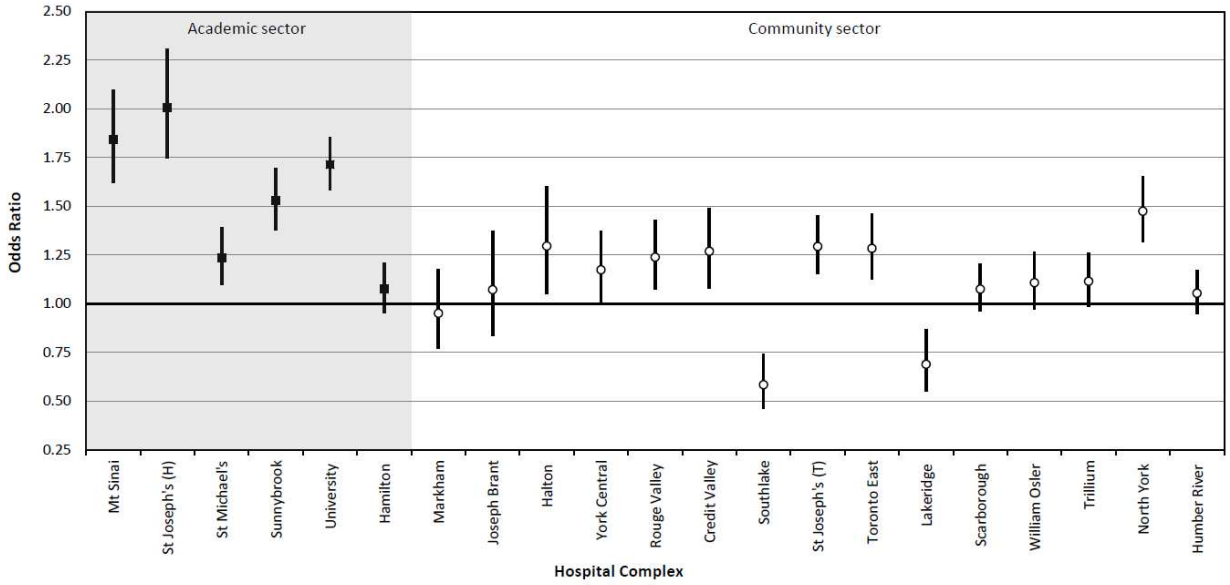


eFigure 4: Comparing Primary and Secondary Hospital Stratification

Appendix Figure 4a: Unadjusted Odds Ratio for 30-day Mortality, Stratified by Secondary Hospital



Appendix Figure 4b: Unadjusted Odds Ratio for 30-day Mortality, Stratified by Primary Hospital



Legend: Data points represent the hospital-specific odds ratio comparing the odds of death within 30 days of alternate-hospital readmission to the odds of death within 30 days of original-hospital readmission. In eFigure 3a, patients were assigned to their secondary (ie readmission) hospital. In eFigure 3b, patients were assigned to their primary (ie admission) hospital. Black square data points indicate academic sector hospitals. White circle data points indicate community sector hospitals. Vertical lines represent the 95% confidence interval for the associated data point.