


## RESEARCH BRIEF

## Resurrecting immortal-time bias in the study of readmissions

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## Abstract

**Objective:** To compare readmission rates as measured by the Centers for Medicare and Medicaid Services and the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) methods.

**Data Sources:** 20 percent sample of national Medicare data for patients undergoing cystectomy, colectomy, abdominal aortic aneurysm (AAA) repair, and total knee arthroplasty (TKA) between 2010 and 2014.

**Study Design:** Retrospective cohort study comparing 30-day readmission rates.

**Data Collection/Extraction Methods:** Patients undergoing cystectomy, colectomy, abdominal aortic aneurysm repair, and total knee arthroplasty between 2010 and 2014 were identified.

**Principal Findings:** Cystectomy had the highest and total knee arthroplasty had the lowest readmission rate. The NSQIP measure reported significantly lower rates for all procedures compared to the CMS measure, which reflects an immortal-time bias.

**Conclusions:** We found significantly different readmission rates across all surgical procedures when comparing CMS and NSQIP measures. Longer length of stay exacerbated these differences. Uniform outcome measures are needed to eliminate ambiguity and synergize research and policy efforts.

## KEYWORDS

administrative data uses, health policy/politics/law/regulation, Medicare, program evaluation, quality of care/patient safety, surgery

## 1 | INTRODUCTION

Readmission following major surgery is common and costly, affecting 15 percent of patients within 30 days of discharge and averaging nearly \$14 000 per episode.<sup>1</sup> Though some readmissions are necessary, preventable readmissions are estimated to cost \$25 million annually.<sup>2</sup> As such, readmission has received significant attention from both researchers and policy makers.

The Hospital Readmissions Reduction Program (HRRP), a Centers for Medicare and Medicaid Services (CMS) policy, addresses excess readmission by penalizing underperforming hospitals.<sup>3</sup> While

initially targeting medical conditions, this policy expanded to include surgical discharges.<sup>4</sup> Positive change has come from HRRP; however, these improvements have been recently found to be overstated.<sup>5</sup> There is an ongoing nuanced discussion of readmission in health policy circles, but aspects of readmission measurement in the surgical literature present methodological concerns.<sup>6,7</sup>

One such concern regards the inconsistency between CMS, which reports readmissions within 30 days of the index hospitalization discharge, and the American College of Surgeons National Surgical Quality Improvement Program (NSQIP), which reports readmission within 30 days of the index surgery.<sup>3,8</sup> In this letter, we demonstrate how this inconsistency is a particular concern across surgical procedures with disparate lengths of stay.

Hugar and Borza contributed equally to this work.

## 2 | METHODS

Using a 20 percent sample of national Medicare data, we identified patients undergoing cystectomy, colectomy, abdominal aortic aneurysm (AAA) repair, and total knee arthroplasty (TKA) between 2010 and 2014. These procedures were chosen due to varying index lengths of stay and readmission rates. We included patients with continuous Medicare enrollment for one year prior to surgery and at least 30 days after discharge. We calculated 30-day readmission using both the CMS and NSQIP methods and compared differences using *t* tests.

## 3 | RESULTS

We identified 299 249 patients, whose characteristics are shown in Table 1. Median length of stay was 9 days for cystectomy and colectomy, 3 days for AAA repair, and 4 days for TKA. Regardless of measurement methodology, cystectomy had the highest 30-day readmission rate and TKA had the lowest readmission rate (Figure 1). However, we found an absolute difference in the CMS and NSQIP measurement of readmission of 6.2 percent for cystectomy, 3.7 percent for colectomy, 2.5 percent for AAA repair, and 0.4 percent for TKA. These corresponded to a relative difference of 31 percent for cystectomy, 36 percent for colectomy, 28 percent for AAA repair, and 9 percent for TKA, with the NSQIP measure reporting significantly lower rates for all procedures (all *P* < .001).

### What this study adds

#### What was already known?

- The Hospital Readmissions Reduction Program (HRRP) aims to improve quality.
- HRRP initially targeted medical conditions for readmission benchmarking.
- Under the HRRP, underperforming hospitals receive reduced payments.
- Benchmarks exist for the rate of unplanned readmission after certain surgical procedures.
- Readmission rate is subject to bias in the literature due to differences in measurement method.
- An immortal-time bias exists for one of two commonly used readmission measures.

