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Complete List of Authors:	Lasater, Karen ; University of Pennsylvania; University of Pennsylvania Rosenbaum, Paul; University of Pennsylvania, The Leonard Davis Institute of Health Economics; University of Pennsylvania, The Wharton School Aiken, Linda; University of Pennsylvania School of Nursing, Center for Health Outcomes and Policy Research Brooks-Carthon, J. Margo; University of Pennsylvania , Family & Community Health Kelz, Rachel R.; University of Pennsylvania; University of Pennsylvania Perelman School of Medicine, Department of Surgery Reiter, Joseph G.; Children's Hospital of Philadelphia Silber, Jeffrey H.; University of Pennsylvania; The Children's Hospital of Philadelphia McHugh, Matthew; University of Pennsylvania , School of nursing
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Racial Disparities in Surgical Survival: An Analysis of Patient and Hospital Factors

Karen B. Lasater, PhD, RN[1,2]

Paul R. Rosenbaum, PhD[3,4]

Linda H. Aiken, PhD, RN [1,2]

J. Margo Brooks Carthon, PhD RN[1,2]

Rachel R. Kelz, MD[2,5]

Joseph G. Reiter, MS[3]

Jeffrey H. Silber, MD, PhD [1,2,3,6,7,8]

Matthew D. McHugh, PhD, RN[1,2]

Affiliations:

[1]Center for Health Outcomes and Policy Research, School of Nursing, University of Pennsylvania, Philadelphia, PA USA

[2]The Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA

[3]Center for Outcomes Research, Children's Hospital of Philadelphia, Philadelphia, PA USA

[4]Department of Statistics and Data Science, The Wharton School, University of Pennsylvania, Philadelphia, PA USA

[5]Department of Surgery, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[6]Department of Pediatrics, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[7]Department of Anesthesiology and Critical Care, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[8]Department of Health Care Management, The Wharton School, University of Pennsylvania, Philadelphia, PA USA

Address Correspondence to: Karen B. Lasater. Center for Health Outcomes and Policy Research, University of Pennsylvania School of Nursing. 418 Curie Boulevard, Fagin Hall Philadelphia, PA 19104. (215) 746-8362. karenbl@nursing.upenn.edu

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ABSTRACT

Objectives. Evaluate whether hospital factors, including nurse resources, explain racial differences in Black and White patient surgical outcomes.

Design. Tapered-match cohort design.

Setting. 571 hospitals at two-points in time (Early Era 2003-2005; Recent Era 2013-2015).

Participants. 6,752 Black patients and 3 sets of 6,752 White controls selected from 107,001 potential controls in the Early Era. 4,964 Black patients and 3 sets of 4,964 White controls selected from 74,108 potential controls in the Recent Era.

Interventions. Black patients were matched to White controls on Demographics (age, sex, state, year of procedure), Procedure (Demographics variables plus 136 ICD-9 principal procedure codes), and Presentation (Demographics and Procedure variables plus 34 comorbidities, a mortality risk score, a propensity score for being Black, emergency admission, transfer status, predicted procedure time).

Outcomes. 30-day and 1-year mortality.

Results. Before matching, Black patients had more comorbidities, higher risk of mortality despite being younger, and underwent procedures at different rates than White patients. White controls in the Demographics match had lower mortality at 30-days (5.6% vs 6.7% Early Era; 5.4% vs 5.7% Recent Era) and 1-year (15.5% vs 21.5% Early Era; 12.3% vs 15.9% Recent Era). Black-White 1-year mortality differences were equivalent after matching patients with respect to Presentation, Procedure, and Demographic factors. Black-White 30-day mortality differences were equivalent after matching on Procedure and Demographic factors. Racial disparities in outcomes remained unchanged between the two time periods spanning 10 years. All patients in

hospitals with better nurse resources had significant and sizable lower odds of 30-day (OR 0.60, 95% CI 0.46-0.78, p<0.010) and 1-year mortality (OR 0.77, 95% CI 0.65-0.92, p<0.010) even after accounting for other hospital factors.

Conclusions. Survival disparities among Black and White patients are largely explained by differences in health status. Better nurse resources (e.g., staffing, work environment) were associated with lower mortality for all patients.

INTRODUCTION

Major National Academy of Medicine reports,[1, 2] document the existence of racial disparities in hospital outcomes. Worse outcomes among Black patients have been attributed to differences in illness severity,[3, 4] disparities in treatment,[5] and variation in hospital quality.[6, 7] Each of these factors is a function of structural racism arising out of long-standing discriminatory systems, policies, and institutions across sociopolitical domains including education, housing, criminal justice, and healthcare.[8] Although systematic differences in hospitals where patients receive care may contribute to disparities,[9-12] little evidence specifies exactly which hospital factors are associated with worse disparities.

We focus on a modifiable aspect of hospitals—nurse resources. An evaluation of the role of nurse resources is warranted since they vary widely across hospitals[13, 14] and a large literature shows that patients in hospitals where nurses care for fewer patients at a time, have a skill mix rich in registered nurses (RNs), high proportions of bachelors-educated nurses (BSNs), and a favorable nurse work environment, experience better outcomes including lower mortality.[14-17] Evidence suggests the survival benefits conferred by better nurse resources accrue to all patients; however, they may be particularly beneficial for Black patients.[18-21] Our motivation was to understand whether variation in hospital nurse resources differentially impact survival outcomes of Black and White patients following surgery, and whether improving these resources hold promise as an interventional target for reducing racial disparities and improving outcomes.

METHODS

Design and Data Sources

This observational study uses secondary data of patients and hospitals at two cross-sections in time: 2003-2005 (i.e., Early Era) and 2013-2015 (i.e., Recent Era). Data about patients were obtained from Centers for Medicare and Medicaid Services. Data about hospitals were obtained from the American Hospital Association Annual Survey which provided information on hospital size, the Healthcare Cost Report Information System dataset which provided information on hospital teaching status, and the RN4CAST-US survey which provided information about hospital nurse resources. Time periods for the Early and Recent Era were selected based on the availability of the RN4CAST-US survey data.

Patient Population

The patient sample included non-Hispanic Black and non-Hispanic White Medicare fee-for-service beneficiaries, who were 65.5 years or older and who were admitted to one of the study hospitals for general surgery (Appendix Table 1) either between January 1, 2004–September 30, 2006, or January 1, 2013–September 30, 2015. Using race to characterize patients should not be interpreted as race representing innate biological differences. Race is a social construct; it reflects differences in experiences and exposure to systematic discrimination that produces observable harm and differences in health outcomes. Patient data included Research Identifiable Files: inpatient, outpatient, carrier (physician Part B), hospice, and the master beneficiary summary file. Patients were excluded if there was missing data on age or sex, had an invalid date

of death, or were enrolled in an HMO or lacked Part B coverage in the 6 months prior to their index hospitalization.

For patients with multiple admissions, the index hospitalization was defined by randomly selecting one admission. A 180-day look-back from the index admission was performed across all patient files to identify comorbidities. A 30-day mortality risk model to estimate each patient's probability of death at the time of admission was constructed using a 10% random sample of data that did not overlap with the analytic sample. Propensity scores to be a Black individual were estimated using the covariates controlled in each match (Appendix Tables 2-3). Other characteristics included age, sex, transfer-in status, emergent admission, and 34 comorbidities.

Hospital Sample

The RN4CAST-US is a large panel survey of RNs, conducted at two points in time (i.e., 2005-2006; 2015-2016) in four large U.S. states: California, Florida, New Jersey, Pennsylvania. Both surveys employed the same methodology—a modified Dillman approach[22] to randomly sample actively licensed RNs from state licensure lists.[23] Nurses reported the name of their employer, demographics, and details about resources in their hospital, including patient-to-nurse staffing ratios, nurse skill mix, and the quality of the work environment. Our focus was adult, general, acute care hospitals in the four states.

Averages among RNs in the same hospitals were used to create hospital-level measures of nurse resources. Staffing, i.e., patient-to-nurse ratios, is derived by the number of patients per direct-

care RN on medical-surgical units. Skill mix is the proportion of RNs to all nursing personnel (i.e., RNs, licensed practice nurses, unlicensed assistive personnel). Nurse education is the hospital proportion of RNs holding a BSN or higher. Nurse work environment is derived from the National Quality Forum-endorsed 31-item Practice Environment Scale of the Nursing Work Index, comprised of 5 subscales: Nurse Participation in Hospital Affairs; Nursing Foundations for Quality of Care; Nurse Manager Ability, Leadership and Support of Nurses; Staffing and Resource Adequacy; Collegial Nurse-Physician Relations.[24]

Hospital nurse resources are presented as a three-category variable characterized by terciles of hospitals according to their percentile ranking which ranged from 0% (poorest nurse resources) to 100% (best nurse resources) based on a coherence rank score.[25] The score describes how each hospital compared to others based on the four resources.[15, 26] Hospitals present in both eras were ranked twice, once in each era. Ranks were formed by comparing hospitals two at a time – which of the two hospitals is better? – and then aggregating the pairwise comparisons. If hospital *i* had better nurse resources on all measures than hospital *j*, it received 1 point; if hospital *i* had worse nurse resources than hospital *j*, it lost one point, or received −1 points; and if hospital *i* was better on some measures and worse on others, it received 0 points. The rank for hospital *i* is its total points, i.e., the number of hospitals that were worse than hospital *i* minus the number that were better than hospital *i*.

Outcomes

30-day and 1-year mortality (defined as a death within 30 days and 1 year of admission, respectively). 30-day readmission (or death) outcomes are reported in the Appendix (Tables 5-6).

Statistical Analysis

Matching Methodology

The tapered multivariate matching approach[3, 27-30] sequentially matched the same Black patients to different sets of White patients, controlling for consecutively more variables to understand the contribution of various factors to the outcomes disparity.[27] The Demographics taper included variables for age, sex, state, and year of procedure. The Procedure taper added ICD-9 principal procedure codes. The Presentation taper added patient risk factors related to health status at the time of surgery, including 34 comorbidities, a mortality risk score, emergency admission, transfer status, and predicted procedure time. Patients were exactly matched within era and state (with New Jersey and Pennsylvania combined), for 136 ICD-9 procedure codes, and mortality risk quintile (Appendix Tables 2-3). Fine balance and distance minimization techniques were used to make matched groups as similar as possible.

Statistical Methods

Comparisons within pairs used McNemar's test and conditional logit regression. Difference-in-difference analyses compared Black-White differences in pairs from the Early and Recent Eras, asking: Did the Black-White difference change over time? These analyses used Gart's test[31] to compare disparities in the Early Era to disparities in the Recent Era.[32] Conditional logit regression models were performed at the Presentation Match using data from both eras combined to test nurse resources, race, and combinations of their interactions, accounting for structural hospital characteristics (i.e., size, teaching status, technology capabilities, general surgery volume).

Patient and Public Involvement

None.

RESULTS

Quality of Patient Matches

The matches are shown in Table 1 (Recent Era) and Appendix Table 4 (Early Era). Table 1 describes 4,964 Black patients and 3 sets of 4,964 White controls—selected from a population of 74,108 White patients. In each taper, White controls become more like the Black patients. Matched variables (i.e., left of the zigzag line) were similar: the standardized differences in means never exceeded 0.11 SDs. Unmatched variables (i.e., right of the zigzag line) show the disparity prior to matching. Comparisons in the Demographic match reveal differences in the types of procedures Black and White patients receive. For example, Black patients underwent a laparoscopic cholecystectomy at lower rates (18.9%) than White patients (21.3%, $p<0.01$). Black patients had more comorbidities, and in some cases were much more likely to have a chronic condition such as diabetes (51.3% vs 32.8%), despite being 1.5 years younger on average. The Demographics match removed age, sex, state, and year of procedure differences, the Procedure match included Demographics match variables and removed differences in procedure rates, and the Presentation match included all Demographics and Procedure variables and further matched on variables reflecting health status by selecting White controls that were as clinically ill (e.g., similar mortality risk and comorbidity burden) as Black patients. White patients in the Presentation match are atypical of White patients overall, in that they have the same higher burden of comorbidities present in the Black population.

We made no attempt to match on measures of socioeconomic status (SES), including dual-eligibility, and neighborhood-level socioeconomic variables (i.e., median household income, percentage of high school graduates, percentage of college graduates) because socioeconomic status variables are highly correlated with race in the U.S. Black patients were nearly 4 times more likely to be dual-eligible compared with unmatched Whites, and more likely to live in neighborhoods with markers of lower SES. After matching on Demographic, Procedure, and Presentation variables, White controls looked more like Black patients with respect to SES indicators, however large and important differences remained (e.g., 37.4% Black patients were dual-eligible vs 14.8% of White controls, p<0.001).

Table 1. Quality of Matches for Selected* Variables, Recent Era (2013-2015)

Variable	**Black Patients** (n = 4,964)	**Tapered Matches** Presentation + Procedure + Demographics (n = 4,964)	Procedure + Demographics (n = 4,964)	Demographics (n = 4,964)	White Patients (unmatched) (n = 74,108)
State (%)					
California	24.3	24.3	24.3	24.3	**27.8[c]**
Florida	34.1	34.1	34.1	34.1	35.4
New Jersey / Pennsylvania	41.6	41.6	41.6	41.6	**36.8[c]**
Year of Procedure (%)					
2013	23.1	23.2	23.1	23.1	22.9
2014	43.7	43.7	43.7	43.7	44.6
2015	33.2	33.1	33.2	33.2	32.6
Age at Procedure	75.5	**75.0[b]**	75.4	75.5	**77.0[c]**
% Male	39.3	39.3	39.3	39.3	**44.7[c]**
Procedures (%)					
Laparoscopic cholecystectomy (5123)	18.9	18.9	18.9	**21.3[b]**	**21.6[c]**
Open right hemicolectomy (4573)	7.6	7.6	7.6	**6.4[a]**	**6.6[b]**
Partial resection of small intestine (4562)	7.0	7.0	7.0	**5.7[a]**	**5.6[c]**
Laparoscopic right hemicolectomy (1733)	4.8	4.8	4.8	4.3	4.4
Open cholecystectomy (5122)	3.1	3.1	3.1	3.2	3.3
Selected Comorbidities (%)					
Hypertension	93.2	93.3	**84.9[c]**	**84.7[c]**	**85.1[c]**
Diabetes	51.3	51.1	**33.7[c]**	**32.6[c]**	**32.8[c]**

Congestive heart failure	26.1	25.9	**18.0[c]**	**18.2[c]**	**19.4[c]**
Renal dialysis	42.2	41.7	**26.9[c]**	**26.1[c]**	**28.4[c]**
Renal failure	14.0	6.5	**5.5[c]**	**5.7[c]**	**4.1[c]**
Paraplegia	6.1	**4.5[c]**	**2.1[c]**	**2.1[c]**	**2.1[c]**
Mortality Risk Score (prob)	0.069	0.067	**0.055[c]**	**0.050[c]**	**0.056[c]**
Emergency admission (%)	56.9	58.4	**50.2[c]**	**50.2[c]**	**50.5[c]**
Transfer status (%)	1.1	1.0	0.9	0.9	**0.8[a]**
Anesthesia time (minutes)	155	**150[c]**	**150[c]**	**152[c]**	**151[c]**
Dual-eligible (%)	37.4	**14.8[c]**	**11.7[c]**	**10.6[c]**	**10.4[c]**
Neighborhood median household income ($)	24,267	**32,070[c]**	**32,970[c]**	**32,843[c]**	**32,755[c]**
Neighborhood high school graduate (%)	83.2	**88.8[c]**	**89.3[c]**	**89.2[c]**	**89.2[c]**
Neighborhood college graduate (%)	32.8	**39.9[c]**	**40.9[c]**	**40.9[c]**	**40.9[c]**

Notes. The zigzag diagonal line indicates which variables are controlled in each match: variables to the right of the line are not controlled. The table shows only a few of the variables, – in particular, a few of the surgical procedures – that were controlled in each match. Bolded numbers represent significant differences [a]<0.005; [b]<0.01; [c]<0.001. *The complete balance tables with all variables are available in Appendix Table 3 for Recent Era (2013-2015) patient matches. Dual-eligible is a beneficiary of both Medicare and Medicaid. Measures of patient socioeconomic status were obtained through the American Community Survey and are based on neighborhood-level characteristics: median household income, percentage of high school graduates and percentage of college graduates.

Figure 1 demonstrates differences in Black and White patients' estimated mortality risk on admission prior to matching (i.e., White Unmatched) and at each taper of the match. The largest disparity in estimated mortality risk is observed in the Demographics match—likely because this match requires patients to be the same on age and sex, which selects for White controls who were 1.5 years younger than the typical White patient and fewer males. As we move through the tapers, the racial disparity in estimated mortality risk narrows. The result of the matching process is a White control group that is profoundly different than the initial White population. Appendix Figure 1 presents comparisons in the Early Era with similar findings.

Outcome Results

Mortality outcomes for Black patients and the 3 sets of White controls are reported in Table 2. In the Early and Recent Eras, after matching White controls with similar demographics as the Black cohort (i.e., Demographics match), we observe higher 1-year mortality among Black patients. 1-year mortality differences narrow after matching on procedure but remain significantly higher among Black patients. After selecting White controls that presented as sick as Black patients (i.e., Presentation match), 1-year mortality differences become statistically insignificant. 30-day mortality differences diminished after matching on Procedure. The bottom most panel of Table 2 reports the difference-in-difference, defined by the Black-White difference in the Recent Era minus the Black-White difference in the Early Era. Survival disparities did not change significantly over the two eras separated by 10 years. Survival curves of Black patients and White controls are presented in Figure 2. In the Early and Recent Eras, White controls at the Presentation Match had the lower probability of survival in the time-period most proximal to hospital admission; however, at 1-year from hospitalization Black patients had lower survival odds.

Table 2. Mortality Outcomes for Black Study Population and 3 Matched White Populations: Early Era (2003-2005), Recent Era (2013, 2015), and the Difference-in-Difference between the Eras to Evaluate whether the Black-White Difference is Different in the Two Eras

			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	1-year mortality	21.45%	20.51%	17.54%***	15.52%***
	30-day mortality	6.71%	7.81%**	6.47%	5.60%**
Recent Era (2013-2015)	1-year mortality	15.87%	16.16%	12.99%***	12.29%***
	30-day mortality	5.70%	7.88%***	5.74%	5.42%
Difference in Difference (Recent - Early)	1-year mortality	--	-1.23%	-1.03%	-2.35%
	30-day mortality	--	-1.08%	-0.28%	-0.83%

Note. Difference in difference is defined by the Black-White difference in Recent Era minus the Black-White difference in Early Era. Significance tests for binary variables used McNemar test (* <0.05, ** <0.01, ***<0.001). For the difference in difference across eras, Gart's test for binary outcomes was used (+ < 0.05, ++ < 0.01, +++ < 0.001). The symbols were marked in the later era if the difference in difference was significant.

Conditional logit models further analyze Black-White patient pairs (Table 3). These models attempt to tease apart race, nurse resources, their interaction, and other hospital attributes. Model 1a is like the Table 2 Presentation Match in which Black patients have lower odds of 30-day mortality (OR 0.77, 95% CI 0.69-0.85, p <0.001). In Model 2a, high nurse resources are associated with substantially lower mortality (OR 0.58, 95% CI 0.46-0.74, p<0.001), and this pattern appears to be the same or nearly so for Black and White patients. As in Table 2, 1-year mortality outcomes are not significantly different among Black and White patients who were matched on Demographic, Procedure, and Presentation characteristics (Models 1b-4b). High nurse resources are strongly associated with lower 1-year mortality (Model 2b), apparently in the same way for Blacks and Whites (Model 3c), persisting even after adjusting for hospital-level characteristics (Model 4b). Findings were similar for 30-day readmission (Appendix Table 5).

The simplest model that fits well includes race and nurse resources (Models 2a and 2b). The addition of interactions between race and nurse resources or additional hospital attributes did not improve the model. This is evident in the test-statistics reported in the bottom of Table 3 which describe the improvement in fit for each model compared to the prior model. P-values greater than 0.05 mean we fail to reject the simpler model in favor of the more complex model.

Table 3. Effect of Race and Hospital Nurse Resources on 30-day and 1-year Mortality Odds, After Matching Patients on Demographics, Procedure, and Presentation Variables

	30-day mortality				1-year mortality			
	Model 1a	Model 2a	Model 3a	Model 4a	Model 1b	Model 2b	Model 3b	Model 4b
Variables in the Model	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Black	0.77*** (0.69-0.85)	0.79*** (0.71-0.88)	0.75*** (0.64-0.87)	0.75*** (0.64-0.88)	1.02 (0.96-1.11)	1.06 (0.98-1.13)	1.04 (0.95-1.17)	1.05 (0.94-1.16)
Nurse Resources (High vs Low)	---	0.58*** (0.46-0.74)	0.59*** (0.46-0.74)	0.60** (0.46-0.78)	---	0.75*** (0.64-0.88)	0.75*** (0.64-0.88)	0.77** (0.65-0.92)
Nurse Resources (Middle vs Low)	---	0.83 (0.68-1.00)	0.82* (0.68-1.00)	0.83 (0.68-1.01)	---	0.94 (0.80-1.03)	0.91 (0.80-1.03)	0.91 (0.80-1.04)
Black*Nurse Resources (High vs Low)	---	---	0.91 (0.78-1.07)	0.92 (0.78-1.08)	---	---	1.01 (0.90-1.13)	1.02 (0.91-1.13)
Black*Nurse Resources (Middle vs Low)	---	---	0.95 (0.80-1.13)	0.95 (0.80-1.13)	---	---	0.99 (0.88-1.11)	0.99 (0.88-1.11)
Major Teaching Hospital	---	---	---	0.93 (0.72-1.21)	---	---	---	0.97 (0.82-1.15)
Minor Teaching Hospital	---	---	---	0.97 (0.80-1.18)	---	---	---	1.03 (0.90-1.17)
Large Size (>250 beds)	---	---	---	0.98 (0.81-1.19)	---	---	---	0.97 (0.85-1.10)
High Technology Hospital	---	---	---	1.08 (0.90-1.29)	---	---	---	1.07 (0.94-1.21)
General Surgery Volume	---	---	---	0.99 (0.96-1.01)	---	---	---	0.99 (0.97-1.00)
Test for improvement in fit with greater model complexity								
Chi-square	---	20.03	1.25	1.80	---	12.43	0.13	4.94
Degrees of Freedom	---	2	2	5	---	2	2	5
p-value	---	< 0.0001	0.5350	0.8756	---	0.0020	0.9363	0.4227

Note. Conditional logit models show the effects of race and hospital nurse resources for pairs of Black and White patients who have been closely matched on demographic characteristics (age, sex, state, year of procedure), procedure (ICD-9 principal procedure code), and presentation (34 comorbidities, mortality risk score, propensity score for being Black, emergency admission indicator, transfer status indicator, predicted procedure time). Data from both eras are combined in this analysis. Nurse resources represent a three-category variable characterized by terciles of hospitals according to their percentile ranking. The general surgery volume variable

represents the effect of a 100-patient increase in general surgery volume on patient odds of 30-day mortality. *p<0.05; **p<0.01; ***p<0.001**.** Summary: High levels of nursing resources were associated with substantially lower mortality for both Black and White patients, with no indication of interaction.

DISCUSSION

Study results reveal outcomes disparities are largely explained by significant differences in clinical presentation between Black and White patients. Among Black and White patients matched for Demographics (i.e., age, sex, state, year of procedure), we found significantly higher 30-day and 1-year mortality among Black patients. This is consistent with prior evidence of racial outcomes disparities in surgical patients.[2, 33, 34] Black patients in our sample were more clinically ill upon presentation than White patients. Despite being younger, Black patients had more comorbidities, more emergency admissions, and higher mortality risk upon admission. Black patients also underwent procedures at different rates. Only after closely matching patients to account for these differences did the mortality advantage for White controls disappear.

Our research is not the first to find higher mortality among White patients after accounting for racial differences in clinical presentation.[3, 4, 18, 35-37] Theory and empirical evidence point to racial differences in clinical presentation as resulting from the fundamental driving force of structural racism as the root cause of health disparities.[38] Cumulative effects of centuries of systematic discrimination in virtually all domains of life (e.g., education, housing, criminal justice, policy benefits, job opportunities, pay, political power, access to high quality healthcare) underlie observable clinical presentation differences. Thus, system-level reforms across these domains are necessary to begin to undo the harms generating differences in health status and survival outcomes.

Our second major finding is that surgical disparities—at least for general surgeries—have not narrowed overtime. This is in contrast to what Mehtsun and colleagues found[39]—though that analysis focused on 8 procedures and included orthopedic and vascular surgeries. In our study, we found that while mortality and readmissions were lower in the Recent Era (2013-2015) for both Black patients and White controls, the differences between the two groups remained unchanged overtime.

Our third major finding is that differences in hospitals are a significant contributor to variation in outcomes for all surgical patients, both Black and White. Specifically, receiving care in hospitals with better nurse resources was associated with lower odds of death, even after accounting for other hospital factors (i.e., teaching status, technology capability, size, surgery volume). Being in a hospital with high nurse resources predicted a much larger reduction in mortality than did race. High nurse resources predicted lower mortality for both Black and White patients, to the same or similar degree. Some research has shown that nurse resource deficiencies result in even worse outcomes for Black patients,[18-21] but perhaps this difference is a function of our use of a composite measure which simultaneously evaluates all four aspects of nurse resources versus isolating the effect of a single resource; other investigations focused mainly on nurse staffing.

That our results suggest that better nurse resources, as opposed to other hospital factors are associated with higher survival outcomes, is important. Whereas the other hospital factors we measured here are difficult to modify, nurse resources are modifiable through actions of hospital administrators or policy intervention. Hospital administrators can make it their strategic priority to staff greater numbers of nurses, including higher proportions of BSN-prepared nurses and a

richer skill mix of RNs, and well as improve their nurse work environments via management reforms and evidence-based interventions like the American Nurses Credentialling Center Magnet® Program.[40, 41] At the policy-level, states can follow the example of California—the first and only state to legislate hospitals hire enough nurses to safely care for patients. The result of this policy has improved nurse staffing ratios and made more even the staffing variability across the state.[42, 43] Recent studies show wide variation in the average nurse staffing ratios within states,[13, 44] ranging from 3.3 to 9.7 patients-per-nurse on medical-surgical units.[13] If other states followed California's example by enacting minimum safe nurse staffing policies, it would raise the floor on hospital nurse staffing while making more even the variability across hospitals.

Limitations

Despite carefully matching on demographic, procedure, and presentation differences, we are unable to account for possible within-hospital differences experienced by Black and White patients, for example, the possibility of selection bias wherein surgeons may be less likely to operate on clinically ill Black patients compared to similarly ill White patients.[5, 45] Thus, our analysis of surgical patients may include somewhat healthier Black patients than their matched White controls. Comorbidities utilized for matching patients may be fallible markers of clinical severity and frailty or have within-category variation leading to residual differences in presentation despite careful and comprehensive matching. Finally, although we use the White population as the reference group, it should not be interpreted that the White population's outcomes are the ideal referent or the best that could be achieved in terms of outcomes for Black patients. Studies using other referent groups (e.g., not-low-SES White[46, 47]) would be useful, as

would research within the Black population alone to understand possible strengths that could be leveraged to improve outcomes that may be unique to the population.

Conclusions

In summary, there is a large racial disparity in mortality among Medicare patients undergoing general surgery. Black and White patients present differently even when undergoing the same procedure. Despite being younger, Black patients are more likely to have higher comorbidity burden and greater risk of mortality. We found racial outcomes disparities following surgery have not improved over the decade, but organizational and policy reform have the potential to improve outcomes for Black and White patients alike. Even after accounting for health status, better nurse resources—a modifiable feature of hospitals—were significantly associated with improved survival for both Black and White patients.

Ethics Approval Statement

This study was approved by the Children's Hospital of Philadelphia Institutional Review Board (19-016296).

Contributorship Statement

All authors meet the criteria recommended by the International Committee of Medical Journal Editors (ICMJE). PRR, LHA, JMBC, RRK, JHS, and MDM contributed to the original idea and design of the study. KBL, LHA, JMBC, and MDM contributed to the collection of nurse survey data. JGR conducted the data analysis. All authors contributed to the interpretation of the data and preparation of the submitted manuscript. All authors approved the submitted manuscript.

Competing Interests

None declared.

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Data Sharing Statement

The nurse survey data are not available. The patient data are from the Centers for Medicare and Medicaid Services and approval for their use can be requested directly from CMS.

