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# A preoperative prediction model for risk of multiple admissions after colon cancer surgery



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## ABSTRACT

**Background:** A subset of patients who undergo colon cancer surgery may be at a high risk of multiple subsequent admissions. We developed a simplified model to predict the preoperative risk of multiple postoperative admissions (MuAdm) among patients undergoing colon resection to aid in preoperative planning.

**Methods:** Patients aged  $\geq 18$  y with colon cancer who underwent elective surgical resection identified in discharge claims from California and New York (2008-2011) were included. The primary outcome, MuAdm, was defined as 2 or more admissions in the year following resection. Logistic regression models were developed to identify factors predictive of MuAdm. A weighted point system was developed using beta-coefficients ( $P < 0.05$ ). A random sample of 75% of the data was used for model development, which was validated in the remaining 25% sample.

**Results:** A total of 14,780 patients underwent colon resection for cancer. Almost 30% had an admission in the year after index surgery and 9.8% had MuAdm. The significant predictors of MuAdm were higher Elixhauser comorbidity index score, metastatic disease, payer system, and the number of admissions in the year before surgery. Scores ranged from 0 to 8. Scores  $\leq 1$  had a 7% risk of MuAdm, and scores  $\geq 6$  had a  $>30\%$  risk of MuAdm.

**Conclusions:** In the year following discharge after resection of colon cancer, nearly 10% of patients are admitted 2 or more times. A simple, preoperative clinical model can prospectively predict the likelihood of multiple admissions in patients anticipating resection. This model can be used for preoperative planning and setting postoperative expectations more accurately.

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## Introduction

Health-care super-utilizers make-up 5% of the United States population but utilize over 50% of health-care costs within a given year.<sup>1</sup> Medicare and Medicaid studies have shown that patients with multiple medical problems, mental illness, and homelessness were more likely to become high utilizers of medical care.<sup>2,3</sup> Johnson et al.<sup>4</sup> suggest that super-utilizers need to be defined based on their specific characteristics instead of as a single, homogeneous group to appropriately target interventions. Despite their high utilization of health-care services, super-utilizers actually tend to receive worse care because of inconsistent outpatient care, fragmentation of providers, and challenging social factors.<sup>1,3</sup>

Colon cancer is the third most common malignancy in the United States.<sup>5</sup> In the majority of cases, surgical resection is the initial treatment. Readmission in the 30-d window after colorectal cancer surgery has been well-studied, with rates estimated around 25% leading to \$300 million per year of health-care costs.<sup>6</sup> The rates of readmissions double when the window is increased from 30- to 90-d after surgery.<sup>7</sup> Previous studies have not addressed which patients are at risk of becoming super-utilizers in the year following colon cancer resection.

We aimed to develop a simple clinical model to predict the preoperative risk of multiple admissions (MuAdm) in the year after surgery among patients undergoing colon resection for cancer. The intent of this model is to further define patients who are at risk of MuAdm to potentially impact preoperative planning and more accurately define patient expectations.

## Methods

### Selection of study population

The study cohort was drawn from the New York Statewide Planning and Research Cooperative System and the California State Inpatient Database through the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality.<sup>8,9</sup> New York and California data sets were queried because they collect inpatient discharge data on all admissions from all payers in a consistent format that permits linkage across multiple admissions. This study was deemed exempt from review by the Institutional Review Board.

Patients aged  $\geq 18$  y with a new diagnosis of colon cancer who underwent surgical resection between 2008-2011 were included in the study. Selection of patients was based on the presence of an *International Classification of Diseases Ninth Revision, Clinical Modifications* (ICD-9-CM) code for both a colon cancer diagnosis (153.0-153.9) and a colon resection (procedure codes 17.31-17.39, 45.71-45.76, 45.79, 45.81-45.83).<sup>10</sup> Patients with and without metastatic disease (ICD-9 diagnosis codes 196.0-199.1; 789.5) were included. Patients with rectal cancer were not included in this study.

Initially, 34,341 patients were identified who had both an ICD-9 diagnosis of colon cancer and a code for surgical resection in the same admission record. An index hospitalization was defined as an inpatient claim that contained both a colon cancer diagnoses as well as a surgical resection code.<sup>11</sup> Patients

with a colon cancer diagnoses during a previous hospital admission in the year before operative admission were first excluded ( $n = 4063$ ). The goal of the study was to evaluate risk factors for MuAdm in patients who underwent an operation as their index cancer treatment, and it was not possible to exclude prior cancer treatments in these patients. Transfer patients were next excluded as it was unclear if these patients may have undergone prior treatment for their colon cancer and a preoperative prediction model would not be useful ( $n = 1407$ ).

It is recognized that postoperative complications can result in unplanned readmissions to the hospital. Our aim, however, was to identify risk factors for postoperative hospital admissions independent of postoperative complications during the index admission to predict increased inpatient care utilization. As such, patients with postoperative complications during the index admission, including cardiac, thromboembolic, cerebrovascular, respiratory, gastrointestinal, septic, respiratory, infectious, and genitourinary complication, during the operative admission were excluded ( $n = 4807$ ).<sup>11</sup> Patients who died during the index admission were also excluded ( $n = 165$ ).

Patients who did not have a primary diagnosis of cancer were excluded as it could not be confirmed that their surgery was for an oncologic resection or another etiology ( $n = 1319$ ). An additional 54 patients were excluded as they had negative procedure days indicating that their operation occurred in a prior admission or was an error in the database. Patients who underwent emergency surgery defined as admission through the Emergency Department were excluded as our goal was to develop a tool that could be used in the preoperative outpatient setting ( $n = 5203$ ). Patients who underwent resection after the first day of admission were also excluded as it could not be confirmed if outpatient planning for the procedure had occurred or that the case was truly elective ( $n = 2543$ ) (Figure).

### Outcome measure

The primary outcome of this study, MuAdm, was defined as 2 or more admissions in the year postresection. The indications for hospital admissions following the index operative admission were classified using a published 12 category system.<sup>12</sup>

### Predictor variables

Patient demographics and clinical variables were collected. Patient demographics included age, gender, and primary payer type (Medicare, Medicaid, commercial, self, and other). The clinical variables included the number of admissions in the year before surgery, evidence of metastasis at the time of surgical resection, and Elixhauser comorbidity index score. The Elixhauser comorbidity index has been extensively used as a measure for overall disease burden and in-patient mortality.<sup>13</sup> The Elixhauser comorbidity index consists of 30 variables for acute and chronic conditions identified by ICD-9 codes to assign a single numeric score.<sup>13</sup> The indications for prior admissions were categorized in the same fashion as MuAdm explained above.

### Statistical analysis

We used Chi-squared tests to compare descriptive characteristics between MuAdm and non-MuAdm cohorts. Factors

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