#### What do we know now?

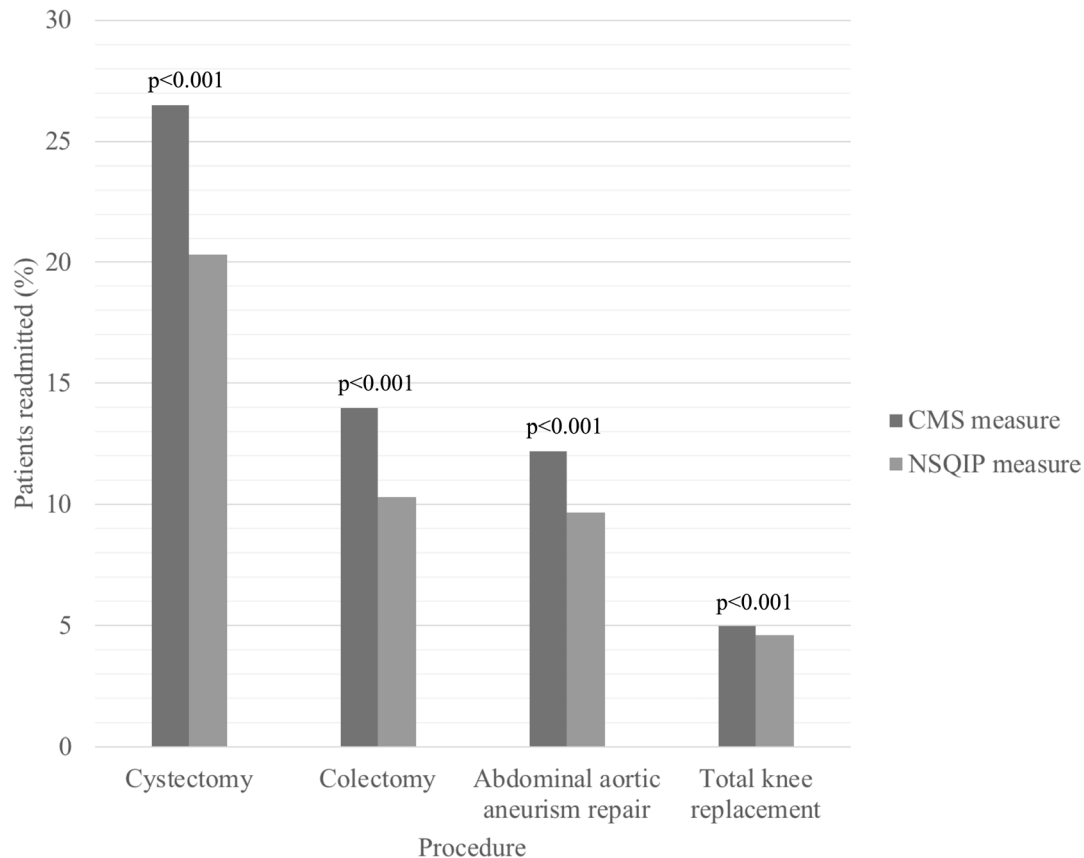
- The American College of Surgeons National Surgical Quality Improvement Program method of measuring readmission underestimates the true readmission rate.
- Immortal-time bias is strengthened as the duration and variability of length of stay increase.
- Reoperation rate or complication rate may be a more appropriate measure of quality for surgical procedures with relatively low or widely variable lengths of stay.