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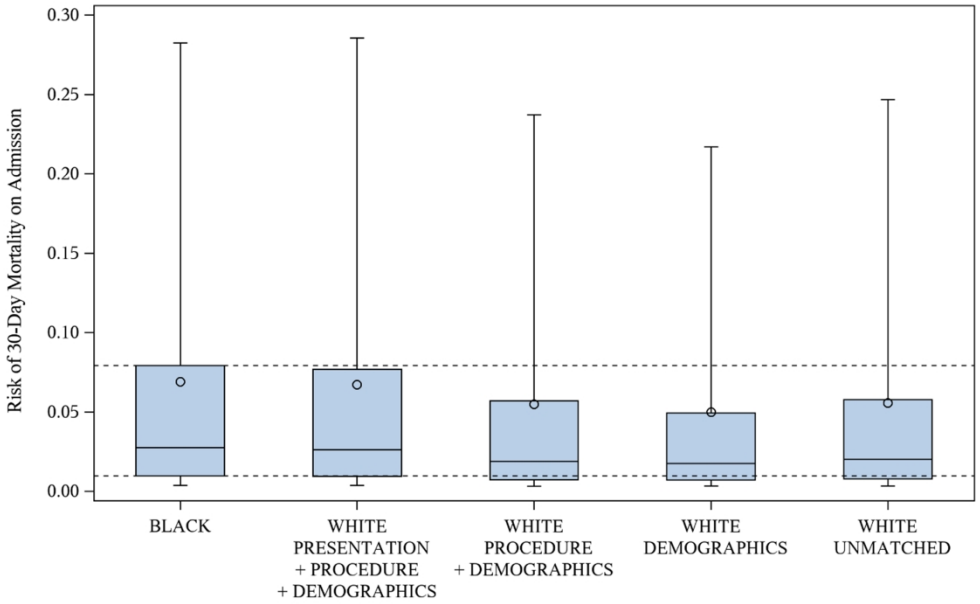
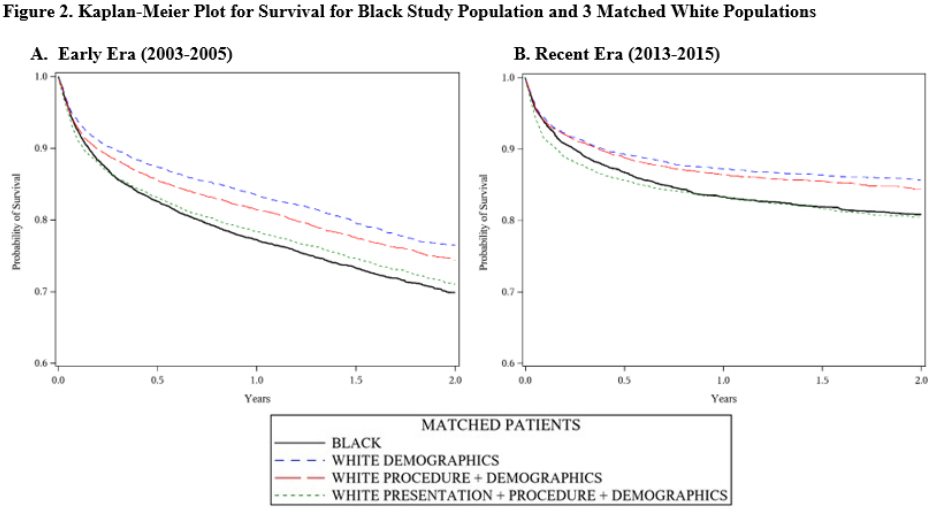
Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Recent Era (2013-2015)



Note. The tails of each box plot represent the lower 5% and upper 95% of the distribution. The mortality risk estimates presented here are based on risk at the time of admission. Early Era results look similar and are presented in Appendix Figure 1. Summary: Until matched for surgical procedure and comorbid conditions in the "White Presentation" match, Black patients had a combination of surgical procedures and comorbid conditions that placed them at elevated risk of death compared to White controls.

Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Recent Era (2013-2015)



Summary. The substantially higher mortality among Black patients is most evident over a longer span of time, is not concentrated in the brief period around surgery, and reflects a greater burden of comorbid conditions and a more frequent need for higher risk procedures. Black and White patients had lower mortality in the Recent Era (2013-2015), but there is no clear indication that the Black-White disparity has diminished.

Figure 2. Kaplan-Meier Plot for Survival for Black Study Population and 3 Matched White Populations

APPENDIX

Table 1. List of General Surgical Procedures on Which Black and White Patients Were Exact Matched

Procedure Code	Procedure Name
PPX 062	Unilateral thyroid lobectomy
PPX 0631	Excision of lesion of thyroid
PPX 0639	Other partial thyroidectomy
PPX 064	Complete thyroidectomy
PPX 0650	Substernal thyroidectomy, not otherwise specified
PPX 0651	Partial substernal thyroidectomy
PPX 0652	Complete substernal thyroidectomy
PPX 0681	Complete parathyroidectomy
PPX 0689	Other parathyroidectomy
PPX 0722	Unilateral adrenalectomy
PPX 1711	Laparoscopic repair of direct inguinal hernia with graft or prosthesis
PPX 1712	Laparoscopic repair of indirect inguinal hernia with graft or prosthesis
PPX 1713	Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 1721	Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis
PPX 1722	Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis
PPX 1723	Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis
PPX 1724	Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 1731	Laparoscopic multiple segmental resection of large intestine
PPX 1732	Laparoscopic cecectomy
PPX 1733	Laparoscopic right hemicolectomy
PPX 1734	Laparoscopic resection of transverse colon
PPX 1735	Laparoscopic left hemicolectomy
PPX 1736	Laparoscopic sigmoidectomy
PPX 1739	Other laparoscopic partial excision of large intestine
PPX 415	Total splenectomy
PPX 4240	Esophagectomy, not otherwise specified
PPX 4241	Partial esophagectomy
PPX 4242	Total esophagectomy
PPX 427	Esophagomyotomy
PPX 4342	Local excision of other lesion or tissue of stomach
PPX 435	Partial gastrectomy with anastomosis to esophagus
PPX 436	Partial gastrectomy with anastomosis to duodenum
PPX 437	Partial gastrectomy with anastomosis to jejunum
PPX 4389	Open and other partial gastrectomy
PPX 4399	Other total gastrectomy
PPX 4429	Other pyloroplasty
PPX 4438	Laparoscopic gastroenterostomy
PPX 4439	Other gastroenterostomy without gastrectomy
PPX 4441	Suture of gastric ulcer site
PPX 4442	Suture of duodenal ulcer site
PPX 4466	Other procedures for creation of esophagogastric sphincteric competence

PPX 4467	Laparoscopic procedures for creation of esophagogastric sphincteric competence
PPX 4469	Other repair of stomach
PPX 4561	Multiple segmental resection of small intestine
PPX 4562	Other partial resection of small intestine
PPX 4563	Total removal of small intestine
PPX 4571	Open and other multiple segmental resection of large intestine
PPX 4572	Open and other cecectomy
PPX 4573	Open and other right hemicolectomy
PPX 4574	Open and other resection of transverse colon
PPX 4575	Open and other left hemicolectomy
PPX 4576	Open and other sigmoidectomy
PPX 4579	Other and unspecified partial excision of large intestine
PPX 458	Other and unspecified partial excision of large intestine
PPX 4581	Laparoscopic total intra-abdominal colectomy
PPX 4582	Open total intra-abdominal colectomy
PPX 4583	Other and unspecified total intra-abdominal colectomy
PPX 4590	Intestinal anastomosis, not otherwise specified
PPX 4591	Small-to-small intestinal anastomosis
PPX 4592	Anastomosis of small intestine to rectal stump
PPX 4593	Other small-to-large intestinal anastomosis
PPX 4594	Large-to-large intestinal anastomosis
PPX 4595	Anastomosis to anus
PPX 4601	Exteriorization of small intestine
PPX 4603	Exteriorization of large intestine
PPX 4610	Colostomy, not otherwise specified
PPX 4611	Temporary colostomy
PPX 4613	Permanent colostomy
PPX 4620	Ileostomy, not otherwise specified
PPX 4621	Temporary ileostomy
PPX 4622	Continent ileostomy
PPX 4623	Other permanent ileostomy
PPX 4639	Other enterostomy
PPX 4642	Repair of pericolostomy hernia
PPX 4651	Closure of stoma of small intestine
PPX 4652	Closure of stoma of large intestine
PPX 4673	Suture of laceration of small intestine, except duodenum
PPX 4674	Closure of fistula of small intestine, except duodenum
PPX 4675	Suture of laceration of large intestine
PPX 4679	Other repair of intestine
PPX 4701	Laparoscopic appendectomy
PPX 4709	Other appendectomy
PPX 4849	Other pull-through resection of rectum
PPX 485	Other pull-through resection of rectum
PPX 4850	Abdominoperineal resection of the rectum, not otherwise specified
PPX 4851	Laparoscopic abdominoperineal resection of the rectum
PPX 4852	Open abdominoperineal resection of the rectum
PPX 4862	Anterior resection of rectum with synchronous colostomy
PPX 4863	Other anterior resection of rectum
PPX 4869	Other resection of rectum

PPX 4875	Abdominal proctopexy
PPX 4876	Other proctopexy
PPX 5022	Partial hepatectomy
PPX 5029	Other destruction of lesion of liver
PPX 503	Lobectomy of liver
PPX 5122	Cholecystectomy
PPX 5123	Laparoscopic cholecystectomy
PPX 5124	Laparoscopic partial cholecystectomy
PPX 5132	Anastomosis of gallbladder to intestine
PPX 5136	Choledochoenterostomy
PPX 5137	Anastomosis of hepatic duct to gastrointestinal tract
PPX 5141	Common duct exploration for removal of calculus
PPX 5151	Exploration of common duct
PPX 5252	Distal pancreatectomy
PPX 5259	Other partial pancreatectomy
PPX 526	Total pancreatectomy
PPX 527	Radical pancreaticoduodenectomy
PPX 5300	Unilateral repair of inguinal hernia, not otherwise specified
PPX 5301	Other and open repair of direct inguinal hernia
PPX 5302	Other and open repair of indirect inguinal hernia
PPX 5303	Other and open repair of direct inguinal hernia with graft or prosthesis
PPX 5304	Other and open repair of indirect inguinal hernia with graft or prosthesis
PPX 5305	Repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 5310	Bilateral repair of inguinal hernia, not otherwise specified
PPX 5311	Other and open bilateral repair of direct inguinal hernia
PPX 5313	Other and open bilateral repair of inguinal hernia, one direct and one indirect
PPX 5314	Other and open bilateral repair of direct inguinal hernia with graft or prosthesis
PPX 5315	Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis
PPX 5316	Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis
PPX 5317	Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified
PPX 5321	Unilateral repair of femoral hernia with graft or prosthesis
PPX 5329	Other unilateral femoral herniorrhaphy
PPX 5341	Other and open repair of umbilical hernia with graft or prosthesis
PPX 5349	Other open umbilical herniorrhaphy
PPX 5351	Incisional hernia repair
PPX 5359	Repair of other hernia of anterior abdominal wall
PPX 5361	Other open incisional hernia repair with graft or prosthesis
PPX 5369	Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis
PPX 537	Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis
PPX 5372	Other and open repair of diaphragmatic hernia, abdominal approach
PPX 5451	Laparoscopic lysis of peritoneal adhesions
PPX 5459	Other lysis of peritoneal adhesions
PPX 5493	Creation of cutaneoperitoneal fistula
PPX 7072	Repair of colovaginal fistula
PPX 7073	Repair of rectovaginal fistula
PPX 7074	Repair of other vaginoenteric fistula

Table 2. Complete balance table for Early Era (2003-2005)

Variable	Black Patients	Tapered Matches			White Patients (unmatched)
		Presentation + Procedure + Demographics	Procedure + Demographics	Demographics	
N	6,752	6,752	6,752	6,752	107,001
Age	75.99	75.84	75.98	75.99	77.48
Year of match	2005.12	2005.10	2005.12	2005.12	2005.12
Age 65-69 (%)	0.25	0.23	0.25	0.25	0.18
Age 70-74 (%)	0.24	0.25	0.25	0.24	0.21
Age 75-79 (%)	0.21	0.24	0.21	0.21	0.24
Age 80-84 (%)	0.16	0.17	0.16	0.16	0.21
Age 85 plus (%)	0.13	0.11	0.13	0.13	0.17
State- California (%)	0.23	0.23	0.23	0.23	0.25
State- New Jersey (%)	0.24	0.27	0.23	0.24	0.16
State- Florida (%)	0.34	0.34	0.34	0.34	0.35
State- Pennsylvania (%)	0.19	0.16	0.19	0.19	0.24
State- NJ/PA (%)	0.43	0.43	0.43	0.43	0.40
Male (%)	0.39	0.39	0.39	0.39	0.43
Year of match- 2004 (%)	0.22	0.23	0.22	0.22	0.22
Year of match- 2005 (%)	0.44	0.45	0.44	0.44	0.45
Year of match- 2006 (%)	0.34	0.32	0.34	0.34	0.33
Open and other cecectomy	0.01	0.01	0.01	0.01	0.01
Laparoscopic cholecystectomy	0.16	0.16	0.16	0.21	0.20
Open and other right hemicolectomy	0.14	0.14	0.14	0.11	0.12
Other anterior resection of rectum	0.01	0.01	0.01	0.02	0.02
Cholecystectomy	0.06	0.06	0.06	0.05	0.05
Open and other sigmoidectomy	0.05	0.05	0.05	0.06	0.07
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.00	0.00	0.00	0.01	0.01
Radical pancreaticoduodenectomy	0.01	0.01	0.01	0.01	0.01
Other partial resection of small intestine	0.06	0.06	0.06	0.05	0.05
Other lysis of peritoneal adhesions	0.06	0.06	0.06	0.05	0.05
Other resection of rectum	0.00	0.00	0.00	0.00	0.01
Other and open repair of indirect inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Distal pancreatectomy	0.00	0.00	0.00	0.00	0.00

Closure of stoma of small intestine	0.00	0.00	0.00	0.00	0.00
Other unilateral femoral herniorrhaphy	NR	NR	NR	0.00	0.00
Open and other left hemicolectomy	0.04	0.04	0.04	0.03	0.03
Other and unspecified partial excision of large intestine	0.01	0.01	0.01	0.01	0.01
Unilateral adrenalectomy	0.00	0.00	0.00	0.00	0.00
Abdominal proctopexy	NR	NR	NR	NR	0.00
Other gastroenterostomy without gastrectomy	0.01	0.01	0.01	0.01	0.01
Exteriorization of large intestine	0.01	0.01	0.01	0.01	0.01
Anterior resection of rectum with synchronous colostomy	0.00	0.00	0.00	0.00	0.00
Total splenectomy	0.00	0.00	0.00	0.01	0.01
Other procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	0.00	0.00
Other total gastrectomy	0.01	0.01	0.01	0.00	0.00
Other and unspecified partial excision of large intestine	0.02	0.02	0.02	0.02	0.02
Other pull-through resection of rectum	0.01	0.01	0.01	0.01	0.01
Other open umbilical herniorrhaphy	0.01	0.01	0.01	0.00	0.00
Laparoscopic appendectomy	0.01	0.01	0.01	0.02	0.02
Complete parathyroidectomy	0.00	0.00	0.00	NR	0.00
Incisional hernia repair	0.01	0.01	0.01	0.01	0.01
Temporary colostomy	0.00	0.00	0.00	NR	0.00
Repair of rectovaginal fistula	NR	NR	NR	NR	0.00
Other pull-through resection of rectum	NR	NR	NR	NR	0.00
Other destruction of lesion of liver	0.00	0.00	0.00	0.00	0.00
Small-to-small intestinal anastomosis	0.00	0.00	0.00	NR	0.00
Other open incisional hernia repair with graft or prosthesis	0.02	0.02	0.02	0.03	0.03
Partial esophagectomy	NR	NR	NR	0.00	0.00
Laparoscopic gastroenterostomy	0.00	0.00	0.00	0.00	0.00

Open and other resection of transverse colon	0.01	0.01	0.01	0.01	0.01
Exteriorization of small intestine	0.00	0.00	0.00	0.00	0.00
Other enterostomy	0.01	0.01	0.01	0.00	0.00
Unilateral thyroid lobectomy	0.02	0.02	0.02	0.01	0.01
Complete thyroidectomy	0.02	0.02	0.02	0.01	0.01
Partial gastrectomy with anastomosis to duodenum	0.00	0.00	0.00	NR	0.00
Other and open repair of direct inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Other parathyroidectomy	0.02	0.02	0.02	0.01	0.01
Laparoscopic lysis of peritoneal adhesions	0.01	0.01	0.01	0.01	0.01
Lobectomy of liver	0.00	0.00	0.00	NR	0.00
Anastomosis of hepatic duct to gastrointestinal tract	NR	NR	NR	NR	0.00
Suture of laceration of large intestine	NR	NR	NR	NR	0.00
Repair of pericolostomy hernia	NR	NR	NR	0.00	0.00
Common duct exploration for removal of calculus	NR	NR	NR	NR	0.00
Total esophagectomy	NR	NR	NR	NR	0.00
Open and other partial gastrectomy	0.01	0.01	0.01	0.00	0.00
Partial hepatectomy	0.00	0.00	0.00	0.00	0.00
Esophagectomy, not otherwise specified	NR	NR	NR	0.00	0.00
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Laparoscopic procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	0.01	0.01
Closure of stoma of large intestine	0.00	0.00	0.00	0.01	0.01
Resection of vessel with replacement, other vessels of head and neck	0.00	0.00	0.00	0.00	0.00
Other repair of intestine	0.00	0.00	0.00	NR	0.00
Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00

Esophagomyotomy	0.00	0.00	0.00	NR	0.00
Other appendectomy	0.01	0.01	0.01	0.02	0.02
Local excision of other lesion or tissue of stomach	0.00	0.00	0.00	NR	0.00
Unilateral repair of femoral hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Ileostomy, not otherwise specified	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to jejunum	0.02	0.02	0.02	0.01	0.01
Other small-to-large intestinal anastomosis	0.00	0.00	0.00	NR	0.00
Other and open repair of indirect inguinal hernia	0.00	0.00	0.00	0.00	0.00
Repair of other hernia of anterior abdominal wall	0.01	0.01	0.01	0.00	0.00
Repair of inguinal hernia with graft or prosthesis, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Large-to-large intestinal anastomosis	0.00	0.00	0.00	0.00	0.00
Suture of duodenal ulcer site	0.01	0.01	0.01	0.01	0.01
Colostomy, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Creation of cutaneoperitoneal fistula	0.00	0.00	0.00	0.00	0.00
Open and other multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Closure of fistula of small intestine, except duodenum	NR	NR	NR	0.00	0.00
Multiple segmental resection of small intestine	0.00	0.00	0.00	0.00	0.00
Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Permanent colostomy	0.00	0.00	0.00	NR	0.00
Suture of gastric ulcer site	0.00	0.00	0.00	0.00	0.00
Excision of lesion of thyroid	NR	NR	NR	NR	0.00
Anastomosis of gallbladder to intestine	NR	NR	NR	NR	0.00
Other and open repair of umbilical hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Complete substernal thyroidectomy	0.00	0.00	0.00	NR	0.00

Exploration of common duct	NR	NR	NR	0.00	0.00
Other partial thyroidectomy	0.01	0.01	0.01	0.00	0.00
Suture of laceration of small intestine, except duodenum	0.01	0.01	0.01	0.01	0.00
Repair of colovaginal fistula	NR	NR	NR	NR	0.00
Other and open bilateral repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Other proctopexy	NR	NR	NR	0.00	0.00
Unilateral repair of inguinal hernia, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Other and open repair of direct inguinal hernia	0.00	0.00	0.00	0.00	0.00
Other permanent ileostomy	NR	NR	NR	0.00	0.00
Other pyloroplasty	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to esophagus	NR	NR	NR	NR	0.00
Total pancreatectomy	NR	NR	NR	NR	0.00
Choledochoenterostomy	0.00	0.00	0.00	0.00	0.00
Other partial pancreatectomy	NR	NR	NR	0.00	0.00
Bilateral repair of inguinal hernia, not otherwise specified	NR	NR	NR	0.00	NR
Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	NR	0.00
Partial substernal thyroidectomy	NR	NR	NR	NR	0.00
Other and open bilateral repair of direct inguinal hernia	NR	NR	NR	NR	0.00
Other repair of stomach	0.00	0.00	0.00	NR	0.00
Temporary ileostomy	NR	NR	NR	NR	0.00
Intestinal anastomosis, not otherwise specified	NR	NR	NR	0.00	NR
Other and open bilateral repair of inguinal hernia, one direct and one indirect	NR	NR	NR	NR	0.00
Anastomosis of small intestine to rectal stump	0.00	0.00	0.00	0.00	NR
Anastomosis to anus	NR	NR	NR	NR	0.00

Repair of other vaginoenteric fistula	NR	NR	NR	0.00	NR
Number of Comorbidities	5.81	5.67	5.27	5.14	5.27
Number of Comorbidities in Near Fine balance list of variables	0.38	0.33	0.48	0.46	0.46
Anesthesia Score	147.95	143.90	142.36	140.55	141.21
More than six comorbidities (%)	0.49	0.49	0.41	0.39	0.41
Congestive Heart Failure	0.26	0.26	0.22	0.20	0.22
Stroke	0.15	0.15	0.09	0.08	0.10
Seizure	0.02	0.02	0.01	0.01	0.01
Dementia	0.15	0.15	0.09	0.09	0.10
Alcohol abuse	0.03	0.03	0.02	0.02	0.02
Drug abuse	0.01	0.01	0.01	0.00	0.00
Past MI	0.09	0.08	0.09	0.10	0.10
Past Arrhythmia	0.25	0.25	0.29	0.28	0.30
Unstable Angina	0.05	0.03	0.04	0.04	0.04
Angina	0.08	0.06	0.08	0.08	0.08
Hypertension	0.90	0.90	0.78	0.79	0.79
Valvular Heart Disease	0.27	0.29	0.28	0.27	0.29
Chronic Lung Disease	0.27	0.27	0.30	0.29	0.30
Asthma	0.11	0.12	0.10	0.09	0.09
Liver Disease	0.16	0.15	0.14	0.13	0.13
Renal Dialysis	0.23	0.23	0.13	0.12	0.13
Renal Failure	0.16	0.15	0.08	0.07	0.08
Diabetes	0.47	0.46	0.29	0.29	0.29
Paraplegia	0.05	0.04	0.02	0.02	0.02
Collagen Vascular Disease	0.05	0.05	0.06	0.06	0.06
Coagulation disorders	0.00	NR	0.00	0.00	0.00
Thrombocytopenia	0.02	0.01	0.02	0.03	0.02
Congenital Coagulation disorder	0.06	0.05	0.06	0.06	0.06
Smoking History	0.07	0.05	0.09	0.09	0.09
Post Pulmonary Fibrosis	0.03	0.02	0.04	0.04	0.04
Cushing's disease	NR	NR	NR	NR	0.00
Graves' disease	0.01	0.01	0.01	0.01	0.01
Cancer	0.47	0.47	0.51	0.48	0.50
Abdominal Cancer	0.06	0.06	0.06	0.05	0.05
Hypothyroidism	0.15	0.12	0.23	0.22	0.22
Chronic Peptic Ulcer	0.01	0.01	0.01	0.00	0.00
AIDS	0.00	NR	NR	NR	0.00
Weight Loss	0.20	0.18	0.14	0.13	0.14
Sickle Cell Anemia	NR	NR	NR	NR	0.00

Any Comorbidity	0.99	0.99	0.98	0.98	0.98
Cardiac with CHF	0.56	0.56	0.55	0.54	0.56
Cardiac without CHF	0.49	0.49	0.51	0.50	0.52
Stroke/Paraplegia	0.16	0.16	0.10	0.09	0.10
Any Angina	0.12	0.08	0.11	0.11	0.11
Cancer/Abdominal Cancer	0.47	0.47	0.51	0.48	0.50
Chronic Lung/Asthma	0.32	0.32	0.34	0.33	0.33
Emergency type admission (%)	0.47	0.52	0.37	0.39	0.38
Transfer-in (%)	0.01	0.01	0.01	0.01	0.01

Note. NR, Not Reportable N<11

Table 3. Complete balance table for Recent Era (2013-2015)

Variable	Black Patients	Tapered Matches: Presentation + Procedure + Demographics	Tapered Matches: Procedure + Demographics	Tapered Matches: Demographics	White Patients (unmatched)
N	4,964	4,964	4,964	4,964	74,108
Age	75.46	75.01	75.45	75.46	77.03
Year of match	2014.10	2014.10	2014.10	2014.10	2014.10
Age 65-69 (%)	0.27	0.28	0.27	0.27	0.22
Age 70-74 (%)	0.25	0.28	0.26	0.25	0.23
Age 75-79 (%)	0.21	0.19	0.20	0.21	0.20
Age 80-84 (%)	0.14	0.14	0.15	0.14	0.17
Age 85 plus (%)	0.12	0.11	0.12	0.12	0.18
State- California (%)	0.24	0.24	0.24	0.24	0.28
State- New Jersey (%)	0.23	0.24	0.22	0.23	0.15
State- Florida (%)	0.34	0.34	0.34	0.34	0.35
State- Pennsylvania (%)	0.19	0.17	0.19	0.19	0.21
State- NJ/PA (%)	0.42	0.42	0.42	0.42	0.37
Male (%)	0.39	0.39	0.39	0.39	0.45
Year of match- 2013 (%)	0.23	0.23	0.23	0.23	0.23
Year of match- 2014 (%)	0.44	0.44	0.44	0.44	0.45
Year of match- 2015 (%)	0.33	0.33	0.33	0.33	0.33
Procedure type (%)					
Open and other cecectomy	0.01	0.01	0.01	0.00	0.00
Laparoscopic cholecystectomy	0.19	0.19	0.19	0.21	0.22
Open and other right hemicolectomy	0.08	0.08	0.08	0.06	0.07
Other anterior resection of rectum	0.01	0.01	0.01	0.02	0.02
Cholecystectomy	0.03	0.03	0.03	0.03	0.03
Open and other sigmoidectomy	0.03	0.03	0.03	0.05	0.05
Radical pancreaticoduodenectomy	0.01	0.01	0.01	0.01	0.01
Other partial resection of small intestine	0.07	0.07	0.07	0.06	0.06
Other lysis of peritoneal adhesions	0.05	0.05	0.05	0.04	0.04
Other resection of rectum	0.00	0.00	0.00	0.01	0.01
Other and open repair of indirect inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Distal pancreatectomy	0.00	0.00	0.00	0.01	0.01
Closure of stoma of small intestine	0.01	0.01	0.01	0.01	0.01

Other unilateral femoral herniorrhaphy	NR	NR	NR	0.00	0.00
Open and other left hemicolectomy	0.02	0.02	0.02	0.02	0.02
Unilateral adrenalectomy	0.01	0.01	0.01	0.00	0.00
Abdominal proctopexy	NR	NR	NR	0.00	0.00
Other gastroenterostomy without gastrectomy	0.01	0.01	0.01	0.00	0.00
Exteriorization of large intestine	0.01	0.01	0.01	0.01	0.01
Anterior resection of rectum with synchronous colostomy	0.00	0.00	0.00	0.00	0.00
Total splenectomy	0.00	0.00	0.00	0.01	0.01
Other procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	NR	0.00
Other total gastrectomy	0.00	0.00	0.00	NR	0.00
Other and unspecified partial excision of large intestine	0.01	0.01	0.01	0.01	0.01
Other open umbilical herniorrhaphy	0.00	0.00	0.00	0.00	0.00
Laparoscopic appendectomy	0.03	0.03	0.03	0.04	0.04
Complete parathyroidectomy	NR	NR	NR	NR	0.00
Incisional hernia repair	0.01	0.01	0.01	0.01	0.01
Temporary colostomy	NR	NR	NR	NR	0.00
Repair of rectovaginal fistula	NR	NR	NR	NR	0.00
Other pull-through resection of rectum	NR	NR	NR	NR	0.00
Other destruction of lesion of liver	0.00	0.00	0.00	NR	0.00
Small-to-small intestinal anastomosis	NR	NR	NR	NR	0.00
Other open incisional hernia repair with graft or prosthesis	0.02	0.02	0.02	0.03	0.03
Partial esophagectomy	NR	NR	NR	0.00	0.00
Laparoscopic gastroenterostomy	0.01	0.01	0.01	0.01	0.01
Open and other resection of transverse colon	0.01	0.01	0.01	0.01	0.01
Exteriorization of small intestine	0.00	0.00	0.00	0.00	0.00
Other enterostomy	0.00	0.00	0.00	NR	0.00

Unilateral thyroid lobectomy	0.01	0.01	0.01	0.00	0.00
Complete thyroidectomy	0.02	0.02	0.02	0.01	0.01
Partial gastrectomy with anastomosis to duodenum	NR	NR	NR	NR	0.00
Other and open repair of direct inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Other parathyroidectomy	0.01	0.01	0.01	0.00	0.00
Laparoscopic lysis of peritoneal adhesions	0.02	0.02	0.02	0.01	0.02
Lobectomy of liver	NR	NR	NR	0.00	0.00
Anastomosis of hepatic duct to gastrointestinal tract	NR	NR	NR	NR	0.00
Suture of laceration of large intestine	NR	NR	NR	NR	0.00
Repair of pericolostomy hernia	0.00	0.00	0.00	0.00	0.00
Common duct exploration for removal of calculus	NR	NR	NR	NR	0.00
Total esophagectomy	NR	NR	NR	NR	0.00
Open and other partial gastrectomy	0.01	0.01	0.01	0.00	0.00
Partial hepatectomy	0.00	0.00	0.00	0.00	0.01
Esophagectomy, not otherwise specified	NR	NR	NR	NR	0.00
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Laparoscopic procedures for creation of esophagogastric sphincteric competence	0.00	0.00	0.00	0.02	0.01
Closure of stoma of large intestine	0.01	0.01	0.01	0.01	0.01
Other repair of intestine	NR	NR	NR	NR	0.00
Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00
Esophagomyotomy	0.00	0.00	0.00	0.00	0.00
Other appendectomy	0.01	0.01	0.01	0.01	0.01
Local excision of other lesion or tissue of stomach	0.01	0.01	0.01	0.00	0.00
Unilateral repair of femoral hernia with graft or prosthesis	NR	NR	NR	0.00	0.00

