Continuity of Care and Patient Outcomes After Hospital Discharge

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BACKGROUND: Patients are often treated in hospital by physicians other than their regular community doctor. After they are discharged, their care is often returned to their regular community doctor and patients may not see the hospital physician. Transfer of information between physicians can be poor. We determined whether early postdischarge outcomes changed when patients were seen after discharge by physicians who treated them in the hospital.

METHODS: This cohort study used population-based administrative databases to follow 938,833 adults from Ontario, Canada, after they were discharged alive from a nonelective medical or surgical hospitalization between April 1, 1995, and March 1, 2000. We determined when patients were seen after discharge by physicians who treated them in the hospital, physicians who treated them 3 months prior to admission (community physicians), and specialists. The outcome of interest was 30-day death or nonelective readmission to hospital.

RESULTS: Of patients studied, 7.7% died or were readmitted. The adjusted relative risk of death or readmission decreased by 5% (95% confidence interval [CI], 4% to 5%) and 3% (95% CI, 2% to 3%) with each additional visit to a hospital physician rather than a community physician or specialist, respectively. The effect of hospital physician visits was cumulative, with the adjusted risk of 30-day death or nonelective readmission reduced to 7.3%, 7.0%, and 6.7% if patients had 1, 2, or 3 visits, respectively, with a hospital rather than a community physician. The effect was consistent across important subgroups.

CONCLUSIONS: Patient outcomes could be improved if their early postdischarge visits were with physicians who treated them in hospital rather than with other physicians. Follow-up visits with a hospital physician, rather than another physician, could be a modifiable factor to improve patient outcomes following discharge from hospital.

KEY WORDS: continuity of care; hospital readmission; population-based; administrative databases.

J GEN INTERN MED 2004;19:624-631.

Hospital readmissions are costly¹ and common.² Studies have identified factors that increase readmission risk, including patient age,^{3,4} male gender,⁴ length of stay,⁵ complications during hospitalization, comorbidities,⁴⁻⁶ medical rather than surgical admissions,⁴ particular diagnoses,⁷⁻⁹ increased case complexity,¹⁰ low patient socioeconomic status,¹¹ day of discharge,¹² and prior hospital utilization.^{3-5,9,13-15} This research identifies patients with a high risk of readmission. However, these factors are primarily immutable.

Modifiable factors associated with poor outcomes after discharge suggest interventions to improve patient care. Coordination of care is one such factor. Care can be coordinated by improving continuity of information or increasing the continuity of care. The former occurs when patients are treated by physicians who know what other physicians who have been treating the patient are doing. Postdischarge outcomes may improve when patient hospital information is disseminated to follow-up physicians.¹⁶ However, transfer of patient information between hospitals and community physicians can be poor.¹⁷⁻²³ Therefore, hospital-physician continuity of care—which occurs when patients are seen in follow-up by physicians who treated them during the hospitalization—may be particularly important when patients are discharged from hospital.

One randomized trial tested whether outcomes after discharge changed with increased hospital-physician continuity of care.²⁴ Male veterans discharged from hospital were randomized to regular care or intensive follow-up provided by study physicians and nurses who saw the patient prior to discharge. Over a 6-month period, there was no difference between the intervention and control group in the likelihood of nonelective readmissions (80% vs 77%) or preventable readmissions (35% vs 37%). The generalizability and validity of this trial has been questioned because the patients were likely unrepresentative,^{25,26} and the intervention health staff did not actively treat the patient during the hospitalization.²⁷

The effect of hospital-physician continuity of care upon early outcomes is increasingly important because family physicians are less likely to treat hospitalized patients.²⁸ We therefore used a population-based cohort study to determine whether outcomes changed when physicians who cared for patients during the hospitalization saw them in follow-up.

METHODS

This cohort study took place in Ontario, Canada. During the study period, between 50% and 60% of Ontario family physicians cared for inpatients.²⁹ In 1998, 33.8% of medical inpatients were cared for, at least in part, by their family physician.³⁰

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Databases Used for This Study

This study used 3 administrative databases. The Discharge Abstract Database (DAD) records all admissions to Ontario hospitals and documents demographic, diagnostic, procedural, and hospitalization information in a standardized fashion. The Physician Services Database (PSD) records physician claims for visits of more than 95% of family physicians and almost all specialists. The date of each visit, the patient, and the specialty of the physician are recorded for each claim. The Registered Patients Database (RPD) records the death date of all Ontarians, including those who died outside of the province. All databases are anonymous and were linked by common patient unique identifiers. The study was approved by the research ethics board of the Sunnybrook and Women's College Hospital.