**TABLE 1** Demographic characteristics of Medicare beneficiaries undergoing major surgery

Characteristic	Cystectomy	Colectomy	AAA	TKR
	n = 3544	n = 70 608	n = 20 065	n = 205 032
Age, year (median, IQR)	75 (71-80)	77 (71-83)	77 (72-82)	74 (70-79)
Race/ethnicity, no. (%)				
White	3276 (92)	62 467 (89)	18 660 (93)	187 214 (91)
Black	163 (5)	5461 (8)	853 (4)	10 482 (5)
Hispanic	26 (1)	834 (1)	117 (1)	2288 (1)
Asian	22 (1)	703 (1)	177 (1)	1778 (1)
Other	57 (2)	1143 (2)	258 (1)	3270 (2)
Average number of HCCs (SD)	2.1 (1.8)	1.8 (2)	2.1 (2)	1.2 (1)
Socioeconomic class, no. (%)				
Low	1144 (32)	22 906 (32)	6523 (33)	65 558 (32)
Medium	1136 (32)	22 771 (32)	6529 (33)	65 777 (32)
High	1165 (33)	23 188 (33)	6527 (33)	68 487 (33)
Residential area, no. (%)				
Large metropolitan county	1587 (45)	31 617 (44)	8255 (41)	86 514 (42)
Smaller metropolitan county	1165 (33)	24 003 (34)	6942 (35)	73 006 (36)
Urban county	697 (20)	13 153 (19)	4239 (21)	39 744 (20)
Smaller urban or rural county	92 (3)	1763 (3)	606 (3)	5600 (3)
Length of stay, days (median, IQR)	9 (8-13)	9 (6-14)	3 (2-7)	4 (4-4)

Note: Percentages may not add to 100 due to rounding.

Abbreviations: AAA, abdominal aortic aneurysm; CMS, Centers for Medicare and Medicaid Services; HCC, hierarchical condition category; IQR, interquartile range; NSQIP, National Surgical Quality Improvement Program; SD, standard deviation; TKR, total knee replacement.



**FIGURE 1** Comparison of CMS and NSQIP readmission measures in Medicare beneficiaries undergoing major surgery. Abbreviations: CMS, Centers for Medicare and Medicaid Services; and NSQIP, National Surgical Quality Improvement Program. Note: Readmission measure definitions: CMS, 30 days from index hospitalization discharge date; and NSQIP, 30 days from index surgery date.  $P < .001$  for readmission rate differences in all procedures.

#### 4 | DISCUSSION

We found significantly different readmission rates across all surgical procedures when comparing CMS and NSQIP measures. Longer lengths of stay exacerbated these differences. These findings demonstrate the need for uniformity across measurement methodologies to allow for more direct comparisons across studies that seek to examine the intended and unintended effects of changes to readmission policy.

Our findings result from an immortal-time bias, defined as the span of time in the follow-up period during which the outcome of interest could not possibly have occurred.<sup>9</sup> When measuring readmission from the index surgical date, patients are considered “immortal” from readmission until discharge. In 2013, Lucas et.al. showed that longer lengths of stay strengthened immortal-time bias.<sup>10</sup> We show that immortal-time bias is further emphasized across different procedures with disparate lengths of stay. For example, radical cystectomy is a morbid procedure with a longer and more variable length of stay. Estimated readmission rate in the literature ranges from 29 percent using CMS data to 20 percent using ACS NSQIP data.<sup>11,12</sup> The estimate closer to 30 percent is a more accurate reflection of the true readmission rate.

Not only does immortal-time bias artificially lower 30-day readmission rate, it minimizes other risk factors for readmission. These

risk factors include complications that occur during index hospitalizations, postdischarge complications, and patient- and community-level factors in the postdischarge environment.<sup>13,14</sup> Immortal-time bias increasingly attenuates the effect of these risk factors as length of stay increases, by overlooking what occurs during the inpatient hospital stay and shortening the timeframe of potentially harmful postdischarge exposures.

Recognizing immortal-time bias has important implications for surgical outcomes research and informing future health policy. For surgical outcomes research, our data show that the CMS definition more appropriately accounts for readmission risk factors while estimating a more accurate readmission rate. We believe the CMS measure should be uniformly adopted to measure readmission, especially if hypotheses or conclusions regard health policy. However, complication rate or 90-day mortality may be more appropriate quality metrics for morbid procedures with long lengths of stay, such as cystectomy and colectomy. Likewise, measures such as reoperation rate or surgical site infection may facilitate more meaningful quality improvement for procedures with short lengths of stay like arthroplasty.

In conclusion, an immortal-time bias is responsible for a 9 to 36 percent difference in readmission rate when CMS and NSQIP measurement methodologies are compared. This bias is strengthened

as both the duration and variability of length of stay increase. As health services research and health policy become more enmeshed, uniform outcome measures are needed to eliminate ambiguity and synergize results across studies.

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## CONFLICTS OF INTEREST

There are no conflicts of interest to disclose.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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