

# Predictors of readmission to non-index hospitals after colorectal surgery

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Colectomy;  
Travel distance;  
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Geocoding;  
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## Abstract

**BACKGROUND:** Although a significant proportion of patients are readmitted to non-index hospitals after surgery, risk factors for non-index hospital readmission are not well defined.

**METHODS:** Using the California Office of State Health Planning and Development database from 2008 to 2012, patients readmitted to index versus non-index hospitals after colorectal surgery were directly compared. Risk factors for non-index hospital readmission were assessed through logistic regression.

**RESULTS:** Among the 14,401 patients requiring readmission, 10,890 (75.6%) were readmitted to index hospitals, whereas 3,511 (24.4%) were readmitted to non-index hospitals. Patients readmitted to non-index hospitals were more likely to be men and have a greater Charlson comorbidity index, non-private insurance, longer initial length of stay, longer travel distance, and non-home discharge disposition. On multivariable logistic regression analysis, living  $\geq 10$  miles from the index hospital was strongly predictive of non-index hospital readmission (odds ratio, 1.8; 95% confidence interval, 1.63 to 2.00).

**CONCLUSIONS:** Approximately 25% of readmissions after colorectal surgery will be to non-index hospitals. Risks factors include greater comorbidities, non-private health insurance, occurrence of an inpatient complication, longer length of stay, greater travel distance, and non-home discharge disposition.

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Hospital readmission has become an important outcome for clinicians, patients, policy makers, and health care payers. After major surgery, hospital readmission is relatively common, occurring in 5% to 25% of cases.<sup>1-3</sup> This is

important because readmission is associated with increased morbidity, mortality, and health care expenditures.<sup>4-6</sup> Hospital readmission is also an important surgical quality indicator as hospitals with higher surgical volume and lower mortality are associated with lower readmission rates.<sup>1</sup> Recently, as part of the Patient Protection and Affordable Care Act, Medicare began assigning financial penalties to hospitals with high unplanned readmission rates after surgery.<sup>7,8</sup>

Recent evidence suggests that as many as 40% of patients who require rehospitalization after major surgery are readmitted to a different hospital than the hospital where surgery was performed.<sup>2,9-12</sup> Furthermore, several studies have

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demonstrated that readmission to a different hospital in the postoperative period is associated with increased mortality.<sup>2,9</sup> Given this important finding, the purpose of this study was to identify factors associated with readmission to non-index hospitals after colorectal surgery.

## Methods

The California Office of State Health Planning and Development (OSHPD) Patient Discharge Database (PDD) from 2008 to 2012 was used to identify all patients undergoing colectomy or proctectomy (here referred to as colectomy; *International Classification of Disease, Ninth Revision*, codes: 45.71 to 45.8, 48.41, 48.49, 48.5, 48.61 to 48.65, 48.69) who subsequently required readmission to the hospital. Exclusion criteria included age younger than 18 years, residential address outside California, and in-hospital mortality. Hospital readmission was defined as the first inpatient hospitalization for any reason within 30 days after discharge from an acute care hospitalization. A unique hospital identifier was used to identify the location of care for both index and subsequent admission. Demographic information, clinical data, and travel distances were then directly compared between patients admitted to the same hospital as the discharging one (ie, index) and patients admitted to a different hospital (ie, non-index). Finally, univariate and multivariable logistic regression models were built to estimate the odds of readmission to a non-index hospital based on demographic and clinical factors.

The OSHPD-PDD contains records for patients discharged from every general, acute, nonfederal hospital within the state. Demographic variables contained in the data set include age, gender, race, and a unique patient-level record linkage number to associate discharged patients with subsequent hospitalizations. Clinical information contained in the PDD includes principle diagnosis (indication for admission) and up to 24 additional diagnoses with an indicator as to whether the condition was present on admission. The Charlson comorbidity index was calculated based on present on admission comorbidities. The set also contains coding for the principle procedure and up to 20 secondary procedures performed during the index admission.

Details about the admission include a unique hospital identifier, dates of admission and discharge, admission type (scheduled or unscheduled), expected payer/insurance, the occurrence of a complication, and disposition. Complications recorded included urinary tract infection, wound infection, myocardial infarction, deep venous thrombosis, pulmonary embolism, pneumonia, hemorrhage, and sepsis. Complications were assessed using *International Classification of Disease, Ninth Revision, Clinical Modification*, codes with concomitant coding that the diagnosis was not present on admission.

Geocoding was performed using geographical information systems software (ArcGIS 10; Esri Inc., Redlands, CA) to calculate the distance between patients' home and the

initial and readmission hospitals. Hospital locations were geocoded based on street addresses. Patient locations were geocoded into geographic co-ordinates based on their home zip code using zip code geometric centroids. This method has been validated in previous studies.<sup>13,14</sup> All geocoded data were projected to the North America Equidistant Conical Projection co-ordinate system. The median straight-line distance between patients and their treatment hospital was calculated for all patients across the state. Previous empiric comparisons have shown that straight-line distance is highly correlated with road distance and travel time.<sup>15-17</sup> The Office of Rural Health Policy's rural urban commuting area codes were used to designate California counties as either metropolitan or rural.<sup>18</sup>

The chi-square test and student *t* test were used to compare mean values between groups, with statistical significance set as *P* less than .05. All statistical analyses were 2 tailed and performed using SAS 9.4 for windows (SAS Corporation, Cary, NC). Odds ratios were considered significant when the 95% confidence interval did not include 1, and the *P* value was less than .05. Approval for the study was obtained from both the California Committee for the Protection of Human Subjects and the Stanford University Institutional Review Board.

## Results

Among the 75,847 patients who underwent colorectal surgery in California from 2008 to 2012 and met the inclusion criteria, 14,401 (19.0%) required hospital readmission; 10,890 (75.6%) were readmitted to the index hospital, whereas 3,511 (24.4%) were readmitted to a non-index hospital. Patients re-admitted to a non-index hospital were more likely to be men, have a greater Charlson comorbidity index, less likely to have private insurance, have a longer initial length of stay (LOS), less likely to have undergone an emergent initial admission, more likely to live further away from the discharging hospital, and less likely to be discharged home after surgery (Table 1). There was no difference in age or race between the 2 groups. The proportion of patients re-admitted to a non-index hospital increased as the distance between home and the index hospital increased beyond a threshold of approximately 10 miles (Fig. 1).

There was substantial geographic variation in the proportion of readmissions to non-index hospitals throughout the state (Fig. 2). The average proportion of readmissions to non-index hospitals among rural counties was  $43.2 \pm 27.7\%$  compared with  $25.5 \pm 8.3\%$  among urban counties ( $P < .001$ ).

Table 2 lists the results of univariate and multivariable logistic regression analysis for factors associated with readmission to a non-index hospital. On univariate analysis, increasing Charlson comorbidity index scores, greater travel distance, non-private health insurance, a longer initial LOS, the occurrence of an inpatient complication, an elective initial admission, and discharge disposition other than

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