Patients

The DAD identified all Ontarians greater than 20 years of age who were admitted and discharged alive from an acute care hospital between April 1, 1995 and March 1, 2000. Only nonelective medical or surgical admissions were included because such patients are substantially different than electively admitted patients. Patients were excluded if they were admitted from or discharged to another hospital, had an invalid patient identifier, lacked key information, or were significant outliers by exceeding the 99th percentile for hospital length of stay, previous hospitalizations, number of follow-up visits, or case resource consumption. Patients were also excluded if they were discharged from one of two hospitals whose physicians do not submit claims to the PSD. Finally, some patients were admitted multiple times during the study. To ensure that all observations in the dataset were truly independent, we randomly selected one admission for each patient.

Predictive Factors

We identified demographic factors associated with hospital readmission. From the DAD, we determined patient age, gender, comorbidities (measured using the Deyo modification of the Charlson score³¹), and each person's postal code. The postal code was linked to 1996 Canadian Census information to determine whether patients lived in an urban or rural area and the median household income of each person's area of residence. The latter was used as a proxy measure of socioeconomic status.

Prehospitalization factors included whether patients had a nonelective hospitalization during the 6 months prior to the index admission. This was determined using the DAD. Using the PSD, we also measured the number of physician visits, and the number of different physicians visited, during the 3 months prior to admission.

Hospitalization factors included the hospital length of stay. The discharge diagnostic category was classified by the Case Mix Group (CMG), determined by a Canadian

Institute for Health Information (CIHI) algorithm that groups patients with similar diagnoses using diagnostic and procedural codes in the DAD. The CMG was used to classify admissions as medical or surgical. Other hospital information included the weekday of discharge and whether the patient experienced a procedure or complication during the hospitalization. Complications were determined by the presence of any type-2 International Classification of Diseases, Ninth Revision (ICD-9) diagnoses. Finally, case resource consumption was measured using the Resource Intensity Weight (RIW), another CIHI methodology measuring hospitalization costliness with the DAD.

Follow-up factors were all measured with the PSD. We determined the date of all physician visits in the month after discharge from hospital. To measure the effect of community continuity of care, we determined which postdischarge visits were with physicians who saw the patient in the 3 months prior to hospitalization (herewith called a "community physician"). To measure the effect of specialty, we determined which postdischarge visits were with a "specialist" (physician whose specialty code in the PSD was not "general practitioner" or "family physician"). In Canada, internists function as consultants and generally do little primary care. To measure the effect of hospital continuity of care, we determined which postdischarge visits were with physicians who treated the patients during the hospitalization (referred to as a "hospital physician"). The DAD records hospitalization admit and discharge dates. Physicians with assessment claims between admit and discharge dates were a hospital physician for that patient. Community physician, specialist, and hospital physician visits are not mutually exclusive. For example, a particular visit would be with both a community physician and a hospital physician if the physician saw that patient prior to and during the hospitalization. The multivariate analysis in the study was able to distinguish the independent effect of each follow-up physician type.

Outcome

The study outcome was death or nonelective readmissions to hospital in the first 30 days. This combined outcome avoids the bias of censoring deaths when hospital readmission alone is examined.³² In addition, the relationship between readmission and survival varies between diagnoses.⁷ Readmissions were identified in the DAD. Deaths were identified in the RPD.

Analyses

To determine the effect of follow-up visits upon outcomes, we determined the cumulative number of each visit type for each patient during the first 30 days after discharge. These are time-dependent variables because their values change over time. We therefore used proportional hazards techniques with time-dependent covariates to model their effect upon patient outcome after controlling

Table 1. Cohort Description of Baseline, Hospital, and Follow-up Factors and Their Association with 30-Day Risk of Death or Urgent Readmission