Ileostomy, not otherwise specified	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to jejunum	0.01	0.01	0.01	0.01	0.01
Other small-to-large intestinal anastomosis	0.00	0.00	0.00	0.00	0.00
Other and open repair of indirect inguinal hernia	NR	NR	NR	NR	0.00
Repair of other hernia of anterior abdominal wall	0.01	0.01	0.01	0.01	0.01
Repair of inguinal hernia with graft or prosthesis, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Large-to-large intestinal anastomosis	NR	NR	NR	NR	0.00
Laparoscopic sigmoidectomy	0.02	0.02	0.02	0.03	0.02
Suture of duodenal ulcer site	0.01	0.01	0.01	0.01	0.01
Laparoscopic cecectomy	0.01	0.01	0.01	0.00	0.00
Open total intra-abdominal colectomy	0.01	0.01	0.01	0.00	0.01
Laparoscopic abdominoperineal resection of the rectum	NR	NR	NR	NR	0.00
Colostomy, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Creation of cutaneoperitoneal fistula	0.01	0.01	0.01	0.00	0.00
Laparoscopic total intra-abdominal colectomy	NR	NR	NR	NR	0.00
Laparoscopic right hemicolectomy	0.05	0.05	0.05	0.04	0.04
Open and other multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Open abdominoperineal resection of the rectum	0.00	0.00	0.00	0.00	0.00
Closure of fistula of small intestine, except duodenum	NR	NR	NR	NR	0.00
Multiple segmental resection of small intestine	0.00	0.00	0.00	NR	0.00
Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Internal fixation of bone without fracture reduction, tibia and fibula	0.00	0.00	0.00	0.00	0.00
Permanent colostomy	NR	NR	NR	NR	0.00

Suture of gastric ulcer site	0.01	0.01	0.01	0.01	0.00
Total removal of small intestine	NR	NR	NR	NR	0.00
Anastomosis of gallbladder to intestine	NR	NR	NR	NR	NR
Other and open repair of umbilical hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Complete substernal thyroidectomy	NR	NR	NR	NR	0.00
Exploration of common duct	NR	NR	NR	0.00	NR
Other partial thyroidectomy	0.00	0.00	0.00	NR	0.00
Suture of laceration of small intestine, except duodenum	NR	NR	NR	NR	0.00
Repair of colovaginal fistula	NR	NR	NR	NR	0.00
Other proctopexy	NR	NR	NR	0.00	0.00
Unilateral repair of inguinal hernia, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Other and open repair of direct inguinal hernia	NR	NR	NR	NR	0.00
Laparoscopic resection of transverse colon	0.00	0.00	0.00	0.00	0.00
Laparoscopic left hemicolectomy	0.01	0.01	0.01	0.01	0.01
Other laparoscopic partial excision of large intestine	0.00	0.00	0.00	0.00	0.00
Other permanent ileostomy	NR	NR	NR	NR	0.00
Other pyloroplasty	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to esophagus	NR	NR	NR	NR	0.00
Total pancreatectomy	NR	NR	NR	NR	0.00
Choledochoenterostomy	NR	NR	NR	NR	0.00
Other and open repair of diaphragmatic hernia, abdominal approach	NR	NR	NR	0.00	0.00
Abdominoperineal resection of the rectum, not otherwise specified	NR	NR	NR	NR	0.00
Other partial pancreatectomy	NR	NR	NR	NR	0.00
Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	0.00	0.00

Laparoscopic partial cholecystectomy	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	0.00	0.00
Partial substernal thyroidectomy	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified	NR	NR	NR	0.00	0.00
Laparoscopic multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Other and unspecified total intra-abdominal colectomy	NR	NR	NR	NR	0.00
Laparoscopic repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	NR	0.00
Other repair of stomach	NR	NR	NR	NR	0.00
Intestinal anastomosis, not otherwise specified	NR	NR	NR	NR	0.00
Laparoscopic repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Other and open bilateral repair of inguinal hernia, one direct and one indirect	0.00	0.00	0.00	0.00	NR
Anastomosis to anus	NR	NR	NR	NR	0.00
Continent ileostomy	0.00	0.00	0.00	0.00	NR
Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Substernal thyroidectomy, not otherwise specified	0.00	0.00	0.00	0.00	NR
Number of Comorbidities	6.63	6.51	5.96	5.85	6.00
Number of Comorbidities in Near Fine balance list of variables	0.63	0.62	0.76	0.76	0.76
Anesthesia Score	155.01	150.37	150.15	151.78	150.71

More than six comorbidities (%)	0.61	0.61	0.51	0.51	0.53
Congestive Heart Failure	0.26	0.26	0.18	0.18	0.19
Stroke	0.21	0.21	0.13	0.13	0.14
Seizure	0.05	0.03	0.03	0.02	0.02
Dementia	0.17	0.16	0.11	0.10	0.12
Alcohol abuse	0.03	0.03	0.03	0.03	0.03
Drug abuse	0.03	0.03	0.02	0.02	0.02
Past MI	0.11	0.10	0.10	0.10	0.11
Past Arrhythmia	0.32	0.31	0.32	0.32	0.35
Unstable Angina	0.03	0.02	0.02	0.02	0.02
Angina	0.06	0.05	0.05	0.05	0.05
Hypertension	0.93	0.93	0.85	0.85	0.85
Valvular Heart Disease	0.26	0.27	0.28	0.27	0.28
Chronic Lung Disease	0.27	0.27	0.28	0.27	0.28
Asthma	0.14	0.14	0.12	0.11	0.11
Liver Disease	0.21	0.20	0.20	0.20	0.20
Renal Dialysis	0.42	0.42	0.27	0.26	0.28
Renal Failure	0.14	0.13	0.07	0.05	0.06
Diabetes	0.51	0.51	0.34	0.33	0.33
Paraplegia	0.06	0.04	0.02	0.02	0.02
Collagen Vascular Disease	0.07	0.07	0.08	0.08	0.08
Coagulation disorders	0.00	0.00	0.01	0.01	0.01
Thrombocytopenia	0.04	0.03	0.04	0.03	0.04
Congenital Coagulation disorder	0.06	0.06	0.06	0.06	0.06
Smoking History	0.23	0.23	0.28	0.28	0.28
Post Pulmonary Fibrosis	0.03	0.02	0.03	0.03	0.03
Cushing's disease	NR	NR	NR	NR	0.00
Graves' disease	0.01	0.01	0.01	0.00	0.00

Note. NR, Not Reportable N<11

Table 4. Quality of Matches for Selected* Variables, Early Era (2003-2005)

Variable	**Black Patients** (n = 6,752)	**Tapered Matches** Presentation + Procedure + Demographics (n = 6,752)	Procedure + Demographics (n = 6,752)	Demographics (n = 6,752)	White Patients (unmatched) (n = 107,001)
State (%)					
California	23.2	23.2	23.2	23.2	**24.9**[c]
Florida	34.0	34.0	34.0	34.0	**35.5**[a]
New Jersey / Pennsylvania	42.8	42.8	42.8	42.8	**39.6**[c]
Year of Procedure (%)					
2004	21.7	22.7	21.7	21.7	21.6
2005	44.5	44.9	44.5	44.5	45.1
2006	33.8	32.4	33.8	33.8	33.3
Age at Procedure	76.0	75.8	76.0	76.0	**77.5**[c]
% Male	38.6	38.6	38.6	38.6	**43.1**[c]
Procedures (%)					
Laparoscopic cholecystectomy (5123)	15.8	15.8	15.8	**21.0**[c]	**19.9**[c]
Open right hemicolectomy (4573)	13.6	13.6	13.6	**11.3**[c]	**12.1**[c]
Lysis of peritoneal adhesion (5459)	6.2	6.2	6.2	**4.6**[c]	**4.6**[c]
Partial resection of small intestine (4562)	5.7	5.7	5.7	**4.6**[b]	**4.9**[b]
Open cholecystectomy (5122)	5.6	5.6	5.6	5.5	5.4
Selected Comorbidities (%)					
Hypertension	89.8	90.0	**78.3**[c]	**79.3**[c]	**79.5**[c]
Diabetes	46.5	46.5	**28.5**[c]	**29.3**[c]	**28.5**[c]
Congestive heart failure	25.8	25.7	**21.6**[c]	**20.3**[c]	**21.6**[c]
Renal dialysis	23.2	23.0	**13.1**[c]	**12.4**[c]	**13.4**[c]
Renal failure	15.6	15.4	**7.7**[c]	**7.1**[c]	**7.7**[c]
Paraplegia	4.8	**3.6**[c]	**1.8**[c]	**1.7**[c]	**1.9**[c]
Mortality Risk Score (prob)	0.078	0.078	**0.062**[c]	**0.056**[c]	**0.063**[c]
Emergency admission (%)	47.3	**51.6**[c]	**37.5**[c]	**38.6**[c]	**37.9**[c]
Transfer status (%)	0.9	1.0	0.9	**0.6**[a]	0.7
Anesthesia time (minutes)	148	**144**[c]	**142**[c]	**141**[c]	**141**[c]
Dual-eligible (%)	38.8	**12.0**[c]	**10.0**[c]	**9.7**[c]	**9.3**[c]
Neighborhood median household income ($)	23,658	**31,844**[c]	**32,359**[c]	**32,182**[c]	**31,729**[c]
Neighborhood high school graduate (%)	82.2	**88.6**[c]	**88.9**[c]	**88.9**[c]	**88.7**[c]
Neighborhood college graduate (%)	32.2	**39.7**[c]	**40.0**[c]	**40.0**[c]	**39.6**[c]

Notes. Bolded numbers represent significant differences [a]<0.005; [b]<0.01; [c]<0.001. *Complete balance tables with all variables are available in Appendix Table 2 for Early Era (2003-2005) patient matches. Dual-eligible is a beneficiary of both Medicare and Medicaid. Measures of patient socioeconomic status were obtained through the American Community Survey and are based on

neighborhood-level characteristics: median household income, percentage of high school graduates and percentage of college graduates.

Table 5. Readmission Outcomes for Black Study Population and 3 Matched White Populations: Early Era (2003-2005), Recent Era (2013, 2015), and the Difference-in-Difference between the Eras to Evaluate whether the Black-White Difference is Different in the Two Eras

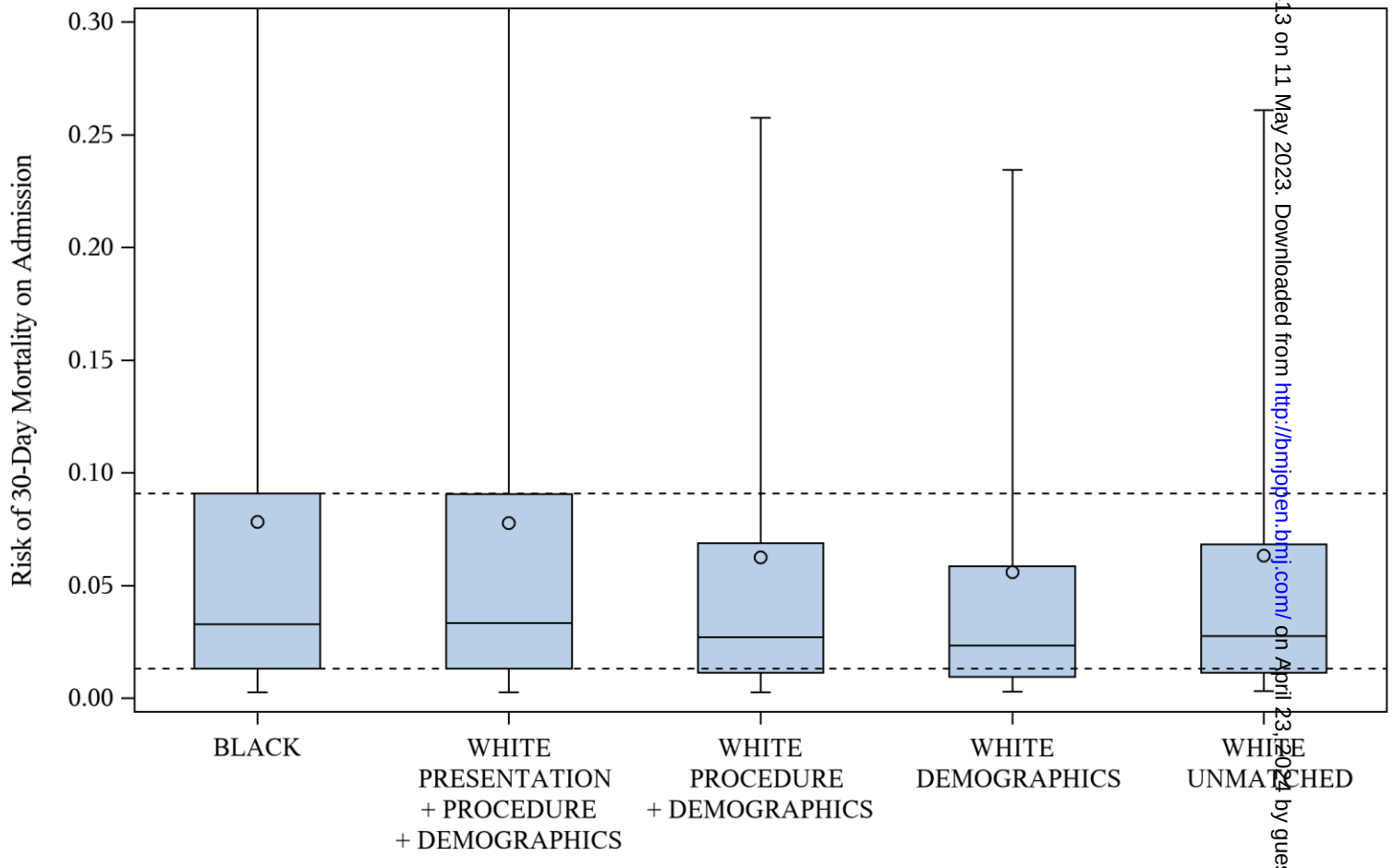
			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	30-day readmission (or death)	24.53	23.58	20.19***	19.12***
Recent Era (2013-2015)	30-day readmission (or death)	21.70	21.68	18.19***	18.39***
Difference in Difference (Recent - Early)	30-day readmission (or death)	--	-0.93%	-0.83%	-2.10%

Notes. Difference in difference is defined by the Black-White difference in Recent Era minus the Black-White difference in Early Era. Significance tests for binary variables used McNemar test (* <0.05, ** <0.01, ***<0.001). For the difference in difference across eras, Gart's test for binary outcomes was used (+ < 0.05, ++ < 0.01, +++ < 0.001). The symbols were marked in the later era if the difference in difference was significant.

Table 6. Effect of race and hospital nursing characteristics on odds of 30-day Readmission or Death, after matching patients on demographics, procedure, and presentation variables

Variables in the Model	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)
Black	1.04 (0.97-1.11)	1.05 (0.98-1.12)	1.00 (0.91-1.09)	0.99 (0.90-1.09)
Nursing Resources (High vs Low)	---	0.86 * (0.75-1.00)	0.86 * (0.75-1.00)	0.87 (0.74-1.01)
Nursing Resources (Middle vs Low)	---	0.93 (0.83-1.05)	0.93 (0.82-1.04)	0.93 (0.82-1.05)
Black*Nursing Resources (High vs Low) Interaction	—	—	0.93 (0.85-1.03)	0.94 (0.85-1.03)
Black*Nursing Resources (Middle vs Low) Interaction	—	—	0.95 (0.85-1.05)	0.95 (0.86-1.06)
Major Teaching Hospital	---	---	—	1.05 (0.90-1.22)
Minor Teaching Hospital	---	---	—	1.00 (0.89-1.13)
Large Size (>250 beds)	---	---	—	0.93 (0.83-1.05)
High Technology Hospital	---	---	—	1.07 (0.96-1.19)
General Surgery Volume	---	---	—	0.99 (0.98-1.01)
Test for improvement in fit with greater model complexity				
Chi-square	---	4.09	2.23	5.06
Degrees of Freedom	---	2	2	5
p-value	---	0.1295	0.3280	0.4085

Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Early Era (2003-2005)



Note. The tails of each box plot represent the lower 5% and upper 95% of the distribution. The mortality risk estimates presented here are based on risk at the time of admission.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State specific objectives, including any prespecified hypotheses	1
Methods			
Study design	4	Present key elements of study design early in the paper	2-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	2 & 3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3 & 4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	2
2Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	2 & 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	3 & 4
Statistical methods5	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	5

(e) Describe any sensitivity analyses

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	2
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	2
		(b) Indicate number of participants with missing data for each variable of interest	n/a
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*n/a*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*n/a*
		Cross-sectional study—Report numbers of outcome events or summary measures	*Tables 1 & 2*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 3
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	9 & 10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11 & 12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Title page, cover letter

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Explaining Racial Disparities in Surgical Survival: A Tapered Match Analysis of Patient and Hospital Factors

Karen B. Lasater, PhD, RN[1,2]

Paul R. Rosenbaum, PhD[3,4]

Linda H. Aiken, PhD, RN [1,2]

J. Margo Brooks Carthon, PhD RN[1,2]

Rachel R. Kelz, MD[2,5]

Joseph G. Reiter, MS[3]

Jeffrey H. Silber, MD, PhD [1,2,3,6,7,8]

Matthew D. McHugh, PhD, RN[1,2]

Affiliations:

[1]Center for Health Outcomes and Policy Research, School of Nursing, University of Pennsylvania, Philadelphia, PA USA

[2]The Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA

[3]Center for Outcomes Research, Children's Hospital of Philadelphia, Philadelphia, PA USA

[4]Department of Statistics and Data Science, The Wharton School, University of Pennsylvania, Philadelphia, PA USA

[5]Department of Surgery, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[6]Department of Pediatrics, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[7]Department of Anesthesiology and Critical Care, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[8]Department of Health Care Management, The Wharton School, University of Pennsylvania, Philadelphia, PA USA

Address Correspondence to: Karen B. Lasater. Center for Health Outcomes and Policy Research, University of Pennsylvania School of Nursing. 418 Curie Boulevard, Fagin Hall Philadelphia, PA 19104. (215) 746-8362. karenbl@nursing.upenn.edu

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ABSTRACT

Objectives. Evaluate whether hospital factors, including nurse resources, explain racial differences in Medicare Black and White patient surgical outcomes, and whether disparities changed over time.

Design. Retrospective tapered-match..

Setting. 571 hospitals at two time-points (Early Era 2003-2005; Recent Era 2013-2015).

Participants. 6,752 Black patients and 3 sets of 6,752 White controls selected from 107,001 potential controls (Early Era). 4,964 Black patients and 3 sets of 4,964 White controls selected from 74,108 potential controls (Recent Era).

Interventions. Black patients were matched to White controls on Demographics (age, sex, state, year of procedure), Procedure (Demographics variables plus 136 ICD-9 principal procedure codes), and Presentation (Demographics and Procedure variables plus 34 comorbidities, a mortality risk score, a propensity score for being Black, emergency admission, transfer status, predicted procedure time).

Outcomes. 30-day and 1-year mortality.

Results. Before matching, Black patients had more comorbidities, higher risk of mortality despite being younger, and underwent procedures at different percentages than White patients. Whites in the Demographics match had lower mortality at 30-days (5.6% vs 6.7% Early Era; 5.4% vs 5.7% Recent Era) and 1-year (15.5% vs 21.5% Early Era; 12.3% vs 15.9% Recent Era). Black-White 1-year mortality differences were equivalent after matching patients with respect to Presentation, Procedure, and Demographic factors. Black-White 30-day mortality differences were equivalent after matching on Procedure and Demographic factors. Racial disparities in outcomes remained unchanged between the two time periods spanning 10 years. All patients in

hospitals with better nurse resources had lower odds of 30-day (OR 0.60, 95% CI 0.46-0.78, p<0.010) and 1-year mortality (OR 0.77, 95% CI 0.65-0.92, p<0.010) even after accounting for other hospital factors.

Conclusions. Survival disparities among Black and White patients are largely explained by differences in Demographic, Procedure, and Presentation factors. Better nurse resources (e.g., staffing, work environment) were associated with lower mortality for all patients.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Tapered multivariate matching approach allows for sequentially matching Black patients to different sets of White patients to understand which patient and hospital-level factors contribute to the observed outcomes disparity.
- Measures of hospital nurse resources are derived directly from staff nurses
- Patient outcomes include 30-day and 1-year mortality and 30-day readmission
- Comorbidities used to match Black and White patients may be fallible markers of clinical severity and frailty

INTRODUCTION

Major National Academy of Medicine reports,[1, 2] document the existence of racial disparities in hospital outcomes. Worse outcomes among Black patients have been attributed to differences in illness severity,[3, 4] disparities in treatment,[5] and variation in hospital quality.[6, 7] Each of these factors is a function of structural racism arising out of long-standing discriminatory systems, policies, and institutions across sociopolitical domains including education, housing, criminal justice, and healthcare.[8] Although systematic differences in hospitals where patients receive care may contribute to disparities,[9-12] little evidence specifies exactly which hospital factors are associated with worse disparities.

We focus on a modifiable aspect of hospitals—nurse resources. An evaluation of the role of nurse resources is warranted since they vary widely across hospitals[13, 14] and a large literature shows that patients in hospitals where nurses care for fewer patients at a time, have a skill mix rich in registered nurses (RNs), high proportions of bachelors-educated nurses (BSNs), and a favorable nurse work environment, experience better outcomes including lower mortality.[14-17] Evidence suggests the survival benefits conferred by better nurse resources accrue to all patients; however, they may be particularly beneficial for Black patients.[18-21] Our motivation was to understand whether variation in hospital nurse resources differentially impact survival outcomes of Black and White patients following surgery, whether improving these resources hold promise as an interventional target for reducing racial disparities and improving outcomes; and whether racial disparities in surgical outcomes have improved or worsened over time.

METHODS

Design and Data Sources

This is a retrospective multivariate tapered matching study that uses secondary data of patients and hospitals at two cross-sections in time: 2003-2005 (i.e., Early Era) and 2013-2015 (i.e., Recent Era). Data about patients were obtained from Centers for Medicare and Medicaid Services. Data about hospitals were obtained from the American Hospital Association Annual Survey which provided information on hospital size, the Healthcare Cost Report Information System dataset which provided information on hospital teaching status, and the RN4CAST-US survey which provided information about hospital nurse resources. Time periods for the Early and Recent Era were selected based on the availability of the RN4CAST-US survey data.

Patient Population

The patient sample included non-Hispanic Black and non-Hispanic White Medicare fee-for-service beneficiaries, who were 65.5 years or older and who were admitted to one of the study hospitals for general surgery (Appendix Table 1) either between January 1, 2004–September 30, 2006, or January 1, 2013–September 30, 2015. Using race to characterize patients should not be interpreted as race representing innate biological differences. Race is a social construct; it reflects differences in experiences and exposure to systematic discrimination that produces observable harm and differences in health outcomes. Patient data included Research Identifiable Files: inpatient, outpatient, carrier (physician Part B), hospice, and the master beneficiary summary file. Patients were excluded if there was missing data on age or sex, had an invalid date

of death, or were enrolled in an HMO or lacked Part B coverage in the 6 months prior to their index hospitalization.

For patients with multiple admissions, the index hospitalization was defined by randomly selecting one admission. A 180-day look-back from the index admission was performed across all patient files to identify comorbidities. A 30-day mortality risk model to estimate each patient's probability of death at the time of admission was constructed using a 10% random sample of data that did not overlap with the analytic sample (Appendix Tables 2a and 2b). Propensity scores to be a Black individual were estimated using the covariates controlled in each match (Appendix Tables 3-4). Other characteristics included age, sex, transfer-in status, emergent admission, and 34 comorbidities.

Hospital Sample

The RN4CAST-US is a large panel survey of RNs, conducted at two points in time (i.e., 2005-2006; 2015-2016) in four large U.S. states: California, Florida, New Jersey, Pennsylvania. Both surveys employed the same methodology—a modified Dillman approach[22] to randomly sample actively licensed RNs from state licensure lists.[23] Nurses reported the name of their employer, demographics, and details about resources in their hospital, including patient-to-nurse staffing ratios, nurse skill mix, and the quality of the work environment. Our focus was adult, general, acute care hospitals in the four states.

Averages among RNs in the same hospitals were used to create aggregated hospital-level measures of nurse resources, consistent with prior research[15] and is a validated method of using

multiple informants to generate organizational measures.[23] Our hospital-level measure of staffing, i.e., patient-to-nurse ratios, is derived by taking the average number of patients per direct-care RN on medical-surgical units within the same hospital. Skill mix is the proportion of RNs to all nursing personnel (i.e., RNs, licensed practice nurses, unlicensed assistive personnel). Nurse education is the hospital proportion of RNs holding a BSN or higher. Nurse work environment is derived from the National Quality Forum-endorsed 31-item Practice Environment Scale of the Nursing Work Index, comprised of 5 subscales: Nurse Participation in Hospital Affairs; Nursing Foundations for Quality of Care; Nurse Manager Ability, Leadership and Support of Nurses; Staffing and Resource Adequacy; Collegial Nurse-Physician Relations.[24]

Hospital nurse resources are presented as a three-category variable characterized by terciles of hospitals according to their percentile ranking which ranged from 0% (poorest nurse resources) to 100% (best nurse resources) based on a coherence rank score.[25] This approach gives equal weight to the four nurse resources in computing the coherence rank score, as we have done in prior studies,[15, 26] since we had no a priori hypothesis that one resource would be more important to patient outcomes than another. The score describes how each hospital compared to others based on the four resources.[15, 26] Hospitals present in both eras were ranked twice, once in each era. Ranks were formed by comparing hospitals two at a time – which of the two hospitals is better? – and then aggregating the pairwise comparisons. If hospital *i* had better nurse resources on all measures than hospital *j*, it received 1 point; if hospital *i* had worse nurse resources than hospital *j*, it lost one point, or received −1 points; and if hospital *i* was better on some measures and worse on others, it received 0 points. The rank for hospital *i* is its total points, i.e., the

number of hospitals that were worse than hospital *i* minus the number that were better than hospital *i*.

Outcomes

30-day and 1-year mortality (defined as a death within 30 days and 1 year of admission, respectively). 30-day readmission (or death) outcomes are reported in the Appendix (Tables 5-6). Mortality and readmission outcomes were 'all-cause' and determined by data reported in the CMS patient files.

Statistical Analysis

Matching Methodology

The tapered multivariate matching approach[3, 27-30] sequentially matches the same Black patients to different sets of White patients, controlling for consecutively more variables to understand the contribution of various factors to the outcomes disparity.[27] The goal is to understand the extent of and factors driving the racial disparities in outcomes between Black and White patients. By incrementally matching White patients to Black patients on additional variables, we can directly observe how the matched White cohort changes with respect to their outcomes. Our tapered matching procedure includes three tapers (or sets of matches). First, the Demographics taper included variables for age, sex, state, and year of procedure. Second, the Procedure taper included all the variables from the Demographics taper and added ICD-9 principal procedure codes. Third, the Presentation taper included all the variables from the Procedure and Demographics tapers and added patient risk factors related to health status at the time of surgery, including 34 comorbidities, a mortality risk score, emergency admission, transfer status, and

predicted procedure time. Patients were exactly matched within era and state (with New Jersey and Pennsylvania combined), for 136 ICD-9 procedure codes, and mortality risk quintile (Appendix Tables 3-4). Fine balance and distance minimization techniques were used to make matched groups as similar as possible.

Statistical Methods

Comparisons within pairs used McNemar's test and conditional logit regression. We compared the Black-White difference in the Early and Late Eras to test whether the disparity changed over time. These analyses used Gart's test[31] to compare disparities in the Early Era to disparities in the Recent Era.[32] Conditional logit regression models were performed at the Presentation Match (i.e. using the White patient cohort that was similar to the Black patients with respect to Demographic, Procedure, and Presentation variables), and using data from both eras combined to test nurse resources, race, and combinations of their interactions, accounting for structural hospital characteristics (i.e., size, teaching status, technology capabilities, general surgery volume). Hospital size was defined as large (>250 beds), medium (101-250 beds), or small (≤100 beds). Teaching status was defined by the medical resident to beds (RB) ratio (nonteaching: 0 RB; minor teaching: >0 RB and ≤0.25 RB; major teaching: >0.25 RB). A high technology hospital was defined as having the capability to perform major organ transplantation and/or open-heart surgery. General surgery volume was defined as a continuous measure of the number of general surgical cases per 100 patients in each hospital during the study period.

Patient and Public Involvement

This is a retrospective study of patient claims data and thus there was no participation consent for patients. Nurses consented to participation in the RN4CAST-US by completing the survey.

RESULTS

Quality of Patient Matches

The matches are shown in Table 1 (Recent Era) and Appendix Table 7 (Early Era). Table 1 describes 4,964 Black patients and 3 sets of 4,964 White controls—selected from a population of 74,108 White patients. In each taper, White controls become more like the Black patients. Matched variables (i.e., left of the zigzag line) were similar: the standardized differences in means never exceeded 0.11 SDs. Unmatched variables (i.e., right of the zigzag line) show the disparity prior to matching. Comparisons in the Demographic match reveal differences in the types of procedures Black and White patients receive. For example, Black patients underwent a laparoscopic cholecystectomy less(18.9%) than White patients (21.3%, $p<0.01$). Black patients had more comorbidities, and in some cases were much more likely to have a chronic condition such as diabetes (51.3% vs 32.8%), despite being 1.5 years younger on average. The Demographics match removed age, sex, state, and year of procedure differences, the Procedure match included Demographics match variables and removed differences in procedures, and the Presentation match included all Demographics and Procedure variables and further matched on variables reflecting health status by selecting White controls that had similar mortality risk and comorbidity burden as Black patients. The cohort of White patients in the Presentation match are different than the 'unmatched' White patients, in that the White patients in the Presentation match have a substantially higher burden of comorbidities that are more comparable to the burden of comorbidities observed in the Black population.

We made no attempt to match on measures of socioeconomic status (SES), including dual-eligibility, and neighborhood-level socioeconomic variables (i.e., median household income, percentage of high school graduates, percentage of college graduates) because socioeconomic status variables are highly correlated with race in the U.S. Black patients were nearly 4 times more likely to be dual-eligible compared with unmatched Whites, and more likely to live in neighborhoods with markers of lower SES. After matching on Demographic, Procedure, and Presentation variables, White controls looked more like Black patients with respect to SES indicators, however large and important differences remained (e.g., 37.4% Black patients were dual-eligible vs 14.8% of White controls, $p<0.001$).

Table 1. Quality of Matches for Selected* Variables, Recent Era (2013-2015)

Variable	Black Patients	Tapered Matches: Presentation + Procedure + Demographics	Tapered Matches: Procedure + Demographics	Tapered Matches: Demographics	White Patients (unmatched)
	(n = 4,964)	(n = 4,964)	(n = 4,964)	(n = 4,964)	(n = 74,108)
State (%)					
California	24.3	24.3	24.3	24.3	**27.8**[c]
Florida	34.1	34.1	34.1	34.1	35.4
New Jersey / Pennsylvania	41.6	41.6	41.6	41.6	**36.8**[c]
Year of Procedure (%)					
2013	23.1	23.2	23.1	23.1	22.9
2014	43.7	43.7	43.7	43.7	44.6
2015	33.2	33.1	33.2	33.2	32.6
Age at Procedure	75.5	**75.0**[b]	75.4	75.5	**77.0**[c]
% Male	39.3	39.3	39.3	39.3	**44.7**[c]
Procedures (%)					
Laparoscopic cholecystectomy (5123)	18.9	18.9	18.9	**21.3**[b]	**21.6**[c]
Open right hemicolectomy (4573)	7.6	7.6	7.6	**6.4**[a]	**6.6**[b]
Partial resection of small intestine (4562)	7.0	7.0	7.0	**5.7**[a]	**5.6**[c]
Laparoscopic right hemicolectomy (1733)	4.8	4.8	4.8	4.3	4.4
Open cholecystectomy (5122)	3.1	3.1	3.1	3.2	3.3
Selected Comorbidities (%)					
Hypertension	93.2	93.3	**84.9**[c]	**84.7**[c]	**85.1**[c]
Diabetes	51.3	51.1	**33.7**[c]	**32.6**[c]	**32.8**[c]
Congestive heart failure	26.1	25.9	**18.0**[c]	**18.2**[c]	**19.4**[c]
Renal dialysis	42.2	41.7	**26.9**[c]	**26.1**[c]	**28.4**[c]
Renal failure	14.0	6.5	**5.5**[c]	**5.7**[c]	**4.1**[c]
Paraplegia	6.1	**4.5**[c]	**2.1**[c]	**2.1**[c]	**2.1**[c]
Mortality Risk Score (prob)	0.069	0.067	**0.055**[c]	**0.050**[c]	**0.056**[c]
Emergency admission (%)	56.9	58.4	**50.2**[c]	**50.2**[c]	**50.5**[c]
Transfer status (%)	1.1	1.0	0.9	0.9	**0.8**[a]
Anesthesia time (minutes)	155	**150**[c]	**150**[c]	**152**[c]	**151**[c]
Dual-eligible (%)	37.4	**14.8**[c]	**11.7**[c]	**10.6**[c]	**10.4**[c]
Neighborhood median household income ($)	24,267	**32,070**[c]	**32,970**[c]	**32,843**[c]	**32,755**[c]
Neighborhood high school graduate (%)	83.2	**88.8**[c]	**89.3**[c]	**89.2**[c]	**89.2**[c]
Neighborhood college graduate (%)	32.8	**39.9**[c]	**40.9**[c]	**40.9**[c]	**40.9**[c]

Notes. The zigzag diagonal line indicates which variables are controlled in each match: variables to the right of the line are not controlled. The table shows only a few of the variables, – in particular, a few of the surgical procedures – that were controlled in each match. Bolded numbers represent significant differences [a]<0.005; [b]<0.01; [c]<0.001. *The complete balance

tables with all variables are available in Appendix Table 4 for Recent Era (2013-2015) patient matches. Dual-eligible is a beneficiary of both Medicare and Medicaid. Measures of patient socioeconomic status were obtained through the American Community Survey and are based on neighborhood-level characteristics: median household income, percentage of high school graduates and percentage of college graduates.

Figure 1 demonstrates differences in Black and White patients' estimated mortality risk on admission prior to matching (i.e., White Unmatched) and at each taper of the match. The largest disparity in estimated mortality risk is observed in the Demographics match—likely because this match requires patients to be the same on age and sex, which selects for White controls who were 1.5 years younger than the typical White patient and fewer males. As we move through the tapers, the racial disparity in estimated mortality risk narrows. The result of the matching process is a White control group that is profoundly different than the initial White population. Appendix Figure 1 presents comparisons in the Early Era with similar findings.

Outcome Results

Mortality outcomes for Black patients and the 3 sets of White controls are reported in Table 2. In the Early and Recent Eras, after matching White controls with similar demographics as the Black cohort (i.e., Demographics match), we observe higher 1-year mortality among Black patients. 1-year mortality differences narrow after matching on procedure but remain significantly higher among Black patients. After selecting White controls that presented as sick as Black patients (i.e., Presentation match), 1-year mortality differences become statistically insignificant. 30-day mortality differences diminished after matching on Procedure. The bottom most panel of Table 2 reports whether the Black-White difference changed over time , defined by the Black-White difference in the Recent Era minus the Black-White difference in the Early Era. Survival disparities did not change significantly over the two eras separated by 10 years. Survival curves

of Black patients and White controls are presented in Figure 2. In the Early and Recent Eras, White controls at the Presentation Match had the lower probability of survival in the time-period most proximal to hospital admission; however, at 1-year from hospitalization Black patients had lower survival odds. The mortality in White control groups changed significantly as more covariates were controlled in all cases, except the move from the Demographics control group to the Demographics + Procedure control group in the Recent Era, where the difference in mortality at 30-days and 1-year was not significant (Appendix Table 8).

Table 2. Mortality Outcomes for Black Study Population and 3 Matched White Populations: Early Era (2003-2005), Recent Era (2013, 2015), and the Difference between the Eras to Evaluate whether the Black-White Difference is Different in the Two Eras

			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	1-year mortality	21.45%	20.51%	17.54%***	15.52%***
	30-day mortality	6.71%	7.81%**	6.47%	5.60%**
Recent Era (2013-2015)	1-year mortality	15.87%	16.16%	12.99%***	12.29%***
	30-day mortality	5.70%	7.88%***	5.74%	5.42%
Difference in Difference (Recent - Early)	1-year mortality	--	-1.23%	-1.03%	-2.35%
	30-day mortality	--	-1.08%	-0.28%	-0.83%

Note. Black-White difference between eras is defined by the Black-White difference in Recent Era minus the Black-White difference in Early Era. Significance tests for binary variables used McNemar test (* <0.05, ** <0.01, ***<0.001). For the difference in difference across eras, Gart's test for binary outcomes was used (+ < 0.05, ++ < 0.01, +++ < 0.001). The symbols were marked in the later era if the difference in difference was significant.

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Conditional logit models further analyze Black-White patient pairs (Table 3). These models attempt to tease apart race, nurse resources, their interaction, and other hospital attributes. Model 1a is like the Table 2 Presentation Match in which Black patients have lower odds of 30-day mortality (OR 0.77, 95% CI 0.69-0.85, p <0.001). In Model 2a, high nurse resources are associated with substantially lower mortality (OR 0.58, 95% CI 0.46-0.74, p<0.001), and this pattern appears to be the same or nearly so for Black and White patients. As in Table 2, 1-year mortality outcomes are not significantly different among Black and White patients who were matched on Demographic, Procedure, and Presentation characteristics (Models 1b-4b). High nurse resources are strongly associated with lower 1-year mortality (Model 2b), apparently in the same way for Blacks and Whites (Model 3c), persisting even after adjusting for hospital-level characteristics (Model 4b). Findings were similar for 30-day readmission (Appendix Table 6).

The simplest model that fits well includes race and nurse resources (Models 2a and 2b). The addition of interactions between race and nurse resources or additional hospital attributes did not improve the model. This is evident in the test-statistics reported in the bottom of Table 3 which describe the improvement in fit for each model compared to the prior model. P-values greater than 0.05 mean we fail to reject the simpler model in favor of the more complex model.

Table 3. Effect of Race and Hospital Nurse Resources on 30-day and 1-year Mortality Odds, After Matching Patients on Demographics, Procedure, and Presentation Variables

	30-day mortality				1-year mortality			
	Model 1a	Model 2a	Model 3a	Model 4a	Model 1b	Model 2b	Model 3b	Model 4b
Variables in the Model	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Black (vs. White)	0.77*** (0.69-0.85)	0.79*** (0.71-0.88)	0.75*** (0.64-0.87)	0.75*** (0.64-0.88)	1.03 (0.96-1.11)	1.05 (0.98-1.13)	1.05 (0.95-1.17)	1.05 (0.94-1.16)
Nurse Resources (High vs Low)	---	0.58*** (0.46-0.74)	0.59*** (0.46-0.74)	0.60** (0.46-0.78)	---	0.75*** (0.64-0.88)	0.75*** (0.64-0.88)	0.77** (0.65-0.92)
Nurse Resources (Middle vs Low)	---	0.83 (0.68-1.00)	0.82* (0.68-1.00)	0.83 (0.68-1.01)	---	0.91 (0.80-1.03)	0.91 (0.80-1.03)	0.91 (0.80-1.04)
Black*Nurse Resources (High vs Low)	---	---	0.91 (0.78-1.07)	0.92 (0.78-1.08)	---	---	1.01 (0.90-1.13)	1.02 (0.91-1.13)
Black*Nurse Resources (Middle vs Low)	---	---	0.95 (0.80-1.13)	0.95 (0.80-1.13)	---	---	0.99 (0.88-1.11)	0.99 (0.88-1.11)
Major Teaching Hospital	---	---	—	0.93 (0.72-1.21)	---	---	—	0.97 (0.82-1.15)
Minor Teaching Hospital	---	---	—	0.97 (0.80-1.18)	---	---	—	1.03 (0.90-1.17)
Large Size (>250 beds)	---	---	—	0.98 (0.81-1.19)	---	---	—	0.97 (0.85-1.10)
High Technology Hospital	---	---	—	1.08 (0.90-1.29)	---	---	—	1.07 (0.94-1.21)
General Surgery Volume, per 100 patients	---	---	—	0.99 (0.96-1.01)	---	---	—	0.99 (0.97-1.00)
Test for improvement in fit with greater model complexity								
Chi-square	---	20.03	1.25	1.80	---	12.4[illegible]	0.13	4.94
Degrees of Freedom	---	2	2	5	---	2	2	5
p-value	---	< 0.0001	0.5350	0.8756	---	0.0020	0.9363	0.4227

Note. Conditional logit models show the effects of race and hospital nurse resources for pairs of Black and White patients who have been closely matched on demographic characteristics (age, sex, state, year of procedure), procedure (ICD-9 principal procedure code), and presentation (34 comorbidities, mortality risk score, propensity score for being Black, emergency admission indicator, transfer status indicator, predicted procedure time). Data from both eras are combined in this analysis. Nurse resources represent a three-category variable characterized by terciles of hospitals according to their percentile ranking. The general surgery volume variable

represents the effect of a 100-patient increase in general surgery volume on patient odds of 30-day mortality. *p<0.05; **p<0.01; ***p<0.001**.** Summary: High levels of nursing resources were associated with substantially lower mortality for both Black and White patients, with no indication of interaction.

DISCUSSION

Study results reveal outcomes disparities are largely explained by significant differences in clinical presentation between Black and White patients. Among Black and White patients matched for Demographics (i.e., age, sex, state, year of procedure), we found significantly higher 30-day and 1-year mortality among Black patients. This is consistent with prior evidence of racial outcomes disparities in surgical patients.[2, 33, 34] Black patients in our sample had a heavier burden of comorbidity and mortality risk than White patients. Despite being younger, Black patients had more comorbidities, more emergency admissions, and higher mortality risk upon admission. Black patients also underwent procedures at different percentages. Only after closely matching patients to account for these differences did the mortality advantage for White controls disappear.

Our research is not the first to find higher mortality among White patients after accounting for racial differences in clinical presentation.[3, 4, 18, 35-37] Cumulative effects of centuries of systematic discrimination in virtually all domains of life (e.g., education, housing, criminal justice, policy benefits, job opportunities, pay, political power, access to high quality healthcare) underlie observable clinical presentation differences. Thus, system-level reforms across these domains are necessary to begin to undo the harms generating differences in health status and survival outcomes.

Our second major finding is that surgical disparities—at least for general surgeries—have not narrowed overtime. This is in contrast to what Mehtsun and colleagues found[38]—though that

analysis focused on 8 procedures and included orthopedic and vascular surgeries. In our study, we found that while mortality and readmissions were lower in the Recent Era (2013-2015) for both Black patients and White controls, the differences between the two groups remained unchanged overtime.

Our third major finding is that differences in hospitals are a significant contributor to variation in outcomes for all surgical patients, both Black and White. Specifically, receiving care in hospitals with better nurse resources was associated with lower odds of death, even after accounting for other hospital factors (i.e., teaching status, technology capability, size, surgery volume). Being in a hospital with high nurse resources predicted a much larger reduction in mortality than did race. High nurse resources predicted lower mortality for both Black and White patients, to the same or similar degree. Some research has shown that nurse resource deficiencies result in even worse outcomes for Black patients,[18-21] but perhaps this difference is a function of our use of a composite measure which simultaneously evaluates all four aspects of nurse resources versus isolating the effect of a single resource; other investigations focused mainly on nurse staffing.

That our results suggest that better nurse resources, as opposed to other hospital factors are associated with higher survival outcomes, is important. Whereas the other hospital factors we measured here are difficult to modify, nurse resources are modifiable through actions of hospital administrators or policy intervention. Hospital administrators can make it their strategic priority to staff greater numbers of nurses, including higher proportions of BSN-prepared nurses and a richer skill mix of RNs, and well as improve their nurse work environments via management reforms and evidence-based interventions like the American Nurses Credentialling Center

Magnet® Program.[39, 40] At the policy-level, states can follow the example of California—the first and only state to legislate hospitals hire enough nurses to safely care for patients. The result of this policy has improved nurse staffing ratios and made more even the staffing variability across the state.[41, 42] Recent studies show wide variation in the average nurse staffing ratios within states,[13, 43] ranging from 3.3 to 9.7 patients-per-nurse on medical-surgical units.[13] If other states followed California's example by enacting minimum safe nurse staffing policies, it would raise the floor on hospital nurse staffing while making more even the variability across hospitals.

Limitations

Despite carefully matching on demographic, procedure, and presentation differences, we are unable to account for possible within-hospital differences experienced by Black and White patients, for example, the possibility of selection bias wherein surgeons may be less likely to operate on Black patients compared to similarly ill White patients.[5, 44] Thus, our analysis of surgical patients may include somewhat healthier Black patients than their matched White controls. Comorbidities utilized for matching patients may be fallible markers of clinical severity and frailty or have within-category variation leading to residual differences in presentation despite careful and comprehensive matching. Next, although we use the White population as the reference group, it should not be interpreted that the White population's outcomes are the ideal referent or the best that could be achieved in terms of outcomes for Black patients. Studies using other referent groups (e.g., not-low-SES White[45, 46]) would be useful, as would research within the Black population alone to understand possible strengths that could be leveraged to improve outcomes that may be unique to the population. Finally, our tapered-matched design makes transparent the comparisons between Black and White patients and shows that the Black-White

survival disparity is largely explained by differences in Demographic, Procedure and Presentation factors. It is possible; however, that unmeasured confounders may be important to further investigate health disparities after discharge, which we did not do in this study but could be relevant to survival outcomes over a year following surgery.

Conclusions

In summary, there is a large racial disparity in mortality among Medicare patients undergoing general surgery. Black and White patients present differently even when undergoing the same procedure. Despite being younger, Black patients are more likely to have higher comorbidity burden and greater risk of mortality. We found racial outcomes disparities following surgery have not improved over the decade, but organizational and policy reform have the potential to improve outcomes for Black and White patients alike. Even after accounting for demographic, procedure, and presentation differences, better nurse resources—a modifiable feature of hospitals—were significantly associated with improved survival for both Black and White patients.

Ethics Approval Statement

This study was approved by the Children's Hospital of Philadelphia Institutional Review Board (19-016296).

Contributorship Statement

All authors meet the criteria recommended by the International Committee of Medical Journal Editors (ICMJE). PRR, LHA, JMBC, RRK, JHS, and MDM contributed to the original idea and design of the study. KBL, LHA, JMBC, and MDM contributed to the collection of nurse survey data. JGR conducted the data analysis. All authors contributed to the interpretation of the data and preparation of the submitted manuscript. All authors approved the submitted manuscript.

Competing Interests

None declared.

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Data Sharing Statement

The nurse survey data are not available. The patient data are from the Centers for Medicare and Medicaid Services and approval for their use can be requested directly from CMS.

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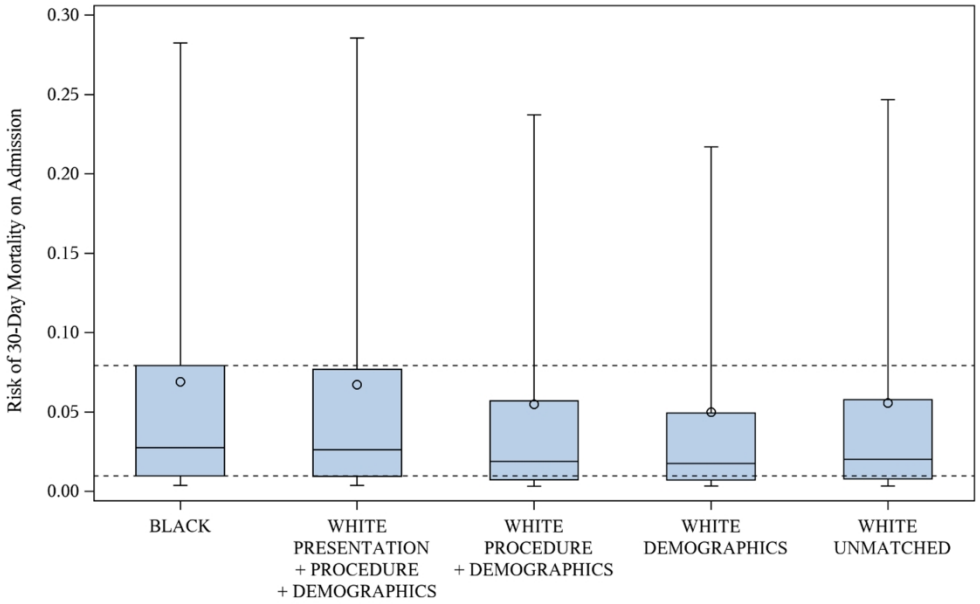
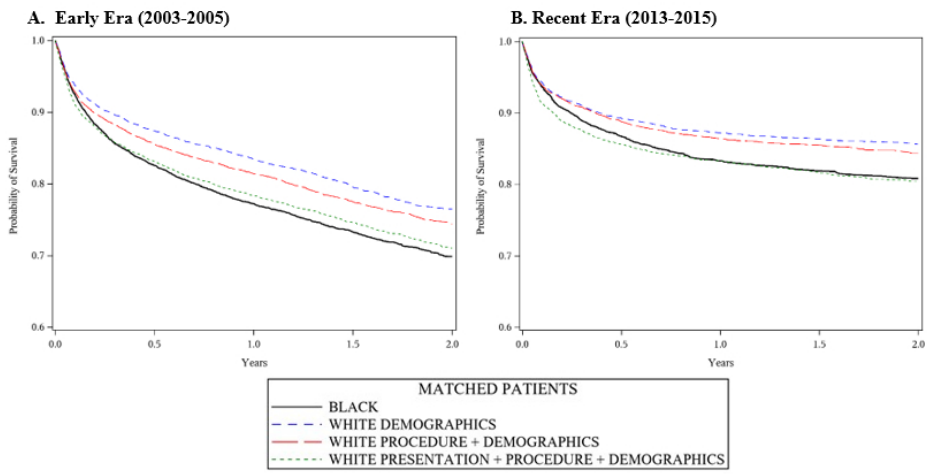
Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Recent Era (2013-2015)



Note. The tails of each box plot represent the lower 5% and upper 95% of the distribution. The mortality risk estimates presented here are based on risk at the time of admission. Early Era results look similar and are presented in Appendix Figure 1. Summary: Until matched for surgical procedure and comorbid conditions in the "White Presentation" match, Black patients had a combination of surgical procedures and comorbid conditions that placed them at elevated risk of death compared to White controls.

Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Recent Era (2013-2015)



Summary. The substantially higher mortality among Black patients is most evident over a longer span of time, is not concentrated in the brief period around surgery, and reflects a greater burden of comorbid conditions and a more frequent need for higher risk procedures. Black and White patients had lower mortality in the Recent Era (2013-2015), but there is no clear indication that the Black-White disparity has diminished.

Figure 2. Kaplan-Meier Plot for Survival for Black Study Population and 3 Matched White Populations

APPENDIX

Table 1. List of General Surgical Procedures on Which Black and White Patients Were Exact Matched

Procedure Code	Procedure Name
PPX 062	Unilateral thyroid lobectomy
PPX 0631	Excision of lesion of thyroid
PPX 0639	Other partial thyroidectomy
PPX 064	Complete thyroidectomy
PPX 0650	Substernal thyroidectomy, not otherwise specified
PPX 0651	Partial substernal thyroidectomy
PPX 0652	Complete substernal thyroidectomy
PPX 0681	Complete parathyroidectomy
PPX 0689	Other parathyroidectomy
PPX 0722	Unilateral adrenalectomy
PPX 1711	Laparoscopic repair of direct inguinal hernia with graft or prosthesis
PPX 1712	Laparoscopic repair of indirect inguinal hernia with graft or prosthesis
PPX 1713	Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 1721	Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis
PPX 1722	Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis
PPX 1723	Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis
PPX 1724	Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 1731	Laparoscopic multiple segmental resection of large intestine
PPX 1732	Laparoscopic cecectomy
PPX 1733	Laparoscopic right hemicolectomy
PPX 1734	Laparoscopic resection of transverse colon
PPX 1735	Laparoscopic left hemicolectomy
PPX 1736	Laparoscopic sigmoidectomy
PPX 1739	Other laparoscopic partial excision of large intestine
PPX 415	Total splenectomy
PPX 4240	Esophagectomy, not otherwise specified
PPX 4241	Partial esophagectomy
PPX 4242	Total esophagectomy
PPX 427	Esophagomyotomy
PPX 4342	Local excision of other lesion or tissue of stomach
PPX 435	Partial gastrectomy with anastomosis to esophagus
PPX 436	Partial gastrectomy with anastomosis to duodenum
PPX 437	Partial gastrectomy with anastomosis to jejunum
PPX 4389	Open and other partial gastrectomy
PPX 4399	Other total gastrectomy
PPX 4429	Other pyloroplasty
PPX 4438	Laparoscopic gastroenterostomy
PPX 4439	Other gastroenterostomy without gastrectomy
PPX 4441	Suture of gastric ulcer site
PPX 4442	Suture of duodenal ulcer site
PPX 4466	Other procedures for creation of esophagogastric sphincteric competence

PPX 4467	Laparoscopic procedures for creation of esophagogastric sphincteric competence
PPX 4469	Other repair of stomach
PPX 4561	Multiple segmental resection of small intestine
PPX 4562	Other partial resection of small intestine
PPX 4563	Total removal of small intestine
PPX 4571	Open and other multiple segmental resection of large intestine
PPX 4572	Open and other cecectomy
PPX 4573	Open and other right hemicolectomy
PPX 4574	Open and other resection of transverse colon
PPX 4575	Open and other left hemicolectomy
PPX 4576	Open and other sigmoidectomy
PPX 4579	Other and unspecified partial excision of large intestine
PPX 458	Other and unspecified partial excision of large intestine
PPX 4581	Laparoscopic total intra-abdominal colectomy
PPX 4582	Open total intra-abdominal colectomy
PPX 4583	Other and unspecified total intra-abdominal colectomy
PPX 4590	Intestinal anastomosis, not otherwise specified
PPX 4591	Small-to-small intestinal anastomosis
PPX 4592	Anastomosis of small intestine to rectal stump
PPX 4593	Other small-to-large intestinal anastomosis
PPX 4594	Large-to-large intestinal anastomosis
PPX 4595	Anastomosis to anus
PPX 4601	Exteriorization of small intestine
PPX 4603	Exteriorization of large intestine
PPX 4610	Colostomy, not otherwise specified
PPX 4611	Temporary colostomy
PPX 4613	Permanent colostomy
PPX 4620	Ileostomy, not otherwise specified
PPX 4621	Temporary ileostomy
PPX 4622	Continent ileostomy
PPX 4623	Other permanent ileostomy
PPX 4639	Other enterostomy
PPX 4642	Repair of pericolostomy hernia
PPX 4651	Closure of stoma of small intestine
PPX 4652	Closure of stoma of large intestine
PPX 4673	Suture of laceration of small intestine, except duodenum
PPX 4674	Closure of fistula of small intestine, except duodenum
PPX 4675	Suture of laceration of large intestine
PPX 4679	Other repair of intestine
PPX 4701	Laparoscopic appendectomy
PPX 4709	Other appendectomy
PPX 4849	Other pull-through resection of rectum
PPX 485	Other pull-through resection of rectum
PPX 4850	Abdominoperineal resection of the rectum, not otherwise specified
PPX 4851	Laparoscopic abdominoperineal resection of the rectum
PPX 4852	Open abdominoperineal resection of the rectum
PPX 4862	Anterior resection of rectum with synchronous colostomy
PPX 4863	Other anterior resection of rectum
PPX 4869	Other resection of rectum

PPX 4875	Abdominal proctopexy
PPX 4876	Other proctopexy
PPX 5022	Partial hepatectomy
PPX 5029	Other destruction of lesion of liver
PPX 503	Lobectomy of liver
PPX 5122	Cholecystectomy
PPX 5123	Laparoscopic cholecystectomy
PPX 5124	Laparoscopic partial cholecystectomy
PPX 5132	Anastomosis of gallbladder to intestine
PPX 5136	Choledochoenterostomy
PPX 5137	Anastomosis of hepatic duct to gastrointestinal tract
PPX 5141	Common duct exploration for removal of calculus
PPX 5151	Exploration of common duct
PPX 5252	Distal pancreatectomy
PPX 5259	Other partial pancreatectomy
PPX 526	Total pancreatectomy
PPX 527	Radical pancreaticoduodenectomy
PPX 5300	Unilateral repair of inguinal hernia, not otherwise specified
PPX 5301	Other and open repair of direct inguinal hernia
PPX 5302	Other and open repair of indirect inguinal hernia
PPX 5303	Other and open repair of direct inguinal hernia with graft or prosthesis
PPX 5304	Other and open repair of indirect inguinal hernia with graft or prosthesis
PPX 5305	Repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 5310	Bilateral repair of inguinal hernia, not otherwise specified
PPX 5311	Other and open bilateral repair of direct inguinal hernia
PPX 5313	Other and open bilateral repair of inguinal hernia, one direct and one indirect
PPX 5314	Other and open bilateral repair of direct inguinal hernia with graft or prosthesis
PPX 5315	Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis
PPX 5316	Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis
PPX 5317	Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified
PPX 5321	Unilateral repair of femoral hernia with graft or prosthesis
PPX 5329	Other unilateral femoral herniorrhaphy
PPX 5341	Other and open repair of umbilical hernia with graft or prosthesis
PPX 5349	Other open umbilical herniorrhaphy
PPX 5351	Incisional hernia repair
PPX 5359	Repair of other hernia of anterior abdominal wall
PPX 5361	Other open incisional hernia repair with graft or prosthesis
PPX 5369	Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis
PPX 537	Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis
PPX 5372	Other and open repair of diaphragmatic hernia, abdominal approach
PPX 5451	Laparoscopic lysis of peritoneal adhesions
PPX 5459	Other lysis of peritoneal adhesions
PPX 5493	Creation of cutaneoperitoneal fistula
PPX 7072	Repair of colovaginal fistula
PPX 7073	Repair of rectovaginal fistula
PPX 7074	Repair of other vaginoenteric fistula

Appendix 2. Risk Model for Defining Probability of 30-day Death

To balance case and control patients on their risk profile, logistic regression models were used to predict each patient's 30-day risk of death. For general surgery patients a model was fit to an external dataset of Medicare claims. The external dataset was created by taking a 10% random sample of Medicare patients in California, Florida, New Jersey, and Pennsylvania for the years 2013-2015 (for the Recent Era) and 2004-2006 (for the Early Era). Patients in this external dataset were not used for matching. Coefficients for each of the variables were then applied to patients in the matching dataset to assign each patient's risk of 30-day death. The resulting risk scores were then used as a matching variable.