	All Patients (N = 938,833)	Dead or Readmitted in 30 Days		Unadjusted Hazard Ratio (95% CI)
		Yes N = 71,944 (7.7%)	No N = 866,889 (92.3%)	
Baseline Factors				
Mean age, y (SD)	57.3 (18.9)	65.6 (17.2)	56.7 (18.9)	1.31 (1.30 to 1.31)*
Male	466,610 (49.7)	37,247 (51.8)	429,363 (49.5)	1.07 (1.06 to 1.09)
Charlson score = 0, n (%)	694,542 (74.0)	37,632 (52.3)	656,910 (75.8)	1.39 (1.38 to 1.39)
Hospitalized in last 6 months, n (%)	114,432 (12.2)	21,292 (29.6)	93,140 (10.7)	3.27 (3.22 to 3.32)
Median MD visits, last 3 months, n	3 (1–6)	5 (2–11)	3 (1–5)	1.05 (1.05 to 1.05)
Median MD visits, last 3 months, n	2 (1–3)	2 (1–4)	2 (1–3)	1.19 (1.19 to 1.19)
Urban locale, n (%)	793,211 (84.5)	61,052 (84.9)	732,159 (84.5)	1.08 (1.06 to 1.10)
Median household incomes, n (%)				
< 38,321	206,066 (22.0)	16,852 (23.4)	189,214 (21.8)	0.97 (0.96 to 0.98)
38,321 to 41,252	222,407 (23.7)	17,797 (24.7)	204,610 (23.6)	
41,252 to 52,620	290,164 (30.9)	21,930 (30.5)	268,234 (30.9)	
> 62,262	220,196 (23.0)	15,365 (21.4)	204,831 (23.6)	
Diagnostic risk scores, n (%)				
< 0.66	218,255 (23.3)	7,583 (10.5)	208,777 (24.3)	1.71 (1.70 to 1.72)
0.66–0.92	328,898 (34.4)	19,793 (27.5)	303,105 (35.0)	
0.92–1.26	264,184 (28.1)	21,974 (30.5)	242,210 (27.9)	
>1.26	133,496 (14.2)	22,594 (31.4)	110,902 (12.8)	
Hospitalization Factors				
Mean length of stay, days (SD)	5.1 (5.5)	7.4 (6.8)	5.1 (5.3)	1.05 (1.05 to 1.05)
Complication, n (%)	64,193 (6.8)	6,999 (9.7)	57,194 (6.6)	1.49 (1.45 to 1.53)
Procedure, n (%)	469,560 (50.0)	33,487 (46.6)	436,073 (50.3)	0.85 (0.84 to 0.86)
Medical admission, n (%)	719,354 (76.6)	61,203 (85.1)	658,151 (75.9)	1.84 (1.80 to 1.88)
Mean RIW (SD)	1.2 (1.0)	1.5 (1.2)	1.2 (1.0)	1.25 (1.24 to 1.25)
Median hospital MD visits, n (IQR)	2 (1–3)	2 (2–4)	2 (1–3)	1.16 (1.15 to 1.16)
Friday discharge, n (%)	181,117 (19.4)	14,511 (21.4)	166,606 (19.2)	1.10 (1.07 to 1.13)
Follow-up Factors, median (IQR)				
All MD visits	2 (1–3)	1 (0–2)	2 (1–3)	1.22 (1.21 to 1.22)
Community MD	1 (0–2)	0 (0–1)	1 (0–2)	1.23 (1.22 to 1.24)
Specialist	0 (0–1)	0 (0–1)	0 (0–1)	1.17 (1.16 to 1.18)
Hospital MD	1 (0–1)	0 (0–1)	1 (0–2)	1.17 (1.16 to 1.18)

The hazard ratio indicates the unadjusted association of each factor with time to death or readmission and is stratified by hospital. Patients with Charlson scores of zero are free of significant comorbidities.

* Hazard ratio indicates changes in death or readmission with increased decade of age.

SD, standard deviation; RIW, resource intensity weighting; IQR, interquartile range; CI, confidence interval.

for significant confounders.³³ Time-dependent covariate analysis avoids survivor treatment selection bias.³⁴

To build our models, we identified demographic, pre-hospitalization, and hospitalization factors that were significantly (two-sided *P* value of .05) associated with 30-day death or nonelective readmission in a univariate proportional hazards model. These variables were offered to a backward-stepping proportional hazards model that determined which were independently associated with the outcome. These independent variables were included in the final model with follow-up visits types (i.e., cumulative number of all physician visits, community physician visits, specialist visits, and hospital physician visits) expressed as time-dependent covariates. The hazard ratios for contrasting follow-up visit types were calculated from this model (see Appendix A, available at www.jgim.org). For example, the hazard ratio for visiting a hospital physician rather than a community physician was $e^{(\beta[\text{hospital physician visit}] - \beta[\text{community physician visit}])}$. Each model was stratified by hospital, which allows the underlying

hazard function to vary between hospitals and adjusts for unmeasured hospital factors.³⁵ We reasoned that patients with more physician visits are sicker and are more likely to die or be readmitted to hospital and controlled for this by including the cumulative number of *all* physician visits in all models.