Table 2a. General Surgery Probability of Death Model, Early Era (2004 – 2006)

Variable	Estimate	Standard Error	Z	P-value
Model Intercept	-10.6767	1.1413	-9.3552	<0.0001
California	0.0109	0.1179	0.0925	0.9263
New Jersey	0.1057	0.1249	0.8459	0.3976
Florida	0.0242	0.1077	0.2249	0.8221
Pennsylvania (reference)	--	--	--	--
Matched in year 2004	0.0068	0.1119	0.0604	0.9518
Matched in year 2005	0.0865	0.0917	0.9439	0.3452
Matched in year 2006 (reference)	--	--	--	--
Sex (male)	0.1616	0.0860	1.8797	0.0601
Age	0.0641	0.0059	10.7924	<0.0001
CHF	0.4098	0.0921	4.4479	<0.0001
Stroke	0.2380	0.1220	1.9517	0.0510
Seizure	0.0450	0.3142	0.1434	0.8860
Dementia	0.3773	0.1029	3.6677	0.0002
History of Alcoholism	0.4503	0.2395	1.8802	0.0601
History of Drug Abuse	0.1532	0.5311	0.2884	0.7731
Past Myocardial Infarction	0.0569	0.1263	0.4505	0.6524
Past Arrhythmia	0.0391	0.0900	0.4345	0.6639
Unstable Angina	-0.0142	0.1883	-0.0752	0.9401
Angina	-0.0150	0.1417	-0.1055	0.9160
Hypertension	-0.5268	0.1019	-5.1726	<0.0001
Valvular Disease	0.1125	0.0868	1.2966	0.1948
Chronic Lung Disease	0.3044	0.0848	3.5886	0.0003
Asthma	-0.2342	0.1468	-1.5947	0.1108
Liver Disease	0.2035	0.1129	1.8030	0.0714
Renal Dysfunction	1.2255	0.0971	12.6197	<0.0001
Renal Failure	0.2284	0.1242	1.8400	0.0658
Diabetes	0.0158	0.0895	0.1759	0.8603
Paraplegia	0.2181	0.2282	0.9561	0.3390
Collagen Vascular Disease	0.2112	0.1649	1.2806	0.2003
Coagulopathy	-0.1163	0.5253	-0.2215	0.8247
Thrombocytopenia	-0.1908	0.2429	-0.7856	0.4321
Other Coagulopathy	0.5029	0.1313	3.8284	0.0001
Smoking History	-0.0286	0.1583	-0.1807	0.8566
Post-Inflammatory Pulmonary Fibrosis	0.2132	0.1633	1.3058	0.1916
Cushings' Disease	0.0084	1.1029	0.0076	0.9939
Graves' Disease	-1.1096	1.0342	-1.0730	0.2833
Cancer	0.0279	0.0915	0.3048	0.7605
Abdominal Cancer	0.4383	0.1706	2.5692	0.0102
Hypothyroidism	-0.0826	0.0994	-0.8313	0.4058
Chronic Peptic Ulcer	-0.2788	0.5092	-0.5477	0.5839
Weight loss	0.4583	0.0920	4.9833	<0.0001
Major Secondary Procedure	0.0107	0.0903	0.1187	0.9055
Emergency admission	0.5653	0.0878	6.4353	<0.0001
Transfer-in status	-0.6881	0.4320	-1.5929	0.1112

Variable	Estimate	Standard Error	Z	P-value
Procedure group A	-0.6929	1.4362	-0.4825	0.6295
PPX 062 Unilateral thyroid lobectomy				
PPX 0631 Excision of lesion of thyroid				
PPX 0639 Other partial thyroidectomy				
PPX 0651 Partial substernal thyroidectomy				
PPX 0652 Complete substernal thyroidectomy				
PPX 0689 Other parathyroidectomy				
Procedure group B	1.5421	1.1639	1.3250	0.1852
PPX 5251 Proximal pancreatectomy				
PPX 526 Total pancreatectomy				
PPX 527 Radical pancreaticoduodenectomy				
Procedure group C	1.1142	1.1878	0.9381	0.3482
PPX 4651 Closure of stoma of small intestine				
PPX 4652 Closure of stoma of large intestine				
PPX 4674 Closure of fistula of small intestine, except duodenum				
PPX 7072 Repair of colovaginal fistula				
PPX 7073 Repair of rectovaginal fistula				
PPX 7074 Repair of other vaginoenteric fistula				
Procedure group D	0.3963	1.4401	0.2752	0.7832
PPX 064 Complete thyroidectomy				
PPX 0681 Complete parathyroidectomy				
Procedure group E	2.0174	1.4668	1.3754	0.1690
PPX 0722 Unilateral adrenalectomy				
PPX 0729 Other partial adrenalectomy				
PPX 073 Bilateral adrenalectomy				
Procedure group F	1.1859	1.4621	0.8111	0.4173
PPX 4240 Esophagectomy, not otherwise specified				
PPX 4241 Partial esophagectomy				
PPX 4242 Total esophagectomy				
PPX 427 Esophagomyotomy				
Procedure group G	2.6137	1.0715	2.4393	0.0147
PPX 435 Partial gastrectomy with anastomosis to esophagus				
PPX 4389 Open and other partial gastrectomy				
PPX 4438 Laparoscopic gastroenterostomy				
PPX 4466 Other procedures for creation of esophagogastric sphincteric competence				
PPX 4467 Laparoscopic procedures for creation of esophagogastric sphincteric competence				
Procedure group H	2.2571	1.0522	2.1450	0.0320
PPX 4561 Multiple segmental resection of small intestine				
PPX 4563 Total removal of small intestine				
PPX 4571 Open and other multiple segmental resection of large intestine				
PPX 4590 Intestinal anastomosis, not otherwise specified				
PPX 4591 Small-to-small intestinal anastomosis				
PPX 4592 Anastomosis of small intestine to rectal stump				
PPX 4594 Large-to-large intestinal anastomosis				
PPX 4595 Anastomosis to anus				
PPX 4601 Exteriorization of small intestine				
PPX 4679 Other repair of intestine				

Variable	Estimate	Standard Error	Z	P-value
PPX 485 Other pull-through resection of rectum PPX 4862 Anterior resection of rectum with synchronous colostomy PPX 4869 Other resection of rectum PPX 4875 Abdominal proctopexy PPX 4879 Other repair of rectum				
Procedure group I	3.5759	1.2358	2.8936	0.0038
PPX 4620 Ileostomy, not otherwise specified PPX 4621 Temporary ileostomy PPX 4623 Other permanent ileostomy				
Procedure group J	1.3203	1.0591	1.2466	0.2126
PPX 4642 Repair of pericolostomy hernia PPX 5300 Unilateral repair of inguinal hernia, not otherwise specified PPX 5301 Other and open repair of direct inguinal hernia PPX 5302 Other and open repair of indirect inguinal hernia PPX 5311 Other and open bilateral repair of direct inguinal hernia PPX 5314 Other and open bilateral repair of direct inguinal hernia with graft or prosthesis PPX 5315 Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis PPX 5316 Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis PPX 5317 Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified PPX 5329 Other unilateral femoral herniorrhaphy PPX 5341 Other and open repair of umbilical hernia with graft or prosthesis PPX 5349 Other open umbilical herniorrhaphy PPX 5351 Incisional hernia repair PPX 5369 Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis PPX 537 Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis				
Procedure group K	1.8689	1.2033	1.5531	0.1204
PPX 5022 Partial hepatectomy PPX 5124 Laparoscopic partial cholecystectomy PPX 5137 Anastomosis of hepatic duct to gastrointestinal tract PPX 5141 Common duct exploration for removal of calculus				
PPX 415 Total splenectomy	3.0118	1.0722	2.8090	0.0050
PPX 4342 Local excision of other lesion or tissue of stomach	2.4438	1.2119	2.0165	0.0437
PPX 436 Partial gastrectomy with anastomosis to duodenum	2.3693	1.4710	1.6107	0.1072
PPX 437 Partial gastrectomy with anastomosis to jejunum	2.2606	1.1008	2.0536	0.0400
PPX 4399 Other total gastrectomy	2.6834	1.1471	2.3393	0.0193
PPX 4429 Other pyloroplasty	2.6902	1.2242	2.1975	0.0280

Variable	Estimate	Standard Error	Z	P-value
PPX 4439 Other gastroenterostomy without gastrectomy	2.7507	1.0853	2.5346	0.0113
PPX 4441 Suture of gastric ulcer site	3.5811	1.0790	3.3191	0.0009
PPX 4442 Suture of duodenal ulcer site	3.1592	1.0644	2.9681	0.0030
PPX 4469 Other repair of stomach	3.0948	1.1845	2.6126	0.0090
PPX 4562 Other partial resection of small intestine	2.7129	1.0359	2.6188	0.0088
PPX 4572 Open and other cecectomy	2.3825	1.0941	2.1777	0.0294
PPX 4573 Open and other right hemicolectomy	2.0967	1.0337	2.0284	0.0425
PPX 4574 Open and other resection of transverse colon	1.8192	1.1066	1.6440	0.1002
PPX 4575 Open and other left hemicolectomy	2.4348	1.0443	2.3315	0.0197
PPX 4576 Open and other sigmoidectomy	2.4521	1.0374	2.3637	0.0181
PPX 4579 Other and unspecified partial excision of large intestine	2.5249	1.0575	2.3876	0.0170
PPX 458 Other and unspecified partial excision of large intestine	3.1493	1.0638	2.9604	0.0031
PPX 4593 Other small-to-large intestinal anastomosis	3.4830	1.1638	2.9929	0.0028
PPX 4603 Exteriorization of large intestine	2.4709	1.0840	2.2795	0.0226
PPX 4610 Colostomy, not otherwise specified	2.1506	1.1349	1.8949	0.0581
PPX 4611 Temporary colostomy	3.0832	1.2425	2.4815	0.0131
PPX 4613 Permanent colostomy	2.8517	1.1870	2.4025	0.0163
PPX 4639 Other enterostomy	3.2038	1.1024	2.9061	0.0037
PPX 4673 Suture of laceration of small intestine, except duodenum	1.4675	1.2663	1.1589	0.2465
PPX 4675 Suture of laceration of large intestine	1.9698	1.2860	1.5317	0.1256
PPX 4701 Laparoscopic appendectomy	0.5288	1.1877	0.4452	0.6562
PPX 4709 Other appendectomy	1.6253	1.0809	1.5037	0.1327
PPX 4849 Other pull-through resection of rectum	1.4432	1.4532	0.9931	0.3207
PPX 4863 Other anterior resection of rectum	1.5437	1.1008	1.4024	0.1608
PPX 4876 Other proctopexy	1.1848	1.4548	0.8144	0.4154
PPX 5029 Other destruction of lesion of liver	2.0090	1.2073	1.6641	0.0961
PPX 503 Lobectomy of liver	2.5060	1.3016	1.9253	0.0542
PPX 5122 Cholecystectomy	1.7448	1.0406	1.6766	0.0936
PPX 5123 Laparoscopic cholecystectomy	0.7542	1.0378	0.7268	0.4674
PPX 5132 Anastomosis of gallbladder to intestine	3.0358	1.3247	2.2917	0.0219
PPX 5136 Choledochoenterostomy	1.9538	1.1765	1.6607	0.0968
PPX 5151 Exploration of common duct	2.9166	1.6234	1.7966	0.0724
PPX 5252 Distal pancreatectomy	1.3841	1.4575	0.9497	0.3423
PPX 5259 Other partial pancreatectomy	3.4507	1.3349	2.5850	0.0097
PPX 5303 Other and open repair of direct inguinal hernia with graft or prosthesis	1.1392	1.1517	0.9892	0.3226
PPX 5304 Other and open repair of indirect inguinal hernia with graft or prosthesis	1.5932	1.1176	1.4255	0.1540
PPX 5305 Repair of inguinal hernia with graft or prosthesis, not otherwise specified	1.2178	1.1193	1.0880	0.2766
PPX 5321 Unilateral repair of femoral hernia with graft or prosthesis	1.0102	1.4631	0.6905	0.4899
PPX 5359 Repair of other hernia of anterior abdominal wall	2.5971	1.1292	2.3000	0.0214
PPX 5361 Other open incisional hernia repair with graft or prosthesis	0.4602	1.1820	0.3893	0.6970
PPX 5451 Laparoscopic lysis of peritoneal adhesions	2.0369	1.0993	1.8530	0.0639
PPX 5459 Other lysis of peritoneal adhesions	2.0646	1.0401	1.9850	0.0471
PPX 5493 Creation of cutaneoperitoneal fistula (reference)	--	--	--	--

Appendix 2b. General Surgery Probability of Death Model, Recent Era (2013 – 2015)

Variable	Estimate	Standard Error	Z	P-value
Model Intercept	-7.7623	0.8017	-9.6828	<0.0001
California	0.3315	0.1497	2.2139	0.0268
New Jersey	-0.1393	0.1756	-0.7933	0.4276
Florida	0.1251	0.1441	0.8681	0.3854
Pennsylvania (reference)	--	--	--	--
Matched in year 2013	0.1045	0.1399	0.7471	0.4550
Matched in year 2014	0.0721	0.1185	0.6089	0.5426
Matched in year 2015 (reference)	--	--	--	--
Sex (male)	-0.0090	0.1104	-0.0814	0.9351
Age	0.0416	0.0072	5.7736	<0.0001
CHF	0.2393	0.1219	1.9622	0.0497
Stroke	-0.0126	0.1395	-0.0906	0.9278
Seizure	-0.0154	0.2886	-0.0535	0.9573
Dementia	0.4284	0.1287	3.3272	0.0009
History of Alcoholism	-0.1263	0.2953	-0.4278	0.6688
History of Drug Abuse	-0.0203	0.3839	-0.0529	0.9578
Past Myocardial Infarction	0.0107	0.1495	0.0716	0.9429
Past Arrhythmia	0.0830	0.1118	0.7426	0.4577
Unstable Angina	0.2467	0.3129	0.7883	0.4305
Angina	-0.5536	0.2582	-2.1440	0.0320
Hypertension	-0.0763	0.1818	-0.4198	0.6746
Valvular Disease	0.1184	0.1120	1.0578	0.2901
Chronic Lung Disease	0.4589	0.1106	4.1506	<0.0001
Asthma	-0.1091	0.1590	-0.6860	0.4927
Liver Disease	0.5820	0.1194	4.8736	<0.0001
Renal Dysfunction	1.1303	0.1150	9.8244	<0.0001
Renal Failure	0.1711	0.1590	1.0755	0.2821
Diabetes	0.1249	0.1093	1.1428	0.2531
Paraplegia	0.0670	0.2688	0.2494	0.8030
Collagen Vascular Disease	0.2492	0.1744	1.4292	0.1530
Coagulopathy	-0.1183	0.4831	-0.2448	0.8066
Thrombocytopenia	0.0510	0.2180	0.2338	0.8151
Other Coagulopathy	0.7014	0.1542	4.5493	<0.0001
Smoking History	0.0218	0.1156	0.1886	0.8504
Post-Inflammatory Pulmonary Fibrosis	0.0723	0.2204	0.3282	0.7428
Cushings' Disease	0.3809	0.8855	0.4301	0.6671
Graves' Disease	0.0801	0.8185	0.0979	0.9220
Cancer	-0.0656	0.1134	-0.5786	0.5629
Abdominal Cancer	0.9023	0.2241	4.0261	<0.0001
Hypothyroidism	-0.0225	0.1144	-0.1963	0.8444
Chronic Peptic Ulcer	0.1119	0.6082	0.1841	0.8540
HIV and AIDS	-0.8002	1.1514	-0.6950	0.4871
Weight loss	0.4314	0.1102	3.9142	<0.0001
Major Secondary Procedure	0.0619	0.1198	0.5169	0.6052
Emergency admission	0.6757	0.1238	5.4589	<0.0001
Transfer-in status	0.3007	0.3961	0.7590	0.4479
Procedure group A	-0.2747	1.1573	-0.2374	0.8123
PPX 062 Unilateral thyroid lobectomy				
PPX 0631 Excision of lesion of thyroid				
PPX 0639 Other partial thyroidectomy				
PPX 0651 Partial substernal thyroidectomy				
PPX 0652 Complete substernal thyroidectomy				
Procedure group B	-2.3159	1.1410	-2.0297	0.0424
PPX 4642 Repair of pericolostomy hernia				

Variable	Estimate	Standard Error	Z	P-value
PPX 5301 Other and open repair of direct inguinal hernia				
PPX 5302 Other and open repair of indirect inguinal hernia				
PPX 5303 Other and open repair of direct inguinal hernia with graft or prosthesis				
PPX 5310 Bilateral repair of inguinal hernia, not otherwise specified				
PPX 5314 Other and open bilateral repair of direct inguinal hernia with graft or prosthesis				
PPX 5315 Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis				
PPX 5316 Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis				
PPX 5317 Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified				
PPX 5372 Other and open repair of diaphragmatic hernia, abdominal approach				
PPX 5375 Repair of diaphragmatic hernia, abdominal approach, not otherwise specified				
Procedure group C	-1.6660	1.1601	-1.4360	0.1510
PPX 4849 Other pull-through resection of rectum				
PPX 4850 Abdominoperineal resection of the rectum, not otherwise specified				
PPX 4851 Laparoscopic abdominoperineal resection of the rectum				
PPX 4852 Open abdominoperineal resection of the rectum				
PPX 4859 Other abdominoperineal resection of the rectum				
PPX 4875 Abdominal proctopexy				
PPX 4879 Other repair of rectum				
Procedure group D	-0.9970	1.2005	-0.8305	0.4063
PPX 5029 Other destruction of lesion of liver				
PPX 503 Lobectomy of liver				
Procedure group E	0.2661	0.9691	0.2745	0.7837
PPX 5132 Anastomosis of gallbladder to intestine				
PPX 5136 Choledochoenterostomy				
PPX 5137 Anastomosis of hepatic duct to gastrointestinal tract				
PPX 5141 Common duct exploration for removal of calculus				
PPX 5151 Exploration of common duct				
Procedure group F	-1.0675	0.9243	-1.1550	0.2481
PPX 5252 Distal pancreatectomy				
PPX 5253 Radical subtotal pancreatectomy				
PPX 5259 Other partial pancreatectomy				
PPX 526 Total pancreatectomy				
Procedure group G	0.2143	0.8537	0.2511	0.8018
PPX 4674 Closure of fistula of small intestine, except duodenum				
PPX 7072 Repair of colovaginal fistula				
PPX 7073 Repair of rectovaginal fistula				
Procedure group H	-1.1694	1.1822	-0.9892	0.3226

Variable	Estimate	Standard Error	Z	P-value
PPX 0681 Complete parathyroidectomy PPX 0689 Other parathyroidectomy				
Procedure group I	0.0563	1.1676	0.0482	0.9616
PPX 0722 Unilateral adrenalectomy PPX 073 Bilateral adrenalectomy				
Procedure group J	-0.5525	0.9042	-0.6110	0.5412
PPX 1711 Laparoscopic repair of direct inguinal hernia with graft or prosthesis PPX 1712 Laparoscopic repair of indirect inguinal hernia with graft or prosthesis PPX 1713 Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified PPX 1722 Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis PPX 1723 Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis PPX 1724 Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified				
Procedure group K	-0.6918	0.9045	-0.7648	0.4444
PPX 1731 Laparoscopic multiple segmental resection of large intestine PPX 1732 Laparoscopic cecectomy PPX 1734 Laparoscopic resection of transverse colon PPX 1739 Other laparoscopic partial excision of large intestine				
Procedure group L	0.1235	0.7115	0.1736	0.8622
PPX 4240 Esophagectomy, not otherwise specified PPX 4241 Partial esophagectomy PPX 4242 Total esophagectomy PPX 427 Esophagomyotomy PPX 437 Partial gastrectomy with anastomosis to jejunum				
Procedure group M	-0.1994	0.6657	-0.2995	0.7646
PPX 4342 Local excision of other lesion or tissue of stomach PPX 435 Partial gastrectomy with anastomosis to esophagus PPX 436 Partial gastrectomy with anastomosis to duodenum PPX 4439 Other gastroenterostomy without gastrectomy PPX 4466 Other procedures for creation of esophagogastric sphincteric competence PPX 4467 Laparoscopic procedures for creation of esophagogastric sphincteric competence PPX 4469 Other repair of stomach				
Procedure group N	-1.1856	0.9060	-1.3087	0.1906
PPX 4561 Multiple segmental resection of small intestine PPX 4563 Total removal of small intestine PPX 4590 Intestinal anastomosis, not otherwise specified				

Variable	Estimate	Standard Error	Z	P-value
PPX 4592 Anastomosis of small intestine to rectal stump				
PPX 4594 Large-to-large intestinal anastomosis				
PPX 4595 Anastomosis to anus				
PPX 4675 Suture of laceration of large intestine				
PPX 4679 Other repair of intestine				
Procedure group O	-1.0196	0.8944	-1.1399	0.2543
PPX 4611 Temporary colostomy				
PPX 4613 Permanent colostomy				
PPX 4623 Other permanent ileostomy				
PPX 4651 Closure of stoma of small intestine				
PPX 064 Complete thyroidectomy	-0.5763	1.1630	-0.4955	0.6202
PPX 1733 Laparoscopic right hemicolectomy	-1.1528	0.6754	-1.7069	0.0878
PPX 1735 Laparoscopic left hemicolectomy	0.6794	0.7159	0.9490	0.3426
PPX 1736 Laparoscopic sigmoidectomy	-0.9619	0.8042	-1.1961	0.2317
PPX 415 Total splenectomy	0.8942	0.6826	1.3099	0.1902
PPX 4389 Open and other partial gastrectomy	0.6574	0.7550	0.8708	0.3839
PPX 4399 Other total gastrectomy	1.0261	0.8420	1.2187	0.2229
PPX 4429 Other pyloroplasty	1.5076	0.9525	1.5828	0.1135
PPX 4438 Laparoscopic gastroenterostomy	-0.6614	1.1515	-0.5744	0.5657
PPX 4441 Suture of gastric ulcer site	0.9163	0.6697	1.3681	0.1713
PPX 4442 Suture of duodenal ulcer site	0.8538	0.6309	1.3533	0.1760
PPX 4562 Other partial resection of small intestine	0.4726	0.5455	0.8664	0.3863
PPX 4571 Open and other multiple segmental resection of large intestine	0.0111	1.2477	0.0089	0.9929
PPX 4572 Open and other cecectomy	0.7480	0.6868	1.0891	0.2761
PPX 4573 Open and other right hemicolectomy	0.1113	0.5510	0.2021	0.8399
PPX 4574 Open and other resection of transverse colon	0.7098	0.6710	1.0578	0.2901
PPX 4575 Open and other left hemicolectomy	1.0367	0.5819	1.7817	0.0748
PPX 4576 Open and other sigmoidectomy	0.4278	0.5561	0.7694	0.4417
PPX 4579 Other and unspecified partial excision of large intestine	0.8866	0.6292	1.4090	0.1588
PPX 4581 Laparoscopic total intra-abdominal colectomy	1.1386	0.9732	1.1701	0.2420
PPX 4582 Open total intra-abdominal colectomy	1.0919	0.6580	1.6596	0.0970
PPX 4583 Other and unspecified total intra-abdominal colectomy	0.7183	1.0545	0.6812	0.4958
PPX 4591 Small-to-small intestinal anastomosis	1.2047	0.9894	1.2176	0.2234
PPX 4593 Other small-to-large intestinal anastomosis	0.0224	0.8288	0.0270	0.9784
PPX 4601 Exteriorization of small intestine	1.1925	0.8477	1.4067	0.1595
PPX 4603 Exteriorization of large intestine	0.3678	0.6649	0.5532	0.5801
PPX 4610 Colostomy, not otherwise specified	0.5630	0.6561	0.8581	0.3908
PPX 4620 Ileostomy, not otherwise specified	0.9933	1.0229	0.9710	0.3315
PPX 4639 Other enterostomy	0.1309	0.8126	0.1611	0.8720
PPX 4652 Closure of stoma of large intestine	-0.9321	0.8942	-1.0424	0.2972
PPX 4673 Suture of laceration of small intestine, except duodenum	1.7739	0.9402	1.8868	0.0592
PPX 4701 Laparoscopic appendectomy	-1.3858	0.6984	-1.9841	0.0472
PPX 4709 Other appendectomy	-0.7078	0.8033	-0.8811	0.3783
PPX 4862 Anterior resection of rectum with synchronous colostomy	0.7268	0.7917	0.9180	0.3586
PPX 4863 Other anterior resection of rectum	0.4889	0.7076	0.6908	0.4897
PPX 4869 Other resection of rectum	-0.0869	0.8376	-0.1037	0.9174
PPX 4876 Other proctopexy	-0.0503	0.9261	-0.0543	0.9567
PPX 5022 Partial hepatectomy	-1.3673	1.1679	-1.1707	0.2417

Variable	Estimate	Standard Error	Z	P-value
PPX 5122 Cholecystectomy	-0.4858	0.5824	-0.8342	0.4042
PPX 5123 Laparoscopic cholecystectomy	-1.3210	0.5504	-2.4000	0.0164
PPX 5124 Laparoscopic partial cholecystectomy	1.1650	1.3361	0.8720	0.3832
PPX 527 Radical pancreaticoduodenectomy	-1.5958	0.8241	-1.9365	0.0528
PPX 5300 Unilateral repair of inguinal hernia, not otherwise specified	-0.5208	0.9271	-0.5617	0.5743
PPX 5304 Other and open repair of indirect inguinal hernia with graft or prosthesis	-1.6579	1.1455	-1.4473	0.1478
PPX 5305 Repair of inguinal hernia with graft or prosthesis, not otherwise specified	-1.2153	0.8939	-1.3596	0.1740
PPX 5321 Unilateral repair of femoral hernia with graft or prosthesis	0.9374	0.7410	1.2650	0.2059
PPX 5329 Other unilateral femoral herniorrhaphy	-0.3655	0.9201	-0.3972	0.6912
PPX 5341 Other and open repair of umbilical hernia with graft or prosthesis	-0.9571	1.1569	-0.8273	0.4081
PPX 5349 Other open umbilical herniorrhaphy	-0.1153	0.8207	-0.1405	0.8883
PPX 5351 Incisional hernia repair	-0.4205	0.7563	-0.5560	0.5782
PPX 5359 Repair of other hernia of anterior abdominal wall	-0.2605	0.9126	-0.2855	0.7753
PPX 5361 Other open incisional hernia repair with graft or prosthesis	-1.1610	0.7296	-1.5913	0.1115
PPX 5369 Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	-0.3512	0.8141	-0.4314	0.6662
PPX 5451 Laparoscopic lysis of peritoneal adhesions	-0.7093	0.7074	-1.0027	0.3160
PPX 5459 Other lysis of peritoneal adhesions	-0.2415	0.5658	-0.4268	0.6695
PPX 5493 Creation of cutaneoperitoneal fistula (reference)	--	--	--	--

Table 3. Complete balance table for Early Era (2003-2005)

Variable	Black Patients	Tapered Matches			White Patients (unmatched)
		Presentation + Procedure + Demographics	Procedure + Demographics	Demographics	
N	6,752	6,752	6,752	6,752	107,001
Age	75.99	75.84	75.98	75.99	77.48
Year of match	2005.12	2005.10	2005.12	2005.12	2005.12
Age 65-69 (%)	0.25	0.23	0.25	0.25	0.18
Age 70-74 (%)	0.24	0.25	0.25	0.24	0.21
Age 75-79 (%)	0.21	0.24	0.21	0.21	0.24
Age 80-84 (%)	0.16	0.17	0.16	0.16	0.21
Age 85 plus (%)	0.13	0.11	0.13	0.13	0.17
State- California (%)	0.23	0.23	0.23	0.23	0.25
State- New Jersey (%)	0.24	0.27	0.23	0.24	0.16
State- Florida (%)	0.34	0.34	0.34	0.34	0.35
State- Pennsylvania (%)	0.19	0.16	0.19	0.19	0.24
State- NJ/PA (%)	0.43	0.43	0.43	0.43	0.40
Male (%)	0.39	0.39	0.39	0.39	0.43
Year of match- 2004 (%)	0.22	0.23	0.22	0.22	0.22
Year of match- 2005 (%)	0.44	0.45	0.44	0.44	0.45
Year of match- 2006 (%)	0.34	0.32	0.34	0.34	0.33
Open and other cecectomy	0.01	0.01	0.01	0.01	0.01
Laparoscopic cholecystectomy	0.16	0.16	0.16	0.21	0.20
Open and other right hemicolectomy	0.14	0.14	0.14	0.11	0.12
Other anterior resection of rectum	0.01	0.01	0.01	0.02	0.02
Cholecystectomy	0.06	0.06	0.06	0.05	0.05
Open and other sigmoidectomy	0.05	0.05	0.05	0.06	0.07
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.00	0.00	0.00	0.01	0.01
Radical pancreaticoduodenectomy	0.01	0.01	0.01	0.01	0.01
Other partial resection of small intestine	0.06	0.06	0.06	0.05	0.05
Other lysis of peritoneal adhesions	0.06	0.06	0.06	0.05	0.05
Other resection of rectum	0.00	0.00	0.00	0.00	0.01
Other and open repair of indirect inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Distal pancreatectomy	0.00	0.00	0.00	0.00	0.00

Closure of stoma of small intestine	0.00	0.00	0.00	0.00	0.00
Other unilateral femoral herniorrhaphy	NR	NR	NR	0.00	0.00
Open and other left hemicolectomy	0.04	0.04	0.04	0.03	0.03
Other and unspecified partial excision of large intestine	0.01	0.01	0.01	0.01	0.01
Unilateral adrenalectomy	0.00	0.00	0.00	0.00	0.00
Abdominal proctopexy	NR	NR	NR	NR	0.00
Other gastroenterostomy without gastrectomy	0.01	0.01	0.01	0.01	0.01
Exteriorization of large intestine	0.01	0.01	0.01	0.01	0.01
Anterior resection of rectum with synchronous colostomy	0.00	0.00	0.00	0.00	0.00
Total splenectomy	0.00	0.00	0.00	0.01	0.01
Other procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	0.00	0.00
Other total gastrectomy	0.01	0.01	0.01	0.00	0.00
Other and unspecified partial excision of large intestine	0.02	0.02	0.02	0.02	0.02
Other pull-through resection of rectum	0.01	0.01	0.01	0.01	0.01
Other open umbilical herniorrhaphy	0.01	0.01	0.01	0.00	0.00
Laparoscopic appendectomy	0.01	0.01	0.01	0.02	0.02
Complete parathyroidectomy	0.00	0.00	0.00	NR	0.00
Incisional hernia repair	0.01	0.01	0.01	0.01	0.01
Temporary colostomy	0.00	0.00	0.00	NR	0.00
Repair of rectovaginal fistula	NR	NR	NR	NR	0.00
Other pull-through resection of rectum	NR	NR	NR	NR	0.00
Other destruction of lesion of liver	0.00	0.00	0.00	0.00	0.00
Small-to-small intestinal anastomosis	0.00	0.00	0.00	NR	0.00
Other open incisional hernia repair with graft or prosthesis	0.02	0.02	0.02	0.03	0.03
Partial esophagectomy	NR	NR	NR	0.00	0.00
Laparoscopic gastroenterostomy	0.00	0.00	0.00	0.00	0.00

Open and other resection of transverse colon	0.01	0.01	0.01	0.01	0.01
Exteriorization of small intestine	0.00	0.00	0.00	0.00	0.00
Other enterostomy	0.01	0.01	0.01	0.00	0.00
Unilateral thyroid lobectomy	0.02	0.02	0.02	0.01	0.01
Complete thyroidectomy	0.02	0.02	0.02	0.01	0.01
Partial gastrectomy with anastomosis to duodenum	0.00	0.00	0.00	NR	0.00
Other and open repair of direct inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Other parathyroidectomy	0.02	0.02	0.02	0.01	0.01
Laparoscopic lysis of peritoneal adhesions	0.01	0.01	0.01	0.01	0.01
Lobectomy of liver	0.00	0.00	0.00	NR	0.00
Anastomosis of hepatic duct to gastrointestinal tract	NR	NR	NR	NR	0.00
Suture of laceration of large intestine	NR	NR	NR	NR	0.00
Repair of pericolostomy hernia	NR	NR	NR	0.00	0.00
Common duct exploration for removal of calculus	NR	NR	NR	NR	0.00
Total esophagectomy	NR	NR	NR	NR	0.00
Open and other partial gastrectomy	0.01	0.01	0.01	0.00	0.00
Partial hepatectomy	0.00	0.00	0.00	0.00	0.00
Esophagectomy, not otherwise specified	NR	NR	NR	0.00	0.00
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Laparoscopic procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	0.01	0.01
Closure of stoma of large intestine	0.00	0.00	0.00	0.01	0.01
Resection of vessel with replacement, other vessels of head and neck	0.00	0.00	0.00	0.00	0.00
Other repair of intestine	0.00	0.00	0.00	NR	0.00
Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00

Esophagomyotomy	0.00	0.00	0.00	NR	0.00
Other appendectomy	0.01	0.01	0.01	0.02	0.02
Local excision of other lesion or tissue of stomach	0.00	0.00	0.00	NR	0.00
Unilateral repair of femoral hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Ileostomy, not otherwise specified	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to jejunum	0.02	0.02	0.02	0.01	0.01
Other small-to-large intestinal anastomosis	0.00	0.00	0.00	NR	0.00
Other and open repair of indirect inguinal hernia	0.00	0.00	0.00	0.00	0.00
Repair of other hernia of anterior abdominal wall	0.01	0.01	0.01	0.00	0.00
Repair of inguinal hernia with graft or prosthesis, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Large-to-large intestinal anastomosis	0.00	0.00	0.00	0.00	0.00
Suture of duodenal ulcer site	0.01	0.01	0.01	0.01	0.01
Colostomy, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Creation of cutaneoperitoneal fistula	0.00	0.00	0.00	0.00	0.00
Open and other multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Closure of fistula of small intestine, except duodenum	NR	NR	NR	0.00	0.00
Multiple segmental resection of small intestine	0.00	0.00	0.00	0.00	0.00
Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Permanent colostomy	0.00	0.00	0.00	NR	0.00
Suture of gastric ulcer site	0.00	0.00	0.00	0.00	0.00
Excision of lesion of thyroid	NR	NR	NR	NR	0.00
Anastomosis of gallbladder to intestine	NR	NR	NR	NR	0.00
Other and open repair of umbilical hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Complete substernal thyroidectomy	0.00	0.00	0.00	NR	0.00

Exploration of common duct	NR	NR	NR	0.00	0.00
Other partial thyroidectomy	0.01	0.01	0.01	0.00	0.00
Suture of laceration of small intestine, except duodenum	0.01	0.01	0.01	0.01	0.00
Repair of colovaginal fistula	NR	NR	NR	NR	0.00
Other and open bilateral repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Other proctopexy	NR	NR	NR	0.00	0.00
Unilateral repair of inguinal hernia, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Other and open repair of direct inguinal hernia	0.00	0.00	0.00	0.00	0.00
Other permanent ileostomy	NR	NR	NR	0.00	0.00
Other pyloroplasty	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to esophagus	NR	NR	NR	NR	0.00
Total pancreatectomy	NR	NR	NR	NR	0.00
Choledochoenterostomy	0.00	0.00	0.00	0.00	0.00
Other partial pancreatectomy	NR	NR	NR	0.00	0.00
Bilateral repair of inguinal hernia, not otherwise specified	NR	NR	NR	0.00	NR
Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	NR	0.00
Partial substernal thyroidectomy	NR	NR	NR	NR	0.00
Other and open bilateral repair of direct inguinal hernia	NR	NR	NR	NR	0.00
Other repair of stomach	0.00	0.00	0.00	NR	0.00
Temporary ileostomy	NR	NR	NR	NR	0.00
Intestinal anastomosis, not otherwise specified	NR	NR	NR	0.00	NR
Other and open bilateral repair of inguinal hernia, one direct and one indirect	NR	NR	NR	NR	0.00
Anastomosis of small intestine to rectal stump	0.00	0.00	0.00	0.00	NR
Anastomosis to anus	NR	NR	NR	NR	0.00

Repair of other vaginoenteric fistula	NR	NR	NR	0.00	NR
Number of Comorbidities	5.81	5.67	5.27	5.14	5.27
Number of Comorbidities in Near Fine balance list of variables	0.38	0.33	0.48	0.46	0.46
Anesthesia Score	147.95	143.90	142.36	140.55	141.21
More than six comorbidities (%)	0.49	0.49	0.41	0.39	0.41
Congestive Heart Failure	0.26	0.26	0.22	0.20	0.22
Stroke	0.15	0.15	0.09	0.08	0.10
Seizure	0.02	0.02	0.01	0.01	0.01
Dementia	0.15	0.15	0.09	0.09	0.10
Alcohol abuse	0.03	0.03	0.02	0.02	0.02
Drug abuse	0.01	0.01	0.01	0.00	0.00
Past MI	0.09	0.08	0.09	0.10	0.10
Past Arrhythmia	0.25	0.25	0.29	0.28	0.30
Unstable Angina	0.05	0.03	0.04	0.04	0.04
Angina	0.08	0.06	0.08	0.08	0.08
Hypertension	0.90	0.90	0.78	0.79	0.79
Valvular Heart Disease	0.27	0.29	0.28	0.27	0.29
Chronic Lung Disease	0.27	0.27	0.30	0.29	0.30
Asthma	0.11	0.12	0.10	0.09	0.09
Liver Disease	0.16	0.15	0.14	0.13	0.13
Renal Dialysis	0.23	0.23	0.13	0.12	0.13
Renal Failure	0.16	0.15	0.08	0.07	0.08
Diabetes	0.47	0.46	0.29	0.29	0.29
Paraplegia	0.05	0.04	0.02	0.02	0.02
Collagen Vascular Disease	0.05	0.05	0.06	0.06	0.06
Coagulation disorders	0.00	NR	0.00	0.00	0.00
Thrombocytopenia	0.02	0.01	0.02	0.03	0.02
Congenital Coagulation disorder	0.06	0.05	0.06	0.06	0.06
Smoking History	0.07	0.05	0.09	0.09	0.09
Post Pulmonary Fibrosis	0.03	0.02	0.04	0.04	0.04
Cushing's disease	NR	NR	NR	NR	0.00
Graves' disease	0.01	0.01	0.01	0.01	0.01
Cancer	0.47	0.47	0.51	0.48	0.50
Abdominal Cancer	0.06	0.06	0.06	0.05	0.05
Hypothyroidism	0.15	0.12	0.23	0.22	0.22
Chronic Peptic Ulcer	0.01	0.01	0.01	0.00	0.00
AIDS	0.00	NR	NR	NR	0.00
Weight Loss	0.20	0.18	0.14	0.13	0.14
Sickle Cell Anemia	NR	NR	NR	NR	0.00

Any Comorbidity	0.99	0.99	0.98	0.98	0.98
Cardiac with CHF	0.56	0.56	0.55	0.54	0.56
Cardiac without CHF	0.49	0.49	0.51	0.50	0.52
Stroke/Paraplegia	0.16	0.16	0.10	0.09	0.10
Any Angina	0.12	0.08	0.11	0.11	0.11
Cancer/Abdominal Cancer	0.47	0.47	0.51	0.48	0.50
Chronic Lung/Asthma	0.32	0.32	0.34	0.33	0.33
Emergency type admission (%)	0.47	0.52	0.37	0.39	0.38
Transfer-in (%)	0.01	0.01	0.01	0.01	0.01

Note. NR, Not Reportable N<11

Table 4. Complete balance table for Recent Era (2013-2015)

Variable	Black Patients	Tapered Matches			White Patients (unmatched)
		Presentation + Procedure + Demographics	Procedure + Demographics	Demographics	
N	4,964	4,964	4,964	4,964	74,108
Age	75.46	75.01	75.45	75.46	77.03
Year of match	2014.10	2014.10	2014.10	2014.10	2014.10
Age 65-69 (%)	0.27	0.28	0.27	0.27	0.22
Age 70-74 (%)	0.25	0.28	0.26	0.25	0.23
Age 75-79 (%)	0.21	0.19	0.20	0.21	0.20
Age 80-84 (%)	0.14	0.14	0.15	0.14	0.17
Age 85 plus (%)	0.12	0.11	0.12	0.12	0.18
State- California (%)	0.24	0.24	0.24	0.24	0.28
State- New Jersey (%)	0.23	0.24	0.22	0.23	0.15
State- Florida (%)	0.34	0.34	0.34	0.34	0.35
State- Pennsylvania (%)	0.19	0.17	0.19	0.19	0.21
State- NJ/PA (%)	0.42	0.42	0.42	0.42	0.37
Male (%)	0.39	0.39	0.39	0.39	0.45
Year of match- 2013 (%)	0.23	0.23	0.23	0.23	0.23
Year of match- 2014 (%)	0.44	0.44	0.44	0.44	0.45
Year of match- 2015 (%)	0.33	0.33	0.33	0.33	0.33
Procedure type (%)					
Open and other cecectomy	0.01	0.01	0.01	0.00	0.00
Laparoscopic cholecystectomy	0.19	0.19	0.19	0.21	0.22
Open and other right hemicolectomy	0.08	0.08	0.08	0.06	0.07
Other anterior resection of rectum	0.01	0.01	0.01	0.02	0.02
Cholecystectomy	0.03	0.03	0.03	0.03	0.03
Open and other sigmoidectomy	0.03	0.03	0.03	0.05	0.05
Radical pancreaticoduodenectomy	0.01	0.01	0.01	0.01	0.01
Other partial resection of small intestine	0.07	0.07	0.07	0.06	0.06
Other lysis of peritoneal adhesions	0.05	0.05	0.05	0.04	0.04
Other resection of rectum	0.00	0.00	0.00	0.01	0.01
Other and open repair of indirect inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Distal pancreatectomy	0.00	0.00	0.00	0.01	0.01
Closure of stoma of small intestine	0.01	0.01	0.01	0.01	0.01

Other unilateral femoral herniorrhaphy	NR	NR	NR	0.00	0.00
Open and other left hemicolectomy	0.02	0.02	0.02	0.02	0.02
Unilateral adrenalectomy	0.01	0.01	0.01	0.00	0.00
Abdominal proctopexy	NR	NR	NR	0.00	0.00
Other gastroenterostomy without gastrectomy	0.01	0.01	0.01	0.00	0.00
Exteriorization of large intestine	0.01	0.01	0.01	0.01	0.01
Anterior resection of rectum with synchronous colostomy	0.00	0.00	0.00	0.00	0.00
Total splenectomy	0.00	0.00	0.00	0.01	0.01
Other procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	NR	0.00
Other total gastrectomy	0.00	0.00	0.00	NR	0.00
Other and unspecified partial excision of large intestine	0.01	0.01	0.01	0.01	0.01
Other open umbilical herniorrhaphy	0.00	0.00	0.00	0.00	0.00
Laparoscopic appendectomy	0.03	0.03	0.03	0.04	0.04
Complete parathyroidectomy	NR	NR	NR	NR	0.00
Incisional hernia repair	0.01	0.01	0.01	0.01	0.01
Temporary colostomy	NR	NR	NR	NR	0.00
Repair of rectovaginal fistula	NR	NR	NR	NR	0.00
Other pull-through resection of rectum	NR	NR	NR	NR	0.00
Other destruction of lesion of liver	0.00	0.00	0.00	NR	0.00
Small-to-small intestinal anastomosis	NR	NR	NR	NR	0.00
Other open incisional hernia repair with graft or prosthesis	0.02	0.02	0.02	0.03	0.03
Partial esophagectomy	NR	NR	NR	0.00	0.00
Laparoscopic gastroenterostomy	0.01	0.01	0.01	0.01	0.01
Open and other resection of transverse colon	0.01	0.01	0.01	0.01	0.01
Exteriorization of small intestine	0.00	0.00	0.00	0.00	0.00
Other enterostomy	0.00	0.00	0.00	NR	0.00

Unilateral thyroid lobectomy	0.01	0.01	0.01	0.00	0.00
Complete thyroidectomy	0.02	0.02	0.02	0.01	0.01
Partial gastrectomy with anastomosis to duodenum	NR	NR	NR	NR	0.00
Other and open repair of direct inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Other parathyroidectomy	0.01	0.01	0.01	0.00	0.00
Laparoscopic lysis of peritoneal adhesions	0.02	0.02	0.02	0.01	0.02
Lobectomy of liver	NR	NR	NR	0.00	0.00
Anastomosis of hepatic duct to gastrointestinal tract	NR	NR	NR	NR	0.00
Suture of laceration of large intestine	NR	NR	NR	NR	0.00
Repair of pericolostomy hernia	0.00	0.00	0.00	0.00	0.00
Common duct exploration for removal of calculus	NR	NR	NR	NR	0.00
Total esophagectomy	NR	NR	NR	NR	0.00
Open and other partial gastrectomy	0.01	0.01	0.01	0.00	0.00
Partial hepatectomy	0.00	0.00	0.00	0.00	0.01
Esophagectomy, not otherwise specified	NR	NR	NR	NR	0.00
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Laparoscopic procedures for creation of esophagogastric sphincteric competence	0.00	0.00	0.00	0.02	0.01
Closure of stoma of large intestine	0.01	0.01	0.01	0.01	0.01
Other repair of intestine	NR	NR	NR	NR	0.00
Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00
Esophagomyotomy	0.00	0.00	0.00	0.00	0.00
Other appendectomy	0.01	0.01	0.01	0.01	0.01
Local excision of other lesion or tissue of stomach	0.01	0.01	0.01	0.00	0.00
Unilateral repair of femoral hernia with graft or prosthesis	NR	NR	NR	0.00	0.00

Ileostomy, not otherwise specified	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to jejunum	0.01	0.01	0.01	0.01	0.01
Other small-to-large intestinal anastomosis	0.00	0.00	0.00	0.00	0.00
Other and open repair of indirect inguinal hernia	NR	NR	NR	NR	0.00
Repair of other hernia of anterior abdominal wall	0.01	0.01	0.01	0.01	0.01
Repair of inguinal hernia with graft or prosthesis, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Large-to-large intestinal anastomosis	NR	NR	NR	NR	0.00
Laparoscopic sigmoidectomy	0.02	0.02	0.02	0.03	0.02
Suture of duodenal ulcer site	0.01	0.01	0.01	0.01	0.01
Laparoscopic cecectomy	0.01	0.01	0.01	0.00	0.00
Open total intra-abdominal colectomy	0.01	0.01	0.01	0.00	0.01
Laparoscopic abdominoperineal resection of the rectum	NR	NR	NR	NR	0.00
Colostomy, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Creation of cutaneoperitoneal fistula	0.01	0.01	0.01	0.00	0.00
Laparoscopic total intra-abdominal colectomy	NR	NR	NR	NR	0.00
Laparoscopic right hemicolectomy	0.05	0.05	0.05	0.04	0.04
Open and other multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Open abdominoperineal resection of the rectum	0.00	0.00	0.00	0.00	0.00
Closure of fistula of small intestine, except duodenum	NR	NR	NR	NR	0.00
Multiple segmental resection of small intestine	0.00	0.00	0.00	NR	0.00
Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Internal fixation of bone without fracture reduction, tibia and fibula	0.00	0.00	0.00	0.00	0.00
Permanent colostomy	NR	NR	NR	NR	0.00

Suture of gastric ulcer site	0.01	0.01	0.01	0.01	0.00
Total removal of small intestine	NR	NR	NR	NR	0.00
Anastomosis of gallbladder to intestine	NR	NR	NR	NR	NR
Other and open repair of umbilical hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Complete substernal thyroidectomy	NR	NR	NR	NR	0.00
Exploration of common duct	NR	NR	NR	0.00	NR
Other partial thyroidectomy	0.00	0.00	0.00	NR	0.00
Suture of laceration of small intestine, except duodenum	NR	NR	NR	NR	0.00
Repair of colovaginal fistula	NR	NR	NR	NR	0.00
Other proctopexy	NR	NR	NR	0.00	0.00
Unilateral repair of inguinal hernia, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Other and open repair of direct inguinal hernia	NR	NR	NR	NR	0.00
Laparoscopic resection of transverse colon	0.00	0.00	0.00	0.00	0.00
Laparoscopic left hemicolectomy	0.01	0.01	0.01	0.01	0.01
Other laparoscopic partial excision of large intestine	0.00	0.00	0.00	0.00	0.00
Other permanent ileostomy	NR	NR	NR	NR	0.00
Other pyloroplasty	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to esophagus	NR	NR	NR	NR	0.00
Total pancreatectomy	NR	NR	NR	NR	0.00
Choledochoenterostomy	NR	NR	NR	NR	0.00
Other and open repair of diaphragmatic hernia, abdominal approach	NR	NR	NR	0.00	0.00
Abdominoperineal resection of the rectum, not otherwise specified	NR	NR	NR	NR	0.00
Other partial pancreatectomy	NR	NR	NR	NR	0.00
Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	0.00	0.00

Laparoscopic partial cholecystectomy	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	0.00	0.00
Partial substernal thyroidectomy	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified	NR	NR	NR	0.00	0.00
Laparoscopic multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Other and unspecified total intra-abdominal colectomy	NR	NR	NR	NR	0.00
Laparoscopic repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	NR	0.00
Other repair of stomach	NR	NR	NR	NR	0.00
Intestinal anastomosis, not otherwise specified	NR	NR	NR	NR	0.00
Laparoscopic repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Other and open bilateral repair of inguinal hernia, one direct and one indirect	0.00	0.00	0.00	0.00	NR
Anastomosis to anus	NR	NR	NR	NR	0.00
Continent ileostomy	0.00	0.00	0.00	0.00	NR
Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Substernal thyroidectomy, not otherwise specified	0.00	0.00	0.00	0.00	NR
Number of Comorbidities	6.63	6.51	5.96	5.85	6.00
Number of Comorbidities in Near Fine balance list of variables	0.63	0.62	0.76	0.76	0.76
Anesthesia Score	155.01	150.37	150.15	151.78	150.71

More than six comorbidities (%)	0.61	0.61	0.51	0.51	0.53
Congestive Heart Failure	0.26	0.26	0.18	0.18	0.19
Stroke	0.21	0.21	0.13	0.13	0.14
Seizure	0.05	0.03	0.03	0.02	0.02
Dementia	0.17	0.16	0.11	0.10	0.12
Alcohol abuse	0.03	0.03	0.03	0.03	0.03
Drug abuse	0.03	0.03	0.02	0.02	0.02
Past MI	0.11	0.10	0.10	0.10	0.11
Past Arrhythmia	0.32	0.31	0.32	0.32	0.35
Unstable Angina	0.03	0.02	0.02	0.02	0.02
Angina	0.06	0.05	0.05	0.05	0.05
Hypertension	0.93	0.93	0.85	0.85	0.85
Valvular Heart Disease	0.26	0.27	0.28	0.27	0.28
Chronic Lung Disease	0.27	0.27	0.28	0.27	0.28
Asthma	0.14	0.14	0.12	0.11	0.11
Liver Disease	0.21	0.20	0.20	0.20	0.20
Renal Dialysis	0.42	0.42	0.27	0.26	0.28
Renal Failure	0.14	0.13	0.07	0.05	0.06
Diabetes	0.51	0.51	0.34	0.33	0.33
Paraplegia	0.06	0.04	0.02	0.02	0.02
Collagen Vascular Disease	0.07	0.07	0.08	0.08	0.08
Coagulation disorders	0.00	0.00	0.01	0.01	0.01
Thrombocytopenia	0.04	0.03	0.04	0.03	0.04
Congenital Coagulation disorder	0.06	0.06	0.06	0.06	0.06
Smoking History	0.23	0.23	0.28	0.28	0.28
Post Pulmonary Fibrosis	0.03	0.02	0.03	0.03	0.03
Cushing's disease	NR	NR	NR	NR	0.00
Graves' disease	0.01	0.01	0.01	0.00	0.00

Note. NR, Not Reportable N<11

Table 5. Readmission Outcomes for Black Study Population and 3 Matched White Populations: Early Era (2003-2005), Recent Era (2013, 2015), and the Difference-in-Difference between the Eras to Evaluate whether the Black-White Difference is Different in the Two Eras

			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	30-day readmission (or death)	24.53	23.58	20.19***	19.12***
Recent Era (2013-2015)	30-day readmission (or death)	21.70	21.68	18.19***	18.39***
Difference in Difference (Recent - Early)	30-day readmission (or death)	--	-0.93%	-0.83%	-2.10%

Notes. Difference in difference is defined by the Black-White difference in Recent Era minus the Black-White difference in Early Era. Significance tests for binary variables used McNemar test (* <0.05, ** <0.01, ***<0.001). For the difference in difference across eras, Gart's test for binary outcomes was used (+ < 0.05, ++ < 0.01, +++ < 0.001). The symbols were marked in the later era if the difference in difference was significant.

Table 6. Effect of race and hospital nursing characteristics on odds of 30-day Readmission or Death, after matching patients on demographics, procedure, and presentation variables

Variables in the Model	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)
Black	1.04 (0.97-1.11)	1.05 (0.98-1.12)	1.00 (0.91-1.09)	0.99 (0.90-1.09)
Nursing Resources (High vs Low)	---	0.86 * (0.75-1.00)	0.86 * (0.75-1.00)	0.87 (0.74-1.01)
Nursing Resources (Middle vs Low)	---	0.93 (0.83-1.05)	0.93 (0.82-1.04)	0.93 (0.82-1.05)
Black*Nursing Resources (High vs Low) Interaction	—	—	0.93 (0.85-1.03)	0.94 (0.85-1.03)
Black*Nursing Resources (Middle vs Low) Interaction	—	—	0.95 (0.85-1.05)	0.95 (0.86-1.06)
Major Teaching Hospital	---	---	—	1.05 (0.90-1.22)
Minor Teaching Hospital	---	---	—	1.00 (0.89-1.13)
Large Size (>250 beds)	---	---	—	0.93 (0.83-1.05)
High Technology Hospital	---	---	—	1.07 (0.96-1.19)
General Surgery Volume	---	---	—	0.99 (0.98-1.01)
Test for improvement in fit with greater model complexity				
Chi-square	---	4.09	2.23	5.06
Degrees of Freedom	---	2	2	5
p-value	---	0.1295	0.3280	0.4085

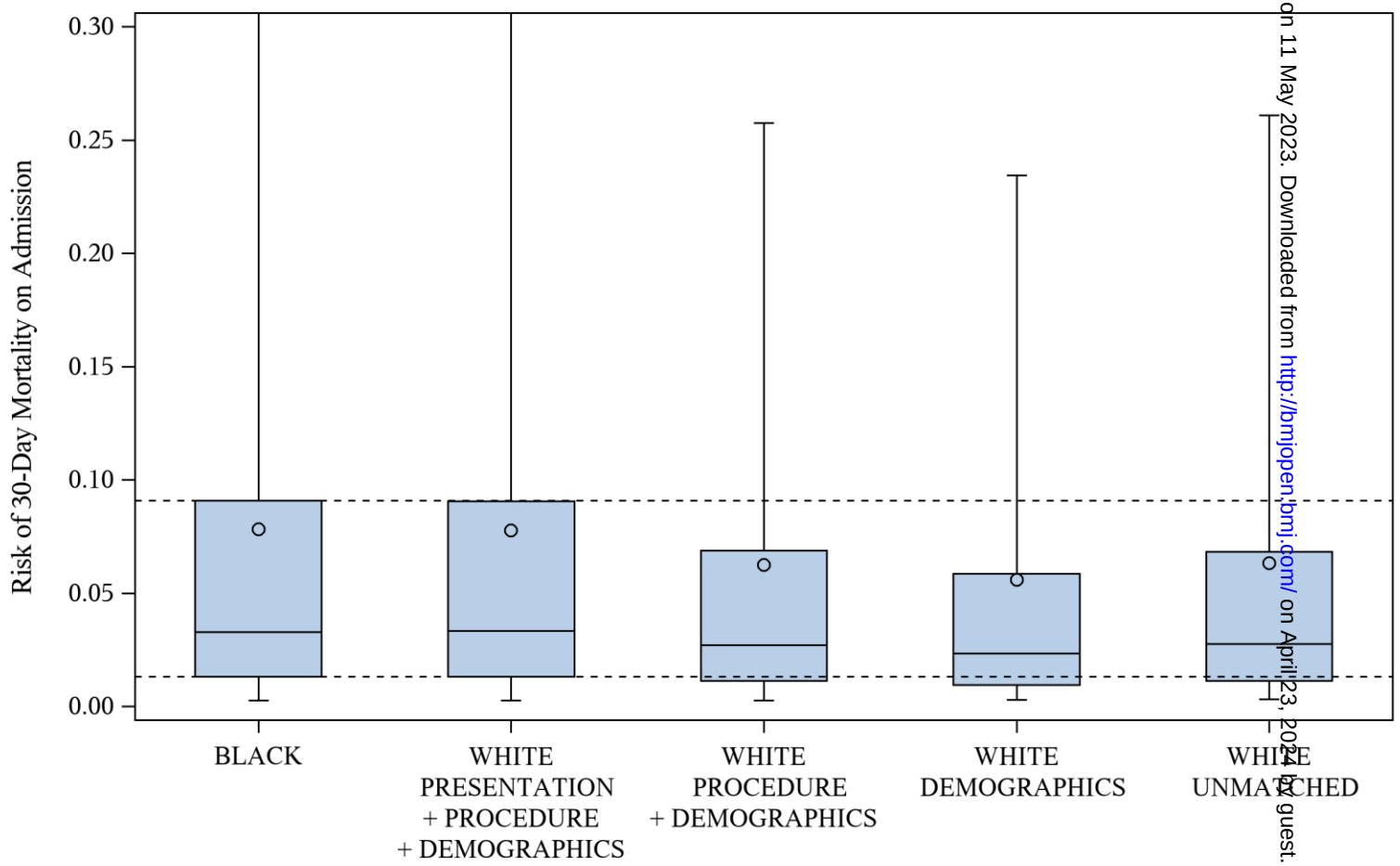
Table 7. Quality of Matches for Selected* Variables, Early Era (2003-2005)

Variable	**Black Patients** (n = 6,752)	**Tapered Matches** Presentation + Procedure + Demographics (n = 6,752)	Procedure + Demographics (n = 6,752)	Demographics (n = 6,752)	White Patients (unmatched) (n = 107,001)
State (%)					
California	23.2	23.2	23.2	23.2	**24.9**[c]
Florida	34.0	34.0	34.0	34.0	**35.5**[a]
New Jersey / Pennsylvania	42.8	42.8	42.8	42.8	**39.6**[c]
Year of Procedure (%)					
2004	21.7	22.7	21.7	21.7	21.6
2005	44.5	44.9	44.5	44.5	45.1
2006	33.8	32.4	33.8	33.8	33.3
Age at Procedure	76.0	75.8	76.0	76.0	**77.5**[c]
% Male	38.6	38.6	38.6	38.6	**43.1**[c]
Procedures (%)					
Laparoscopic cholecystectomy (5123)	15.8	15.8	15.8	**21.0**[c]	**19.9**[c]
Open right hemicolectomy (4573)	13.6	13.6	13.6	**11.3**[c]	**12.1**[c]
Lysis of peritoneal adhesion (5459)	6.2	6.2	6.2	**4.6**[c]	**4.6**[c]
Partial resection of small intestine (4562)	5.7	5.7	5.7	**4.6**[b]	**4.9**[b]
Open cholecystectomy (5122)	5.6	5.6	5.6	5.5	5.4
Selected Comorbidities (%)					
Hypertension	89.8	90.0	**78.3**[c]	**79.3**[c]	**79.5**[c]
Diabetes	46.5	46.5	**28.5**[c]	**29.3**[c]	**28.5**[c]
Congestive heart failure	25.8	25.7	**21.6**[c]	**20.3**[c]	**21.6**[c]
Renal dialysis	23.2	23.0	**13.1**[c]	**12.4**[c]	**13.4**[c]
Renal failure	15.6	15.4	**7.7**[c]	**7.1**[c]	**7.7**[c]
Paraplegia	4.8	**3.6**[c]	**1.8**[c]	**1.7**[c]	**1.9**[c]
Mortality Risk Score (prob)	0.078	0.078	**0.062**[c]	**0.056**[c]	**0.063**[c]
Emergency admission (%)	47.3	**51.6**[c]	**37.5**[c]	**38.6**[c]	**37.9**[c]
Transfer status (%)	0.9	1.0	0.9	**0.6**[a]	0.7
Anesthesia time (minutes)	148	**144**[c]	**142**[c]	**141**[c]	**141**[c]
Dual-eligible (%)	38.8	**12.0**[c]	**10.0**[c]	**9.7**[c]	**9.3**[c]
Neighborhood median household income ($)	23,658	**31,844**[c]	**32,359**[c]	**32,182**[c]	**31,729**[c]
Neighborhood high school graduate (%)	82.2	**88.6**[c]	**88.9**[c]	**88.9**[c]	**88.7**[c]
Neighborhood college graduate (%)	32.2	**39.7**[c]	**40.0**[c]	**40.0**[c]	**39.6**[c]

Notes. Bolded numbers represent significant differences [a]<0.005; [b]<0.01; [c]<0.001. *Complete balance tables with all variables are available in Appendix Table 2 for Early Era (2003-2005) patient matches. Dual-eligible is a beneficiary of both Medicare and Medicaid. Measures of patient socioeconomic status were obtained through the American Community Survey and are based on

neighborhood-level characteristics: median household income, percentage of high school graduates and percentage of college graduates.

Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Early Era (2003-2005)



Note. The tails of each box plot represent the lower 5% and upper 95% of the distribution. The mortality risk estimates presented here are based on risk at the time of admission.

Table 8. Exterior Match to Compare Mortality Differences in White Control Groups

			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	1-year mortality	21.45%	20.51%	17.54%***	15.52%***
	30-day mortality	6.71%	7.81%**	6.47%	5.60%**
	Exterior match	**Pvalue**			
	Demo vs. Proc 1-year	0.0009		x	x
	Proc vs. Pres 1-year	< 0.0001	x	x	
	Demo vs. Pres 1-year	< 0.0001	x		x
	Demo vs. Proc 30-day	0.0261		x	x
	Proc vs. Pres 30-day	0.0012	x	x	
	Demo vs. Pres 30-day	< 0.0001	x		x
Recent Era (2013-2015)	1-year mortality	15.87%	16.16%	12.99%***	12.29%***
	30-day mortality	5.70%	7.88%***	5.74%	5.42%
	Exterior match	**Pvalue**			
	Demo vs. Proc 1-year	0.2752		x	x
	Proc vs. Pres 1-year	< 0.0001	x	x	
	Demo vs. Pres 1-year	< 0.0001	x		x
	Demo vs. Proc 30-day	0.4615		x	x
	Proc vs. Pres 30-day	< 0.0001	x	x	
	Demo vs. Pres 30-day	< 0.0001	x		x
Difference between Eras (Recent - Early)	1-year mortality	--	-1.23%	-1.03%	-2.35%
	30-day mortality	--	-1.08%	-0.28%	-0.83%

Note. The two White control groups being compared are marked with an 'x'. P-values test the equality of the mortality in the two White controls groups being compared. Summary: The White control groups are significantly different in all cases except the Demographics vs Demographics+Procedure groups in the Recent Era for both 1-year and 30-day mortality. This suggests that Black patients were having higher risk procedures than White patients in the Early Era, but not the Recent Era.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State specific objectives, including any prespecified hypotheses	1
Methods			
Study design	4	Present key elements of study design early in the paper	2-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	2 & 3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3 & 4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	2
2Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	2 & 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	3 & 4
Statistical methods5	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	5

(e) Describe any sensitivity analyses

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	2
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	2
		(b) Indicate number of participants with missing data for each variable of interest	n/a
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*n/a*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*n/a*
		Cross-sectional study—Report numbers of outcome events or summary measures	*Tables 1 & 2*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 3
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	9 & 10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11 & 12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Title page, cover letter

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Explaining Racial Disparities in Surgical Survival: A Tapered Match Analysis of Patient and Hospital Factors

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Explaining Racial Disparities in Surgical Survival: A Tapered Match Analysis of Patient and Hospital Factors

Karen B. Lasater, PhD, RN[1,2]

Paul R. Rosenbaum, PhD[3,4]

Linda H. Aiken, PhD, RN [1,2]

J. Margo Brooks Carthon, PhD RN[1,2]

Rachel R. Kelz, MD[2,5]

Joseph G. Reiter, MS[3]

Jeffrey H. Silber, MD, PhD [1,2,3,6,7,8]

Matthew D. McHugh, PhD, RN[1,2]

Affiliations:

[1]Center for Health Outcomes and Policy Research, School of Nursing, University of Pennsylvania, Philadelphia, PA USA

[2]The Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, PA

[3]Center for Outcomes Research, Children's Hospital of Philadelphia, Philadelphia, PA USA

[4]Department of Statistics and Data Science, The Wharton School, University of Pennsylvania, Philadelphia, PA USA

[5]Department of Surgery, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[6]Department of Pediatrics, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[7]Department of Anesthesiology and Critical Care, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA USA

[8]Department of Health Care Management, The Wharton School, University of Pennsylvania, Philadelphia, PA USA

Address Correspondence to: Karen B. Lasater. Center for Health Outcomes and Policy Research, University of Pennsylvania School of Nursing. 418 Curie Boulevard, Fagin Hall Philadelphia, PA 19104. (215) 746-8362. karenbl@nursing.upenn.edu

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ABSTRACT

Objectives. Evaluate whether hospital factors, including nurse resources, explain racial differences in Medicare Black and White patient surgical outcomes, and whether disparities changed over time.

Design. Retrospective tapered-match.

Setting. 571 hospitals at two time-points (Early Era 2003-2005; Recent Era 2013-2015).

Participants. 6,752 Black patients and 3 sets of 6,752 White controls selected from 107,001 potential controls (Early Era). 4,964 Black patients and 3 sets of 4,964 White controls selected from 74,108 potential controls (Recent Era).

Interventions. Black patients were matched to White controls on Demographics (age, sex, state, year of procedure), Procedure (Demographics variables plus 136 ICD-9 principal procedure codes), and Presentation (Demographics and Procedure variables plus 34 comorbidities, a mortality risk score, a propensity score for being Black, emergency admission, transfer status, predicted procedure time).

Outcomes. 30-day and 1-year mortality.

Results. Before matching, Black patients had more comorbidities, higher risk of mortality despite being younger, and underwent procedures at different percentages than White patients. Whites in the Demographics match had lower mortality at 30-days (5.6% vs 6.7% Early Era; 5.4% vs 5.7% Recent Era) and 1-year (15.5% vs 21.5% Early Era; 12.3% vs 15.9% Recent Era). Black-White 1-year mortality differences were equivalent after matching patients with respect to Presentation, Procedure, and Demographic factors. Black-White 30-day mortality differences were equivalent after matching on Procedure and Demographic factors. Racial disparities in outcomes remained unchanged between the two time periods spanning 10 years. All patients in

hospitals with better nurse resources had lower odds of 30-day (OR 0.60, 95% CI 0.46-0.78, p<0.010) and 1-year mortality (OR 0.77, 95% CI 0.65-0.92, p<0.010) even after accounting for other hospital factors.

Conclusions. Survival disparities among Black and White patients are largely explained by differences in Demographic, Procedure, and Presentation factors. Better nurse resources (e.g., staffing, work environment) were associated with lower mortality for all patients.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Tapered multivariate matching approach allows for sequentially matching Black patients to different sets of White patients to understand which patient and hospital-level factors contribute to the observed outcomes disparity.
- Measures of hospital nurse resources are derived directly from staff nurses
- Patient outcomes include 30-day and 1-year mortality and 30-day readmission
- Comorbidities used to match Black and White patients may be fallible markers of clinical severity and frailty

INTRODUCTION

Major National Academy of Medicine reports,[1, 2] document the existence of racial disparities in hospital outcomes. Worse outcomes among Black patients have been attributed to differences in illness severity,[3, 4] disparities in treatment,[5] and variation in hospital quality.[6, 7] Each of these factors is a function of structural racism arising out of long-standing discriminatory systems, policies, and institutions across sociopolitical domains including education, housing, criminal justice, and healthcare.[8] Although systematic differences in hospitals where patients receive care may contribute to disparities,[9-12] little evidence specifies exactly which hospital factors are associated with worse disparities.

We focus on a modifiable aspect of hospitals—nurse resources. An evaluation of the role of nurse resources is warranted since they vary widely across hospitals[13, 14] and a large literature shows that patients in hospitals where nurses care for fewer patients at a time, have a skill mix rich in registered nurses (RNs), high proportions of bachelors-educated nurses (BSNs), and a favorable nurse work environment, experience better outcomes including lower mortality.[14-17] Evidence suggests the survival benefits conferred by better nurse resources accrue to all patients; however, they may be particularly beneficial for Black patients.[18-21] Our motivation was to understand whether variation in hospital nurse resources differentially impact survival outcomes of Black and White patients following surgery, whether improving these resources hold promise as an interventional target for reducing racial disparities and improving outcomes; and whether racial disparities in surgical outcomes have improved or worsened over time.

METHODS

Design and Data Sources

This is a retrospective multivariate tapered matching study that uses secondary data of patients and hospitals at two cross-sections in time: 2003-2005 (i.e., Early Era) and 2013-2015 (i.e., Recent Era). Data about patients were obtained from Centers for Medicare and Medicaid Services. Data about hospitals were obtained from the American Hospital Association Annual Survey which provided information on hospital size, the Healthcare Cost Report Information System dataset which provided information on hospital teaching status, and the RN4CAST-US survey which provided information about hospital nurse resources. Time periods for the Early and Recent Era were selected based on the availability of the RN4CAST-US survey data.

Patient Population

The patient sample included non-Hispanic Black and non-Hispanic White Medicare fee-for-service beneficiaries, who were 65.5 years or older and who were admitted to one of the study hospitals for general surgery (Appendix Table 1) either between January 1, 2004–September 30, 2006, or January 1, 2013–September 30, 2015. Using race to characterize patients should not be interpreted as race representing innate biological differences. Race is a social construct; it reflects differences in experiences and exposure to systematic discrimination that produces observable harm and differences in health outcomes. Patient data included Research Identifiable Files: inpatient, outpatient, carrier (physician Part B), hospice, and the master beneficiary summary file. Patients were excluded if there was missing data on age or sex, had an invalid date

of death, or were enrolled in an HMO or lacked Part B coverage in the 6 months prior to their index hospitalization.

For patients with multiple admissions, the index hospitalization was defined by randomly selecting one admission. A 180-day look-back from the index admission was performed across all patient files to identify comorbidities. A 30-day mortality risk model to estimate each patient's probability of death at the time of admission was constructed using a 10% random sample of data that did not overlap with the analytic sample (Appendix Tables 2a and 2b). Propensity scores to be a Black individual were estimated using the covariates controlled in each match (Appendix Tables 3-4). Other characteristics included age, sex, transfer-in status, emergent admission, and 34 comorbidities. This is a retrospective study of patient claims data and thus there was no participation consent for patients.

Hospital Sample

The RN4CAST-US is a large panel survey of RNs, conducted at two points in time (i.e., 2005-2006; 2015-2016) in four large U.S. states: California, Florida, New Jersey, Pennsylvania. Both surveys employed the same methodology—a modified Dillman approach[22] to randomly sample actively licensed RNs from state licensure lists.[23] Nurses consented to participation in the RN4CAST-US by completing the survey. Nurses reported the name of their employer, demographics, and details about resources in their hospital, including patient-to-nurse staffing ratios, nurse skill mix, and the quality of the work environment. Our focus was adult, general, acute care hospitals in the four states.

Averages among RNs in the same hospitals were used to create aggregated hospital-level measures of nurse resources, consistent with prior research[15] and is a validated method of using multiple informants to generate organizational measures.[23] Our hospital-level measure of staffing, i.e., patient-to-nurse ratios, is derived by taking the average number of patients per direct-care RN on medical-surgical units within the same hospital. Skill mix is the proportion of RNs to all nursing personnel (i.e., RNs, licensed practice nurses, unlicensed assistive personnel). Nurse education is the hospital proportion of RNs holding a BSN or higher. Nurse work environment is derived from the National Quality Forum-endorsed 31-item Practice Environment Scale of the Nursing Work Index, comprised of 5 subscales: Nurse Participation in Hospital Affairs; Nursing Foundations for Quality of Care; Nurse Manager Ability, Leadership and Support of Nurses; Staffing and Resource Adequacy; Collegial Nurse-Physician Relations.[24]

Hospital nurse resources are presented as a three-category variable characterized by terciles of hospitals according to their percentile ranking which ranged from 0% (poorest nurse resources) to 100% (best nurse resources) based on a coherence rank score.[25] This approach gives equal weight to the four nurse resources in computing the coherence rank score, as we have done in prior studies,[15, 26] since we had no a priori hypothesis that one resource would be more important to patient outcomes than another. The score describes how each hospital compared to others based on the four resources.[15, 26] Hospitals present in both eras were ranked twice, once in each era. Ranks were formed by comparing hospitals two at a time – which of the two hospitals is better? – and then aggregating the pairwise comparisons. If hospital *i* had better nurse resources on all measures than hospital *j*, it received 1 point; if hospital *i* had worse nurse resources than hospital *j*, it lost one point, or received −1 points; and if hospital *i* was better on some measures

and worse on others, it received 0 points. The rank for hospital *i* is its total points, i.e., the number of hospitals that were worse than hospital *i* minus the number that were better than hospital *i*.

Outcomes

30-day and 1-year mortality (defined as a death within 30 days and 1 year of admission, respectively). 30-day readmission (or death) outcomes are reported in the Appendix (Tables 5-6). Mortality and readmission outcomes were 'all-cause' and determined by data reported in the CMS patient files.

Statistical Analysis

Matching Methodology

The tapered multivariate matching approach[3, 27-30] sequentially matches the same Black patients to different sets of White patients, controlling for consecutively more variables to understand the contribution of various factors to the outcomes disparity.[27] The goal is to understand the extent of and factors driving the racial disparities in outcomes between Black and White patients. By incrementally matching White patients to Black patients on additional variables, we can directly observe how the matched White cohort changes with respect to their outcomes. Our tapered matching procedure includes three tapers (or sets of matches). First, the Demographics taper included variables for age, sex, state, and year of procedure. Second, the Procedure taper included all the variables from the Demographics taper and added ICD-9 principal procedure codes. Third, the Presentation taper included all the variables from the Procedure and Demographics tapers and added patient risk factors related to health status at the time of surgery,

including 34 comorbidities, a mortality risk score, emergency admission, transfer status, and predicted procedure time. Patients were exactly matched within era and state (with New Jersey and Pennsylvania combined), for 136 ICD-9 procedure codes, and mortality risk quintile (Appendix Tables 3-4). Fine balance and distance minimization techniques were used to make matched groups as similar as possible.

Statistical Methods

Comparisons within pairs used McNemar's test and conditional logit regression. We compared the Black-White difference in the Early and Late Eras to test whether the disparity changed over time. These analyses used Gart's test[31] to compare disparities in the Early Era to disparities in the Recent Era.[32] Conditional logit regression models were performed at the Presentation Match (i.e. using the White patient cohort that was similar to the Black patients with respect to Demographic, Procedure, and Presentation variables), and using data from both eras combined to test nurse resources, race, and combinations of their interactions, accounting for structural hospital characteristics (i.e., size, teaching status, technology capabilities, general surgery volume). Hospital size was defined as large (>250 beds), medium (101-250 beds), or small (≤100 beds). Teaching status was defined by the medical resident to beds (RB) ratio (nonteaching: 0 RB; minor teaching: >0 RB and ≤0.25 RB; major teaching: >0.25 RB). A high technology hospital was defined as having the capability to perform major organ transplantation and/or open-heart surgery. General surgery volume was defined as a continuous measure of the number of general surgical cases per 100 patients in each hospital during the study period.

Patient and Public Involvement

Patients were not directly involved in the development of the research question or outcome measures, the study design, or the recruitment and conduct of the study.

RESULTS

Quality of Patient Matches

The matches are shown in Table 1 (Recent Era) and Appendix Table 7 (Early Era). Table 1 describes 4,964 Black patients and 3 sets of 4,964 White controls—selected from a population of 74,108 White patients. In each taper, White controls become more like the Black patients. Matched variables (i.e., left of the zigzag line) were similar: the standardized differences in means never exceeded 0.11 SDs. Unmatched variables (i.e., right of the zigzag line) show the disparity prior to matching. Comparisons in the Demographic match reveal differences in the types of procedures Black and White patients receive. For example, Black patients underwent a laparoscopic cholecystectomy less (18.9%) than White patients (21.3%, $p<0.01$). Black patients had more comorbidities, and in some cases were much more likely to have a chronic condition such as diabetes (51.3% vs 32.8%), despite being 1.5 years younger on average. The Demographics match removed age, sex, state, and year of procedure differences, the Procedure match included Demographics match variables and removed differences in procedures, and the Presentation match included all Demographics and Procedure variables and further matched on variables reflecting health status by selecting White controls that had similar mortality risk and comorbidity burden as Black patients. The cohort of White patients in the Presentation match are different than the 'unmatched' White patients, in that the White patients in the Presentation

match have a substantially higher burden of comorbidities that are more comparable to the burden of comorbidities observed in the Black population.

We made no attempt to match on measures of socioeconomic status (SES), including dual-eligibility, and neighborhood-level socioeconomic variables (i.e., median household income, percentage of high school graduates, percentage of college graduates) because socioeconomic status variables are highly correlated with race in the U.S. Black patients were nearly 4 times more likely to be dual-eligible compared with unmatched Whites, and more likely to live in neighborhoods with markers of lower SES. After matching on Demographic, Procedure, and Presentation variables, White controls looked more like Black patients with respect to SES indicators, however large and important differences remained (e.g., 37.4% Black patients were dual-eligible vs 14.8% of White controls, $p<0.001$).

Table 1. Quality of Matches for Selected* Variables, Recent Era (2013-2015)

		Tapered Matches	

Variable	**Black Patients**	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics	White Patients (unmatched)
	(n = 4,964)	(n = 4,964)	(n = 4,964)	(n = 4,964)	(n = 74,108)
State (%)					
California	24.3	24.3	24.3	24.3	**27.8**[c]
Florida	34.1	34.1	34.1	34.1	35.4
New Jersey / Pennsylvania	41.6	41.6	41.6	41.6	**36.8**[c]
Year of Procedure (%)					
2013	23.1	23.2	23.1	23.1	22.9
2014	43.7	43.7	43.7	43.7	44.6
2015	33.2	33.1	33.2	33.2	32.6
Age at Procedure	75.5	**75.0**[b]	75.4	75.5	**77.0**[c]
% Male	39.3	39.3	39.3	39.3	**44.7**[c]
Procedures (%)					
Laparoscopic cholecystectomy (5123)	18.9	18.9	18.9	**21.3**[b]	**21.6**[c]
Open right hemicolectomy (4573)	7.6	7.6	7.6	**6.4**[a]	**6.6**[b]
Partial resection of small intestine (4562)	7.0	7.0	7.0	**5.7**[a]	**5.6**[c]
Laparoscopic right hemicolectomy (1733)	4.8	4.8	4.8	4.3	4.4
Open cholecystectomy (5122)	3.1	3.1	3.1	3.2	3.3
Selected Comorbidities (%)					
Hypertension	93.2	93.3	**84.9**[c]	**84.7**[c]	**85.1**[c]
Diabetes	51.3	51.1	**33.7**[c]	**32.6**[c]	**32.8**[c]
Congestive heart failure	26.1	25.9	**18.0**[c]	**18.2**[c]	**19.4**[c]
Renal dialysis	42.2	41.7	**26.9**[c]	**26.1**[c]	**28.4**[c]
Renal failure	14.0	6.5	**5.5**[c]	**5.7**[c]	**4.1**[c]
Paraplegia	6.1	**4.5**[c]	**2.1**[c]	**2.1**[c]	**2.1**[c]
Mortality Risk Score (prob)	0.069	0.067	**0.055**[c]	**0.050**[c]	**0.056**[c]
Emergency admission (%)	56.9	58.4	**50.2**[c]	**50.2**[c]	**50.5**[c]
Transfer status (%)	1.1	1.0	0.9	0.9	**0.8**[a]
Anesthesia time (minutes)	155	**150**[c]	**150**[c]	**152**[c]	**151**[c]
Dual-eligible (%)	37.4	**14.8**[c]	**11.7**[c]	**10.6**[c]	**10.4**[c]
Neighborhood median household income ($)	24,267	**32,070**[c]	**32,970**[c]	**32,843**[c]	**32,755**[c]
Neighborhood high school graduate (%)	83.2	**88.8**[c]	**89.3**[c]	**89.2**[c]	**89.2**[c]
Neighborhood college graduate (%)	32.8	**39.9**[c]	**40.9**[c]	**40.9**[c]	**40.9**[c]

Notes. The zigzag diagonal line indicates which variables are controlled in each match: variables to the right of the line are not controlled. The table shows only a few of the variables, – in particular, a few of the surgical procedures – that were controlled in each match. Bolded numbers represent significant differences [a]<0.005; [b]<0.01; [c]<0.001. *The complete balance tables with all variables are available in Appendix Table 4 for Recent Era (2013-2015) patient matches. Dual-eligible is a beneficiary of both Medicare and Medicaid. Measures of patient

socioeconomic status were obtained through the American Community Survey and are based on neighborhood-level characteristics: median household income, percentage of high school graduates and percentage of college graduates.

Figure 1 demonstrates differences in Black and White patients' estimated mortality risk on admission prior to matching (i.e., White Unmatched) and at each taper of the match. The largest disparity in estimated mortality risk is observed in the Demographics match—likely because this match requires patients to be the same on age and sex, which selects for White controls who were 1.5 years younger than the typical White patient and fewer males. As we move through the tapers, the racial disparity in estimated mortality risk narrows. The result of the matching process is a White control group that is profoundly different than the initial White population. Appendix Figure 1 presents comparisons in the Early Era with similar findings.

Outcome Results

Mortality outcomes for Black patients and the 3 sets of White controls are reported in Table 2. In the Early and Recent Eras, after matching White controls with similar demographics as the Black cohort (i.e., Demographics match), we observe higher 1-year mortality among Black patients. 1-year mortality differences narrow after matching on procedure but remain significantly higher among Black patients. After selecting White controls that presented as sick as Black patients (i.e., Presentation match), 1-year mortality differences become statistically insignificant. 30-day mortality differences diminished after matching on Procedure. The bottom most panel of Table 2 reports whether the Black-White difference changed over time, defined by the Black-White difference in the Recent Era minus the Black-White difference in the Early Era. Survival disparities did not change significantly over the two eras separated by 10 years. Survival curves of Black patients and White controls are presented in Figure 2. In the Early and Recent Eras,

White controls at the Presentation Match had the lower probability of survival in the time-period most proximal to hospital admission; however, at 1-year from hospitalization Black patients had lower survival odds. The mortality in White control groups changed significantly as more covariates were controlled in all cases, except the move from the Demographics control group to the Demographics + Procedure control group in the Recent Era, where the difference in mortality at 30-days and 1-year was not significant (Appendix Table 8).

Table 2. Mortality Outcomes for Black Study Population and 3 Matched White Populations: Early Era (2003-2005), Recent Era (2013, 2015), and the Difference between the Eras to Evaluate whether the Black-White Difference is Different in the Two Eras

			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	1-year mortality	21.45%	20.51%	17.54%***	15.52%***
	30-day mortality	6.71%	7.81%**	6.47%	5.60%**
Recent Era (2013-2015)	1-year mortality	15.87%	16.16%	12.99%***	12.29%***
	30-day mortality	5.70%	7.88%***	5.74%	5.42%
Difference in Difference (Recent - Early)	1-year mortality	--	-1.23%	-1.03%	-2.35%
	30-day mortality	--	-1.08%	-0.28%	-0.83%

Note. Black-White difference between eras is defined by the Black-White difference in Recent Era minus the Black-White difference in Early Era. Significance tests for binary variables used McNemar test (* <0.05, ** <0.01, ***<0.001). For the difference in difference across eras, Gart's test for binary outcomes was used (+ < 0.05, ++ < 0.01, +++ < 0.001). The symbols were marked in the later era if the difference in difference was significant.

In Tables 1 and 2, the statistics (i.e. comparisons of differences in variables between Black and White patients) are crude in the sense that we do not employ regression modeling for adjustments. With each tapered match of our multivariate tapered matching procedure we are selecting a new cohort of White patients who more closely resemble the Black patients on the variables of that match. Thus, there is no formal adjustment procedure occurring since these are the observed characteristics of the White and Black cohorts.

Conditional logit models further analyze Black-White patient pairs (Table 3). These models attempt to tease apart race, nurse resources, their interaction, and other hospital attributes. Each model has a parameter for each matched pair, representing the many covariates that were made similar in that pair. If a covariate is matched, it is already in the model via these pair effects. Aside from the many pair effects, race and hospital-level variables are the only variables in the model. All hospital-level variables (except volume) are two-category variables, and the coefficient is the odds ratio (OR) comparing the two categories. The volume variable is in units of 100 patients on the logit scale, such that an OR 0.9, for example, would be comparing two hospitals, one with 100 more general surgery patients than the other. Model 1a is like the Table 2 Presentation Match in which Black patients have lower odds of 30-day mortality (OR 0.77, 95% CI 0.69-0.85, p <0.001). In Model 2a, high nurse resources are associated with substantially lower mortality (OR 0.58, 95% CI 0.46-0.74, p<0.001), and this pattern appears to be the same or nearly so for Black and White patients. As in Table 2, 1-year mortality outcomes are not significantly different among Black and White patients who were matched on Demographic, Procedure, and Presentation characteristics (Models 1b-4b). High nurse resources are strongly associated with lower 1-year mortality (Model 2b), apparently in the same way for Blacks and

Whites (Model 3c), persisting even after adjusting for hospital-level characteristics (Model 4b). Findings were similar for 30-day readmission (Appendix Table 6).

The simplest model that fits well includes race and nurse resources (Models 2a and 2b). The addition of interactions between race and nurse resources or additional hospital attributes did not improve the model. This is evident in the test-statistics reported in the bottom of Table 3 which describe the improvement in fit for each model compared to the prior model. P-values greater than 0.05 mean we fail to reject the simpler model in favor of the more complex model.