Readmission risk varies widely between diagnoses.⁸ To control for the effect of diagnosis upon outcome, we used established methodology³⁶ to calculate risk scores for each diagnostic group (Appendix B, available at www.jgim.org).³⁷

We conducted several subanalyses to measure the consistency of our findings. Analysis was limited to subgroups of the most predictive baseline factors including propensity score quintiles. We repeated the analysis for patients whose number of physician visits after discharge did not exceed the 75th percentile (3 visits) to determine whether outlier patients with many follow-up visits influenced the association. We *a priori* identified common diagnoses whose postdischarge course either could be, or should not be, influenced by hospital physician follow-up

Table 2. Patient Factors Associated with Seeing at Least One Hospital Physician in the First Month After Discharge from Hospital

All patients (N = 938,833)	Follow-up Visit with a Hospital Physician		P Value
	Yes (N = 474,971, 50.6%)	No (N = 463,862, 49.4%)	
Mean age, y (SD)	58.7 (18.3)	56.0 (19.4)	<.0001
Charlson score = 0, n (%)	344,504 (72.5)	350,038 (75.5)	<.0001
Hospitalized in last 6 months, n (%)	56,414 (11.9)	58,018 (12.5)	<.0001
Diagnostic risk scores, n (%)			
<0.66	103,183 (21.7)	115,072 (24.8)	<.0001
0.66 to 0.92	164,124 (34.5)	158,774 (34.2)	
0.92 to 1.26	136,728 (28.8)	127,456 (27.5)	
>1.26	70,936 (14.9)	62,560 (13.5)	
Medical admission	370,814 (78.1)	348,540 (75.1)	<.0001
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Patients with ≥1 follow-up (N = 751,775)	Yes (N = 474,971, 63.2%)	No (N = 276,804, 36.8%)	
Mean age, y (SD)	58.7 (18.3)	57.1 (18.8)	<.0001
Charlson Score = 0, n (%)	344,504 (72.5)	205,170 (74.1)	<.0001
Hospitalized in last 6 months, n (%)	56,414 (11.9)	35,983 (13.0)	<.0001
Diagnostic risk scores, n (%)			
<0.66	103,183 (21.7)	70,784 (25.6)	<.0001
0.66 to 0.92	164,124 (34.5)	93,037 (33.6)	
0.92 to 1.26	136,728 (28.8)	74,751 (27.0)	
>1.26	70,936 (14.9)	38,232 (13.8)	
Medical admission, n (%)	370,814 (78.1)	206,804 (74.7)	<.0001

The top portion of the table compares all patients based upon who did and who did not see a hospital physician after discharge from hospital. The lower portion limits the comparison to patients who had at least one physician visit. Patients with Charlson scores of zero are free of significant comorbidities.
SD, standard deviation.

(Appendix C, available at www.jgim.org). We hypothesized that hospital physician follow-up should be more beneficial in the former diagnoses. Finally, similar to previous studies,³⁸ we conducted the analysis separately for the 100 most common discharge diagnoses and used the Sign test³⁹ to determine whether the number of diagnoses in which hospital physician follow-up was protective exceeded that expected by chance.

RESULTS

During the study period, 2,607,416 adults had a non-elective hospitalization. Some 1,668,583 hospitalizations were excluded because the patient died during the hospitalization ($n = 89,756$), the patient was transferred to or from another hospital ($n = 97,885$), the patient had an invalid Ontario Health Insurance Plan (OHIP) number ($n = 5$), the patient was discharged from an excluded hospital ($n = 19,287$), the patient was an outlier ($n = 14,614$), the patient was missing data ($n = 19,246$), or the hospitalization was randomly excluded because the patient had other hospitalizations during the study period ($n = 1,427,790$).

This left 938,833 patients in the study (Table 1). Most patients had Charlson-Deyo scores of zero. The most common medical diagnostic groups included acute gastroenteritis or gastrointestinal bleeding (8.6% of medical diagnoses), pneumonia (5.1%), and chest pain (5.1%). For surgery, the most common groups included acute fractures

(8.8%), appendectomy (7.3%), and laparoscopic cholecystectomy (6.1%). Patients were spread equally through the 5 study years and came from 185 different hospitals. During the entire study, 43.5% of patients were treated in hospital by a physician who had seen them during the 3 months prior to admission. This proportion decreased steadily through the study from 45.6% in 1995 to 41.0% in 1999.

Overall, 71,944 (7.7%) patients had an event (Table 1). Deaths accounted for 14.6% of events. The risk of death or readmission was highest if patients were older, had been hospitalized in the last 6 months, had a diagnostic group with a high-risk score, or had a medical admission (Table 1). The relative risk of death or readmission decreased 3% with each year beyond 1995 (independent hazard ratio, 0.97; 95% confidence interval [CI], 0.96 to 0.98). The univariate analysis showed that the risk of death or readmission increased with each additional visit with all physicians, with community physicians, with specialists, or with hospital physicians (Table 1).

Patients had a median of 2 physician visits in the first month after discharge (Table 1). Approximately half of these were with hospital physicians. Of the patients, 751,775 (80.1%) had one or more physician visits, 473,814 (50.5%) saw one or more community physicians, 448,035 (47.7%) saw one or more specialists, and 662,029 (70.5%) saw one or more hospital physicians. Patients who saw hospital physicians appeared sicker because they were older, had higher Charlson and diagnostic risk scores, and were more

Table 3. Independent Effect of Patient, Hospitalization, and Follow-up Factors on 30-Day Death or Nonelective Readmission

	Adjusted Hazard Ratio (95% CI)
Patient Factors	
Age increased by decade	1.16 (1.16 to 1.17)
Patient is male	1.07 (1.06 to 1.09)
Charlson score increased by 1	1.21 (1.21 to 1.22)
Study year increased by 1	0.97 (0.96 to 0.98)
Hospitalization in last 6 months	1.73 (1.69 to 1.76)
Pre-admission MD visits increased by 1	1.01 (1.01 to 1.01)
Pre-admission MDs increased by 1	1.04 (1.03 to 1.04)
Diagnosis risk score increased to next quartile	1.45 (1.44 to 1.46)
Hospital Factors	
Length of stay increased 1 day	1.01 (1.01 to 1.01)
Complication during admission	1.11 (1.08 to 1.14)
Procedure during admission	0.96 (0.94 to 0.98)
Medical admission	1.75 (1.70 to 1.80)
Resource Intensity Weighting increased 1 unit	1.07 (1.06 to 1.08)
Number of hospital MDs increased by 1	1.01 (1.00 to 1.01)
Friday discharge	1.06 (1.03 to 1.08)
Follow-up Factors	
One more visit with hospital MD vs community MD	0.95 (0.95 to 0.96)
One more visit with hospital MD vs specialist	0.97 (0.97 to 0.98)

The hazard ratio indicates the association of each factor with time to death or readmission after adjusting for all other factors in the table. The hazard ratio is stratified by hospital. Resource Intensity Weighting is a measure of hospitalization costliness. A hospital physician is one who saw the patient during their hospitalization. A community physician is one who saw the patient in the 3 months prior to their admission. A specialist is a physician whose specialty was anything other than general or family practitioner. This model controls for the total number of all physician visits. CI, confidence interval.

likely to have a medical admission (Table 2). This was true even when patients with no follow-up visits were excluded (Table 2).

After controlling for important confounders, patients were significantly less likely to die or be readmitted if they were seen in follow-up by a hospital physician rather than a community physician (hazard ratio, 0.95; 95% CI, 0.95 to 0.96) or specialist (hazard ratio, 0.97; 95% CI, 0.97 to 0.98; Table 3). This means that the relative risk of death or readmission decreased by 5% (95% CI, 2% to 4%) when patients followed up with a hospital rather than a community physician. Given a baseline risk of 7.7%, the adjusted risk of 30-day death or nonelective readmission would be 7.3%, 7.0%, and 6.6% for patients who had 1, 2, or 3 visits, respectively, with a hospital rather than a community physician.

The protective effect of hospital physician follow-up was consistent within important subgroups with some

possible exceptions (Table 4). Compared to community physicians, hospital physician follow-up was significantly protective for all subgroups except patients with previous hospitalizations. Compared to specialists, hospital physician follow-up was significantly protective for all subgroups except those with previous hospitalizations, elderly patients, and those with high-risk diagnoses. The benefit of hospital physician follow-up appeared to decrease as the diagnostic risk score increased. Protection with hospital physician follow-up remained when the analysis was limited to patients whose total number of postdischarge visits did not exceed the 75th percentile. Hospital physician follow-up was more effective for diagnoses thought likely be sensitive to hospital physician follow-up (Table 4; Appendix C, online). Follow-up with a hospital physician versus a community physician was equally beneficial when analysis was limited to patients who were not seen in hospital by community physicians (hazard ratio, 0.95; 95% CI, 0.95 to 0.96). Finally, follow-up with a hospital physician appeared protective (i.e., had a hazard ratio of less than 1.0) for 70 out of the 100 most common diagnoses, which significantly exceeds that expected by chance ($P < .0001$).

DISCUSSION

Using population-based administrative databases over a 5-year period, we found that patients having hospital physician follow-up were significantly and independently less likely to die or get urgently readmitted to hospital in the first 30 days following discharge. After controlling for other important factors, the risk of death or readmission decreased when patients were seen by a hospital physician rather than by another physician. This association was consistent across important subgroups.

Although the effect of hospital physician follow-up was smaller than other factors, our findings are still important. Nonelective readmission and death are both clearly important outcomes and any decrease in their frequency is desirable. These events affect many people, thereby making even small decreases in their frequency significant. The effect of hospital physician follow-up is cumulative so that the risk of death or readmission decreases with each visit. Most importantly, hospital physician follow-up is a potentially modifiable factor that could decrease the risk of bad outcomes post discharge.

In contrast to continuity of care in the community,⁴⁰⁻⁴³ the effect of continuity of care with hospital physicians has not been studied extensively. Several issues explain why our results differ from those of Weinberger et al.²⁴ We only examined the first 30 days after discharge from hospital. Our study included all Ontario hospitals and a diverse patient population. Also, all of the hospital physicians in our study treated the patients during, and commonly throughout, their hospitalization. Because our study was population based, included readmissions to all hospitals, and adjusted for important confounders, we believe that it is a very representative assessment of the effect that

Table 4. Subgroup Analysis of the Effect of Hospital Physician Follow-up on 30-Day Death or Nonelective Readmission

		Independent Hazard Ratio of Additional Visit with a Hospital Physician (95% CI)	
		Versus Community MD	Versus Specialist MD
Patient age, y	≤45	0.98 (0.98 to 0.99)	0.91 (0.89 to 0.93)
	46 to 60	0.97 (0.95 to 0.98)	0.96 (0.94 to 0.97)
	61 to 75	0.98 (0.97 to 0.99)	0.98 (0.97 to 0.99)
	>75	0.93 (0.92 to 0.94)	1.00 (0.98 to 1.00)
Charlson score	0	0.96 (0.95 to 0.97)	0.94 (0.93 to 0.95)
	>0	0.95 (0.95 to 0.97)	0.99 (0.98 to 1.00)
Previous hospitalization	No	0.94 (0.93 to 0.95)	0.96 (0.96 to 0.97)
	Yes	1.02 (1.01 to 1.03)	1.02 (1.01 to 1.03)
Diagnostic risk score	<0.66	0.94 (0.92 to 0.95)	0.91 (0.90 to 0.93)
	0.66 to 0.92	0.95 (0.94 to 0.96)	0.96 (0.95 to 0.98)
	0.92 to 1.26	0.96 (0.95 to 0.97)	0.97 (0.96 to 0.99)
	>1.26	0.97 (0.96 to 0.98)	1.01 (1.00 to 1.02)
Admission type	Medical	0.96 (0.95 to 0.96)	0.97 (0.96 to 0.98)
	Surgical	0.93 (0.91 to 0.94)	0.92 (0.90 to 0.93)
Diagnostic type	Hospitalist F/U Sensitive	0.96 (0.94 to 0.98)	0.99 (0.97 to 1.00)
	Hospitalist F/U Insensitive	0.99 (0.98 to 1.01)	0.91 (0.90 to 0.93)
Hospital status	Teaching	0.97 (0.96 to 0.98)	0.98 (0.97 to 0.99)
	Nonteaching	0.95 (0.94 to 0.95)	0.97 (0.96 to 0.97)
Patient residence	Urban	0.95 (0.95 to 0.96)	0.97 (0.97 to 0.98)
	Rural	0.95 (0.93 to 0.97)	0.96 (0.95 to 0.98)
Year	1995	0.97 (0.95 to 0.98)	0.99 (0.98 to 1.00)
	1996	0.96 (0.95 to 0.98)	0.98 (0.96 to 0.99)
	1997	0.93 (0.92 to 0.94)	0.98 (0.97 to 0.99)
	1998	0.95 (0.94 to 0.96)	0.96 (0.95 to 0.97)
	1999	0.96 (0.95 to 0.98)	0.96 (0.94 to 0.97)
Hospital area	North	0.95 (0.93 to 0.97)	0.96 (0.95 to 0.98)
	Eastern	0.98 (0.96 to 0.99)	0.98 (0.97 to 1.00)
	Central East	0.96 (0.95 to 0.98)	0.98 (0.96 to 0.99)
	Toronto	0.96 (0.95 to 0.97)	0.94 (0.93 to 0.96)
	Central West	0.96 (0.95 to 0.98)	0.97 (0.95 to 0.98)
	Central South	0.95 (0.93 to 0.97)	1.01 (0.99 to 1.03)
	South West	0.93 (0.92 to 0.95)	0.99 (0.98 to 1.01)

The proportional hazards analysis was limited to each subgroup listed in the table. The hazards ratio is adjusted for all factors listed in Table 3. F/U, follow-up.

continuity of care after discharge from hospital has upon patient outcomes.

Hospital physician follow-up could improve outcomes through several mechanisms. Hospital information is often inadequately transferred to community physicians¹⁷ and is key to evaluating a patient in the early postdischarge time period. Familiarity with the hospital course allows follow-up physicians to determine therapeutic effectiveness and identify complications of hospital therapies or procedures. Complications that are dealt with early could avoid more serious subsequent problems. Finally, patients are often discharged from hospital with problems that are improving but not yet resolved. Therefore, patients seen early following discharge from hospital can still be very ill. If a physician does not know that a particular patient was worse when they were admitted to hospital, their condition could be interpreted as a deterioration requiring readmission.

This last point highlights a limitation of our study. Although we measured urgent readmissions to all Ontario hospitals, we were unable to determine the appropriateness

of these readmissions. As with any health service, physician practice patterns can influence the decision to admit a patient, possibly independent of a patient's clinical status. Other factors extraneous to the patient's health can also modify the decision to admit a patient to hospital. Despite the "noise" that these factors introduce to this outcome, we still found an independent and significant association between hospital physician follow-up and improved outcomes.

Several aspects of our data support a cause-and-effect relationship between hospital physician follow-up and improved outcomes.⁴⁴ There are many reasons to expect better outcomes with hospital physician follow-up. We found a dose-response effect with further improvement of outcomes with each additional hospital physician visit. Our association was consistent in several distinct populations. Finally, there is no ambiguity in the timing of the hospital physician visit in relation to the death or readmission.

However, our study does not absolutely establish better outcomes with hospital physician follow-up. Relative to other factors, the independent association of hospital

physician follow-up is small. Hospital physician follow-up was not enormously more successful in diagnoses that we thought would be more sensitive to such visits, although this classification is admittedly rather crude and very susceptible to exceptions. This could be from our inability to control for factors that might contribute to outcomes, such as hospital quality of care.⁴⁵⁻⁴⁸ Our study also did not measure or control for dissemination of patient-specific information after discharge from hospital, which may influence patient outcomes.¹⁶ Finally, although the analysis adjusted for many important factors that could influence patient outcome and the results were very consistent in many pertinent subgroups, there still remains a possibility that patients who are seen in follow-up by hospital physicians are systematically distinct from those who are followed by community physicians in important factors that are not measured in the databases used in this study. A better understanding of the effect that hospital physician follow-up has upon patient outcomes requires further research.

What should physicians, patients, and administrators do until such evidence is available? We believe that patients who require physician assessment after being discharged from hospital should be seen by physicians who actually cared for them during the hospitalization. At the very least, physicians who see the patient should have access to as much information regarding the hospitalization as possible.

We thank Drs. Alan Forster, David Juurlink, Alan Karovitch, Stephen Kravcik, Andreas Laupacis, Graham Nichol, Jim Nishikawa, Donald Redelmeier, Tom Stelfox, and James Watters for comments on initial drafts of this paper.

Dr. van Walraven is an Ontario Ministry of Health Career Scientist.

Dr. van Walraven conceived the study and is the responsible author. All authors contributed to the study's design, analysis, interpretation, and writing.

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Appendix A – Calculating the independent effect of different physician types upon outcomes

Estimates of physician effectiveness were derived from a linear combination of coefficients estimated in the survival model. Assume that:

- X_1 denotes the number of visits to a community physician,
- X_2 denotes the number of visits to a specialist physician,
- X_3 denotes the number of visits to a hospital physician,
- X_4 denotes the total number of visits to any physician, and
- X_5 denotes all other patient characteristics.

The following proportional hazards regression model was fit:

$$(1) \quad \log(h_i) = \alpha(t) + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i4} + \beta_5 x_{i5},$$

where $\alpha(t)$ is the logarithm of the baseline hazard function. The physician visit variables X_1 through X_4 are not mutually exclusive. Indeed, it is possible to visit one physician who is simultaneously a specialist, a hospital physician and a community physician. However, the above regression model can be used to compare the relative reduction in an outcome associated with an additional visit to one of the above physicians *compared* with an additional visit to a different type of physician. Consider the following scenario comparing two individuals with a different number of physician visits:

	Patient 1	Patient 2
Community physician visits	$n + 1$	n
Specialist physicians visits	k	k
Hospital physicians visits	m	$m + 1$
Total physician visits	$n + k + m + 1$	$n + k + m + 1$

Note that these patients have the same number of total physician visits. This number is included in the model to adjust for overall illness severity and health needs. Patient 1 has had one additional visit to a community physician than has patient 2, while patient 2 has had one additional visit to a hospital physician than has patient 1. Assuming that the two patients are similar in all other aspects, model (1) becomes:

$$(2) \quad \log(h_1) = \alpha(t) + \beta_1(n + 1) + \beta_2(k) + \beta_3(m) + \beta_4(n + k + m + 1) + \beta_5 x_{2,5} \text{ for patient 1.}$$

$$(3) \quad \log(h_2) = \alpha(t) + \beta_1(n) + \beta_2(k) + \beta_3(m + 1) + \beta_4(n + k + m + 1) + \beta_5 x_{2,5} \text{ for patient 2.}$$

Comparing the differences in log-hazard ratios for the two patients, we have that:

$$\log(h_2) - \log(h_1) = -\beta_1 + \beta_3. \text{ Thus, we have that: } \log\left(\frac{h_2}{h_1}\right) = \beta_3 - \beta_1. \text{ Finally, } \frac{h_2}{h_1} = \exp(\beta_3 - \beta_1).$$

Therefore, we can determine the adjusted hazard ratio for one additional visit to a hospital physician compared to an additional visit to a community physician.

Appendix B: Calculation of diagnostic group risk score.

To control for factors inherent to each diagnosis that could influence 30-day death or non-elective readmissions, we calculated risk scores for each diagnostic group. This was accomplished by computing standardised mortality ratios using indirect standardisation via logistic regression. Specifically, we:

- a) used all patients to create a logistic regression model that determined the risk of 30-day death or non-elective readmission based upon demographic factors (patient age, sex, and co-morbidities), pre-hospitalization factors (hospitalization in the previous 6 months), and hospitalization factors (length of stay, medical/surgical status, occurrence of a complication or procedure, hospitalization costliness, and number of hospital physicians).
- b) used the logistic model from 'a' to calculate each patient's expected risk of 30 day death or readmission based upon their covariates in the logistic model.
- c) determined for each Case Mix Group (CMG) the observed proportion of patients who died or were readmitted in 30 days.
- d) calculated for each CMG the proportion of patients expected to die or be readmitted by summing the expected risks (from 'b') and dividing by the number of people with that CMG.
- e) the diagnostic group risk score was the observed proportion of dead or readmitted patients divided by the expected proportion (i.e. 'c'/'d').

Diagnostic groups with risk scores exceeding one have an increased risk of death or readmission after controlling for the covariates in 'a'. Including the diagnostic group risk score in the analysis helps control for factors particular to that diagnostic group that independently increase the risk of death or readmission without requiring an indicator variable for each CMG.

Appendix C – Specific diagnoses and the influence that follow-up with a hospital, rather than another, physician might have on post-discharge course.

	<i>Diagnoses</i>	<i>ICD-9 Codes</i>	<i>Reason Diagnoses Should / Should not Be Sensitive to Hospital Physician Follow-Up</i>
<i>Diagnoses Likely Sensitive to Hospital Physician Follow-Up</i>	Diabetes	514.9, 225.4, 215.6	Knowledge of control in hospital and events that possibly resulted in admission essential to avoid recurrence of acute diabetic complications
	Congestive Heart Failure	428.0, 428.1	Knowledge of hospital volume, respiratory, and functional status and medications is essential to assess course since discharge and to decide upon treatment modifications
	Asthma or COPD exacerbations or pneumonia	466.0, 481.0, 485.0, 486.0, 487.1, 490.0, 491.2, 493.9, 496.0	Knowing the severity of previous dyspnea and exercise function helps assess post-discharge course
	Abdominal pain	789.0	Knowledge of pain severity in hospital, and possible causes (based on investigations) could permit better assessment and plan in f/u.
	Potential abscess associated processes	566.0, 998.5	Surgeon who saw patient in hospital could use local surgery to treat abscess; such interventions could decrease risk of disease propagation
	Infection of graft, device, or implant	996.6	Surgeon who placed device or graft likely more attuned to reversible complications and may treat them earlier
<i>Diagnoses Likely Insensitive to Hospital Physician Follow-Up</i>	Acute Gastroenteritis	008.4, 008.8, 788.2	Knowledge of hospital course not required to determine if patient dehydrated at follow-up or if diarrhea worsening post-discharge.
	Acute Coronary Syndromes	410.0, 411.0, 413.0, 414.0, 414.9, 786.5	Knowledge of hospital course unlikely to influence whether or not ischemia recurs or its management (since all recurrences or suspected recurrences would be readmitted to hospital).
	Acute venous thromboembolism	415.1, 451.1, 453.8	Monitoring of warfarin and determining if symptoms recurred unlikely to be influenced by knowledge of hospitalization
	Cellulitis	682.0, 682.3, 682.3, 682.6, 682.7	Assessment of response to antibiotics, or complications of disease, unlikely dependent upon knowledge of hospital course.
	Acute appendicitis	540.9	Development of complications, such as appendiceal abscess or ileus, or their treatment is likely independent of knowledge of hospital course
	Inguinal hernia	550.1, 550.9	Hernial recurrence is probably independent of knowing hospital course
	Nephrolithiasis	592.0, 592.1, 788.0	Recurrence of stone probably independent of knowing hospital course
	Pyelonephritis and urinary tract infection	590.1, 590.8, 599.0	Assessment of response to antibiotics, or complications of disease, unlikely dependent upon knowledge of hospital course.