Table 3. Effect of Race and Hospital Nurse Resources on 30-day and 1-year Mortality Odds, After Matching Patients on Demographics, Procedure, and Presentation Variables

	30-day mortality				1-year mortality			
	Model 1a	Model 2a	Model 3a	Model 4a	Model 1b	Model 2b	Model 3b	Model 4b
Variables in the Model	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Black (vs. White)	0.77*** (0.69-0.85)	0.79*** (0.71-0.88)	0.75*** (0.64-0.87)	0.75*** (0.64-0.88)	1.03 (0.96-1.11)	1.08 (0.98-1.13)	1.05 (0.95-1.17)	1.05 (0.94-1.16)
Nurse Resources (High vs Low)	---	0.58*** (0.46-0.74)	0.59*** (0.46-0.74)	0.60** (0.46-0.78)	---	0.75*** (0.64-0.88)	0.75*** (0.64-0.88)	0.77** (0.65-0.92)
Nurse Resources (Middle vs Low)	---	0.83 (0.68-1.00)	0.82* (0.68-1.00)	0.83 (0.68-1.01)	---	0.94 (0.80-1.03)	0.91 (0.80-1.03)	0.91 (0.80-1.04)
Black*Nurse Resources (High vs Low)	---	---	0.91 (0.78-1.07)	0.92 (0.78-1.08)	---	---	1.01 (0.90-1.13)	1.02 (0.91-1.13)
Black*Nurse Resources (Middle vs Low)	---	---	0.95 (0.80-1.13)	0.95 (0.80-1.13)	---	---	0.99 (0.88-1.11)	0.99 (0.88-1.11)
Major Teaching Hospital	---	---	---	0.93 (0.72-1.21)	---	---	---	0.97 (0.82-1.15)
Minor Teaching Hospital	---	---	---	0.97 (0.80-1.18)	---	---	---	1.03 (0.90-1.17)
Large Size (>250 beds)	---	---	---	0.98 (0.81-1.19)	---	---	---	0.97 (0.85-1.10)
High Technology Hospital	---	---	---	1.08 (0.90-1.29)	---	---	---	1.07 (0.94-1.21)
General Surgery Volume, per 100 patients	---	---	---	0.99 (0.96-1.01)	---	---	---	0.99 (0.97-1.00)
Test for improvement in fit with greater model complexity								
Chi-square	---	20.03	1.25	1.80	---	12.42	0.13	4.94
Degrees of Freedom	---	2	2	5	---	2	2	5
p-value	---	< 0.0001	0.5350	0.8756	---	0.0020	0.9363	0.4227

Note. Conditional logit models show the effects of race and hospital nurse resources for pairs of Black and White patients who have been closely matched on demographic characteristics (age, sex, state, year of procedure), procedure (ICD-9 principal procedure code), and presentation (34 comorbidities, mortality risk score, propensity score for being Black, emergency admission indicator, transfer status indicator, predicted procedure time). Data from both eras are combined in this analysis. Nurse resources represent a three-category variable characterized by terciles of hospitals according to their percentile ranking. The general surgery volume variable

represents the effect of a 100-patient increase in general surgery volume on patient odds of 30-day mortality. *p<0.05; **p<0.01; ***p<0.001**.** Summary: High levels of nursing resources were associated with substantially lower mortality for both Black and White patients, with no indication of interaction.

DISCUSSION

Study results reveal outcomes disparities are largely explained by significant differences in clinical presentation between Black and White patients. Among Black and White patients matched for Demographics (i.e., age, sex, state, year of procedure), we found significantly higher 30-day and 1-year mortality among Black patients. This is consistent with prior evidence of racial outcomes disparities in surgical patients.[2, 33, 34] Black patients in our sample had a heavier burden of comorbidity and mortality risk than White patients. Despite being younger, Black patients had more comorbidities, more emergency admissions, and higher mortality risk upon admission. Black patients also underwent procedures at different percentages. Only after closely matching patients to account for these differences did the mortality advantage for White controls disappear.

Our research is not the first to find higher mortality among White patients after accounting for racial differences in clinical presentation.[3, 4, 18, 35-37] Cumulative effects of centuries of systematic discrimination in virtually all domains of life (e.g., education, housing, criminal justice, policy benefits, job opportunities, pay, political power, access to high quality healthcare) underlie observable clinical presentation differences. Thus, system-level reforms across these domains are necessary to begin to undo the harms generating differences in health status and survival outcomes.

Our second major finding is that surgical disparities—at least for general surgeries—have not narrowed overtime. This is in contrast to what Mehtsun and colleagues found[38]—though that

analysis focused on 8 procedures and included orthopedic and vascular surgeries. In our study, we found that while mortality and readmissions were lower in the Recent Era (2013-2015) for both Black patients and White controls, the differences between the two groups remained unchanged overtime.

Our third major finding is that differences in hospitals are a significant contributor to variation in outcomes for all surgical patients, both Black and White. Specifically, receiving care in hospitals with better nurse resources was associated with lower odds of death, even after accounting for other hospital factors (i.e., teaching status, technology capability, size, surgery volume). Being in a hospital with high nurse resources predicted a much larger reduction in mortality than did race. High nurse resources predicted lower mortality for both Black and White patients, to the same or similar degree. Some research has shown that nurse resource deficiencies result in even worse outcomes for Black patients,[18-21] but perhaps this difference is a function of our use of a composite measure which simultaneously evaluates all four aspects of nurse resources versus isolating the effect of a single resource; other investigations focused mainly on nurse staffing.

That our results suggest that better nurse resources, as opposed to other hospital factors are associated with higher survival outcomes, is important. Whereas the other hospital factors we measured here are difficult to modify, nurse resources are modifiable through actions of hospital administrators or policy intervention. Hospital administrators can make it their strategic priority to staff greater numbers of nurses, including higher proportions of BSN-prepared nurses and a richer skill mix of RNs, as well as improve their nurse work environments via management reforms and evidence-based interventions like the American Nurses Credentialling Center

Magnet® Program.[39, 40] At the policy-level, states can follow the example of California—the first and only state to legislate hospitals hire enough nurses to safely care for patients. The result of this policy has improved nurse staffing ratios and made more even the staffing variability across the state.[41, 42] Recent studies show wide variation in the average nurse staffing ratios within states,[13, 43] ranging from 3.3 to 9.7 patients-per-nurse on medical-surgical units.[13] If other states followed California's example by enacting minimum safe nurse staffing policies, it would raise the floor on hospital nurse staffing while making more even the variability across hospitals.

Limitations

Despite carefully matching on demographic, procedure, and presentation differences, we are unable to account for possible within-hospital differences experienced by Black and White patients, for example, the possibility of selection bias wherein surgeons may be less likely to operate on Black patients compared to similarly ill White patients.[5, 44] Thus, our analysis of surgical patients may include somewhat healthier Black patients than their matched White controls. Comorbidities utilized for matching patients may be fallible markers of clinical severity and frailty or have within-category variation leading to residual differences in presentation despite careful and comprehensive matching. Next, although we use the White population as the reference group, it should not be interpreted that the White population's outcomes are the ideal referent or the best that could be achieved in terms of outcomes for Black patients. Studies using other referent groups (e.g., not-low-SES White[45, 46]) would be useful, as would research within the Black population alone to understand possible strengths that could be leveraged to improve outcomes that may be unique to the population. Finally, our tapered-matched design makes transparent the comparisons between Black and White patients and shows that the Black-White

survival disparity is largely explained by differences in Demographic, Procedure and Presentation factors. It is possible; however, that unmeasured confounders may be important to further investigate health disparities after discharge, which we did not do in this study but could be relevant to survival outcomes over a year following surgery.

Conclusions

In summary, there is a large racial disparity in mortality among Medicare patients undergoing general surgery. Black and White patients present differently even when undergoing the same procedure. Despite being younger, Black patients are more likely to have higher comorbidity burden and greater risk of mortality. We found racial outcomes disparities following surgery have not improved over the decade, but organizational and policy reform have the potential to improve outcomes for Black and White patients alike. Even after accounting for demographic, procedure, and presentation differences, better nurse resources—a modifiable feature of hospitals—were significantly associated with improved survival for both Black and White patients.

Ethics Approval Statement

This study was approved by the Children's Hospital of Philadelphia Institutional Review Board (19-016296).

Contributorship Statement

All authors meet the criteria recommended by the International Committee of Medical Journal Editors (ICMJE). PRR, LHA, JMBC, RRK, JHS, and MDM contributed to the original idea and design of the study. KBL, LHA, JMBC, and MDM contributed to the collection of nurse survey data. JGR conducted the data analysis. All authors contributed to the interpretation of the data and preparation of the submitted manuscript. All authors approved the submitted manuscript.

Competing Interests

None declared.

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Data Sharing Statement

The nurse survey data are not available. The patient data are from the Centers for Medicare and Medicaid Services and approval for their use can be requested directly from CMS.

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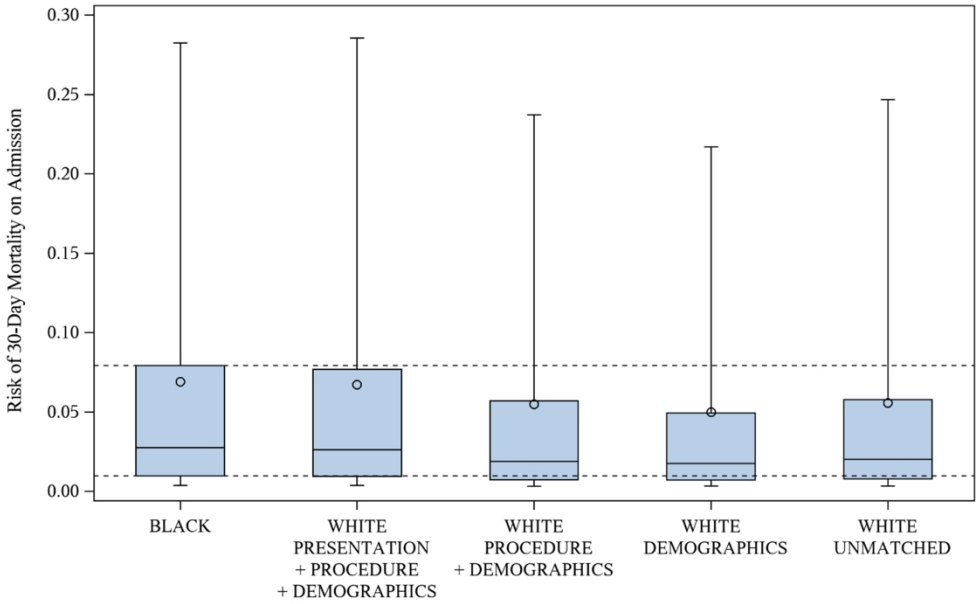
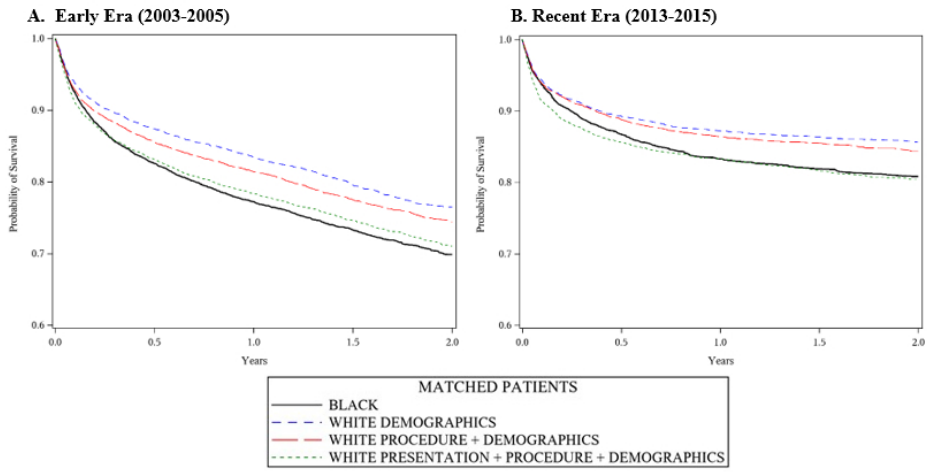
Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Recent Era (2013-2015)



Note. The tails of each box plot represent the lower 5% and upper 95% of the distribution. The mortality risk estimates presented here are based on risk at the time of admission. Early Era results look similar and are presented in Appendix Figure 1. Summary: Until matched for surgical procedure and comorbid conditions in the "White Presentation" match, Black patients had a combination of surgical procedures and comorbid conditions that placed them at elevated risk of death compared to White controls.

Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Recent Era (2013-2015)



Summary. The substantially higher mortality among Black patients is most evident over a longer span of time, is not concentrated in the brief period around surgery, and reflects a greater burden of comorbid conditions and a more frequent need for higher risk procedures. Black and White patients had lower mortality in the Recent Era (2013-2015), but there is no clear indication that the Black-White disparity has diminished.

Figure 2. Kaplan-Meier Plot for Survival for Black Study Population and 3 Matched White Populations

APPENDIX

Table 1. List of General Surgical Procedures on Which Black and White Patients Were Exact Matched

Procedure Code	Procedure Name
PPX 062	Unilateral thyroid lobectomy
PPX 0631	Excision of lesion of thyroid
PPX 0639	Other partial thyroidectomy
PPX 064	Complete thyroidectomy
PPX 0650	Substernal thyroidectomy, not otherwise specified
PPX 0651	Partial substernal thyroidectomy
PPX 0652	Complete substernal thyroidectomy
PPX 0681	Complete parathyroidectomy
PPX 0689	Other parathyroidectomy
PPX 0722	Unilateral adrenalectomy
PPX 1711	Laparoscopic repair of direct inguinal hernia with graft or prosthesis
PPX 1712	Laparoscopic repair of indirect inguinal hernia with graft or prosthesis
PPX 1713	Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 1721	Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis
PPX 1722	Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis
PPX 1723	Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis
PPX 1724	Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 1731	Laparoscopic multiple segmental resection of large intestine
PPX 1732	Laparoscopic cecectomy
PPX 1733	Laparoscopic right hemicolectomy
PPX 1734	Laparoscopic resection of transverse colon
PPX 1735	Laparoscopic left hemicolectomy
PPX 1736	Laparoscopic sigmoidectomy
PPX 1739	Other laparoscopic partial excision of large intestine
PPX 415	Total splenectomy
PPX 4240	Esophagectomy, not otherwise specified
PPX 4241	Partial esophagectomy
PPX 4242	Total esophagectomy
PPX 427	Esophagomyotomy
PPX 4342	Local excision of other lesion or tissue of stomach
PPX 435	Partial gastrectomy with anastomosis to esophagus
PPX 436	Partial gastrectomy with anastomosis to duodenum
PPX 437	Partial gastrectomy with anastomosis to jejunum
PPX 4389	Open and other partial gastrectomy
PPX 4399	Other total gastrectomy
PPX 4429	Other pyloroplasty
PPX 4438	Laparoscopic gastroenterostomy
PPX 4439	Other gastroenterostomy without gastrectomy
PPX 4441	Suture of gastric ulcer site
PPX 4442	Suture of duodenal ulcer site
PPX 4466	Other procedures for creation of esophagogastric sphincteric competence

PPX 4467	Laparoscopic procedures for creation of esophagogastric sphincteric competence
PPX 4469	Other repair of stomach
PPX 4561	Multiple segmental resection of small intestine
PPX 4562	Other partial resection of small intestine
PPX 4563	Total removal of small intestine
PPX 4571	Open and other multiple segmental resection of large intestine
PPX 4572	Open and other cecectomy
PPX 4573	Open and other right hemicolectomy
PPX 4574	Open and other resection of transverse colon
PPX 4575	Open and other left hemicolectomy
PPX 4576	Open and other sigmoidectomy
PPX 4579	Other and unspecified partial excision of large intestine
PPX 458	Other and unspecified partial excision of large intestine
PPX 4581	Laparoscopic total intra-abdominal colectomy
PPX 4582	Open total intra-abdominal colectomy
PPX 4583	Other and unspecified total intra-abdominal colectomy
PPX 4590	Intestinal anastomosis, not otherwise specified
PPX 4591	Small-to-small intestinal anastomosis
PPX 4592	Anastomosis of small intestine to rectal stump
PPX 4593	Other small-to-large intestinal anastomosis
PPX 4594	Large-to-large intestinal anastomosis
PPX 4595	Anastomosis to anus
PPX 4601	Exteriorization of small intestine
PPX 4603	Exteriorization of large intestine
PPX 4610	Colostomy, not otherwise specified
PPX 4611	Temporary colostomy
PPX 4613	Permanent colostomy
PPX 4620	Ileostomy, not otherwise specified
PPX 4621	Temporary ileostomy
PPX 4622	Continent ileostomy
PPX 4623	Other permanent ileostomy
PPX 4639	Other enterostomy
PPX 4642	Repair of pericolostomy hernia
PPX 4651	Closure of stoma of small intestine
PPX 4652	Closure of stoma of large intestine
PPX 4673	Suture of laceration of small intestine, except duodenum
PPX 4674	Closure of fistula of small intestine, except duodenum
PPX 4675	Suture of laceration of large intestine
PPX 4679	Other repair of intestine
PPX 4701	Laparoscopic appendectomy
PPX 4709	Other appendectomy
PPX 4849	Other pull-through resection of rectum
PPX 485	Other pull-through resection of rectum
PPX 4850	Abdominoperineal resection of the rectum, not otherwise specified
PPX 4851	Laparoscopic abdominoperineal resection of the rectum
PPX 4852	Open abdominoperineal resection of the rectum
PPX 4862	Anterior resection of rectum with synchronous colostomy
PPX 4863	Other anterior resection of rectum
PPX 4869	Other resection of rectum

PPX 4875	Abdominal proctopexy
PPX 4876	Other proctopexy
PPX 5022	Partial hepatectomy
PPX 5029	Other destruction of lesion of liver
PPX 503	Lobectomy of liver
PPX 5122	Cholecystectomy
PPX 5123	Laparoscopic cholecystectomy
PPX 5124	Laparoscopic partial cholecystectomy
PPX 5132	Anastomosis of gallbladder to intestine
PPX 5136	Choledochoenterostomy
PPX 5137	Anastomosis of hepatic duct to gastrointestinal tract
PPX 5141	Common duct exploration for removal of calculus
PPX 5151	Exploration of common duct
PPX 5252	Distal pancreatectomy
PPX 5259	Other partial pancreatectomy
PPX 526	Total pancreatectomy
PPX 527	Radical pancreaticoduodenectomy
PPX 5300	Unilateral repair of inguinal hernia, not otherwise specified
PPX 5301	Other and open repair of direct inguinal hernia
PPX 5302	Other and open repair of indirect inguinal hernia
PPX 5303	Other and open repair of direct inguinal hernia with graft or prosthesis
PPX 5304	Other and open repair of indirect inguinal hernia with graft or prosthesis
PPX 5305	Repair of inguinal hernia with graft or prosthesis, not otherwise specified
PPX 5310	Bilateral repair of inguinal hernia, not otherwise specified
PPX 5311	Other and open bilateral repair of direct inguinal hernia
PPX 5313	Other and open bilateral repair of inguinal hernia, one direct and one indirect
PPX 5314	Other and open bilateral repair of direct inguinal hernia with graft or prosthesis
PPX 5315	Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis
PPX 5316	Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis
PPX 5317	Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified
PPX 5321	Unilateral repair of femoral hernia with graft or prosthesis
PPX 5329	Other unilateral femoral herniorrhaphy
PPX 5341	Other and open repair of umbilical hernia with graft or prosthesis
PPX 5349	Other open umbilical herniorrhaphy
PPX 5351	Incisional hernia repair
PPX 5359	Repair of other hernia of anterior abdominal wall
PPX 5361	Other open incisional hernia repair with graft or prosthesis
PPX 5369	Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis
PPX 537	Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis
PPX 5372	Other and open repair of diaphragmatic hernia, abdominal approach
PPX 5451	Laparoscopic lysis of peritoneal adhesions
PPX 5459	Other lysis of peritoneal adhesions
PPX 5493	Creation of cutaneoperitoneal fistula
PPX 7072	Repair of colovaginal fistula
PPX 7073	Repair of rectovaginal fistula
PPX 7074	Repair of other vaginoenteric fistula

Appendix 2. Risk Model for Defining Probability of 30-day Death

To balance case and control patients on their risk profile, logistic regression models were used to predict each patient's 30-day risk of death. For general surgery patients a model was fit to an external dataset of Medicare claims. The external dataset was created by taking a 10% random sample of Medicare patients in California, Florida, New Jersey, and Pennsylvania for the years 2013-2015 (for the Recent Era) and 2004-2006 (for the Early Era). Patients in this external dataset were not used for matching. Coefficients for each of the variables were then applied to patients in the matching dataset to assign each patient's risk of 30-day death. The resulting risk scores were then used as a matching variable.

Table 2a. General Surgery Probability of Death Model, Early Era (2004 – 2006)

Variable	Estimate	Standard Error	Z	P-value
Model Intercept	-10.6767	1.1413	-9.3552	<0.0001
California	0.0109	0.1179	0.0925	0.9263
New Jersey	0.1057	0.1249	0.8459	0.3976
Florida	0.0242	0.1077	0.2249	0.8221
Pennsylvania (reference)	--	--	--	--
Matched in year 2004	0.0068	0.1119	0.0604	0.9518
Matched in year 2005	0.0865	0.0917	0.9439	0.3452
Matched in year 2006 (reference)	--	--	--	--
Sex (male)	0.1616	0.0860	1.8797	0.0601
Age	0.0641	0.0059	10.7924	<0.0001
CHF	0.4098	0.0921	4.4479	<0.0001
Stroke	0.2380	0.1220	1.9517	0.0510
Seizure	0.0450	0.3142	0.1434	0.8860
Dementia	0.3773	0.1029	3.6677	0.0002
History of Alcoholism	0.4503	0.2395	1.8802	0.0601
History of Drug Abuse	0.1532	0.5311	0.2884	0.7731
Past Myocardial Infarction	0.0569	0.1263	0.4505	0.6524
Past Arrhythmia	0.0391	0.0900	0.4345	0.6639
Unstable Angina	-0.0142	0.1883	-0.0752	0.9401
Angina	-0.0150	0.1417	-0.1055	0.9160
Hypertension	-0.5268	0.1019	-5.1726	<0.0001
Valvular Disease	0.1125	0.0868	1.2966	0.1948
Chronic Lung Disease	0.3044	0.0848	3.5886	0.0003
Asthma	-0.2342	0.1468	-1.5947	0.1108
Liver Disease	0.2035	0.1129	1.8030	0.0714
Renal Dysfunction	1.2255	0.0971	12.6197	<0.0001
Renal Failure	0.2284	0.1242	1.8400	0.0658
Diabetes	0.0158	0.0895	0.1759	0.8603
Paraplegia	0.2181	0.2282	0.9561	0.3390
Collagen Vascular Disease	0.2112	0.1649	1.2806	0.2003
Coagulopathy	-0.1163	0.5253	-0.2215	0.8247
Thrombocytopenia	-0.1908	0.2429	-0.7856	0.4321
Other Coagulopathy	0.5029	0.1313	3.8284	0.0001
Smoking History	-0.0286	0.1583	-0.1807	0.8566
Post-Inflammatory Pulmonary Fibrosis	0.2132	0.1633	1.3058	0.1916
Cushings' Disease	0.0084	1.1029	0.0076	0.9939
Graves' Disease	-1.1096	1.0342	-1.0730	0.2833
Cancer	0.0279	0.0915	0.3048	0.7605
Abdominal Cancer	0.4383	0.1706	2.5692	0.0102
Hypothyroidism	-0.0826	0.0994	-0.8313	0.4058
Chronic Peptic Ulcer	-0.2788	0.5092	-0.5477	0.5839
Weight loss	0.4583	0.0920	4.9833	<0.0001
Major Secondary Procedure	0.0107	0.0903	0.1187	0.9055
Emergency admission	0.5653	0.0878	6.4353	<0.0001
Transfer-in status	-0.6881	0.4320	-1.5929	0.1112

Variable	Estimate	Standard Error	Z	P-value
Procedure group A	-0.6929	1.4362	-0.4825	0.6295
PPX 062 Unilateral thyroid lobectomy				
PPX 0631 Excision of lesion of thyroid				
PPX 0639 Other partial thyroidectomy				
PPX 0651 Partial substernal thyroidectomy				
PPX 0652 Complete substernal thyroidectomy				
PPX 0689 Other parathyroidectomy				
Procedure group B	1.5421	1.1639	1.3250	0.1852
PPX 5251 Proximal pancreatectomy				
PPX 526 Total pancreatectomy				
PPX 527 Radical pancreaticoduodenectomy				
Procedure group C	1.1142	1.1878	0.9381	0.3482
PPX 4651 Closure of stoma of small intestine				
PPX 4652 Closure of stoma of large intestine				
PPX 4674 Closure of fistula of small intestine, except duodenum				
PPX 7072 Repair of colovaginal fistula				
PPX 7073 Repair of rectovaginal fistula				
PPX 7074 Repair of other vaginoenteric fistula				
Procedure group D	0.3963	1.4401	0.2752	0.7832
PPX 064 Complete thyroidectomy				
PPX 0681 Complete parathyroidectomy				
Procedure group E	2.0174	1.4668	1.3754	0.1690
PPX 0722 Unilateral adrenalectomy				
PPX 0729 Other partial adrenalectomy				
PPX 073 Bilateral adrenalectomy				
Procedure group F	1.1859	1.4621	0.8111	0.4173
PPX 4240 Esophagectomy, not otherwise specified				
PPX 4241 Partial esophagectomy				
PPX 4242 Total esophagectomy				
PPX 427 Esophagomyotomy				
Procedure group G	2.6137	1.0715	2.4393	0.0147
PPX 435 Partial gastrectomy with anastomosis to esophagus				
PPX 4389 Open and other partial gastrectomy				
PPX 4438 Laparoscopic gastroenterostomy				
PPX 4466 Other procedures for creation of esophagogastric sphincteric competence				
PPX 4467 Laparoscopic procedures for creation of esophagogastric sphincteric competence				
Procedure group H	2.2571	1.0522	2.1450	0.0320
PPX 4561 Multiple segmental resection of small intestine				
PPX 4563 Total removal of small intestine				
PPX 4571 Open and other multiple segmental resection of large intestine				
PPX 4590 Intestinal anastomosis, not otherwise specified				
PPX 4591 Small-to-small intestinal anastomosis				
PPX 4592 Anastomosis of small intestine to rectal stump				
PPX 4594 Large-to-large intestinal anastomosis				
PPX 4595 Anastomosis to anus				
PPX 4601 Exteriorization of small intestine				
PPX 4679 Other repair of intestine				

Variable	Estimate	Standard Error	Z	P-value
PPX 485 Other pull-through resection of rectum PPX 4862 Anterior resection of rectum with synchronous colostomy PPX 4869 Other resection of rectum PPX 4875 Abdominal proctopexy PPX 4879 Other repair of rectum				
Procedure group I	3.5759	1.2358	2.8936	0.0038
PPX 4620 Ileostomy, not otherwise specified PPX 4621 Temporary ileostomy PPX 4623 Other permanent ileostomy				
Procedure group J	1.3203	1.0591	1.2466	0.2126
PPX 4642 Repair of pericolostomy hernia PPX 5300 Unilateral repair of inguinal hernia, not otherwise specified PPX 5301 Other and open repair of direct inguinal hernia PPX 5302 Other and open repair of indirect inguinal hernia PPX 5311 Other and open bilateral repair of direct inguinal hernia PPX 5314 Other and open bilateral repair of direct inguinal hernia with graft or prosthesis PPX 5315 Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis PPX 5316 Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis PPX 5317 Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified PPX 5329 Other unilateral femoral herniorrhaphy PPX 5341 Other and open repair of umbilical hernia with graft or prosthesis PPX 5349 Other open umbilical herniorrhaphy PPX 5351 Incisional hernia repair PPX 5369 Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis PPX 537 Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis				
Procedure group K	1.8689	1.2033	1.5531	0.1204
PPX 5022 Partial hepatectomy PPX 5124 Laparoscopic partial cholecystectomy PPX 5137 Anastomosis of hepatic duct to gastrointestinal tract PPX 5141 Common duct exploration for removal of calculus				
PPX 415 Total splenectomy	3.0118	1.0722	2.8090	0.0050
PPX 4342 Local excision of other lesion or tissue of stomach	2.4438	1.2119	2.0165	0.0437
PPX 436 Partial gastrectomy with anastomosis to duodenum	2.3693	1.4710	1.6107	0.1072
PPX 437 Partial gastrectomy with anastomosis to jejunum	2.2606	1.1008	2.0536	0.0400
PPX 4399 Other total gastrectomy	2.6834	1.1471	2.3393	0.0193
PPX 4429 Other pyloroplasty	2.6902	1.2242	2.1975	0.0280

Variable	Estimate	Standard Error	Z	P-value
PPX 4439 Other gastroenterostomy without gastrectomy	2.7507	1.0853	2.5346	0.0113
PPX 4441 Suture of gastric ulcer site	3.5811	1.0790	3.3191	0.0009
PPX 4442 Suture of duodenal ulcer site	3.1592	1.0644	2.9681	0.0030
PPX 4469 Other repair of stomach	3.0948	1.1845	2.6126	0.0090
PPX 4562 Other partial resection of small intestine	2.7129	1.0359	2.6188	0.0088
PPX 4572 Open and other cecectomy	2.3825	1.0941	2.1777	0.0294
PPX 4573 Open and other right hemicolectomy	2.0967	1.0337	2.0284	0.0425
PPX 4574 Open and other resection of transverse colon	1.8192	1.1066	1.6440	0.1002
PPX 4575 Open and other left hemicolectomy	2.4348	1.0443	2.3315	0.0197
PPX 4576 Open and other sigmoidectomy	2.4521	1.0374	2.3637	0.0181
PPX 4579 Other and unspecified partial excision of large intestine	2.5249	1.0575	2.3876	0.0170
PPX 458 Other and unspecified partial excision of large intestine	3.1493	1.0638	2.9604	0.0031
PPX 4593 Other small-to-large intestinal anastomosis	3.4830	1.1638	2.9929	0.0028
PPX 4603 Exteriorization of large intestine	2.4709	1.0840	2.2795	0.0226
PPX 4610 Colostomy, not otherwise specified	2.1506	1.1349	1.8949	0.0581
PPX 4611 Temporary colostomy	3.0832	1.2425	2.4815	0.0131
PPX 4613 Permanent colostomy	2.8517	1.1870	2.4025	0.0163
PPX 4639 Other enterostomy	3.2038	1.1024	2.9061	0.0037
PPX 4673 Suture of laceration of small intestine, except duodenum	1.4675	1.2663	1.1589	0.2465
PPX 4675 Suture of laceration of large intestine	1.9698	1.2860	1.5317	0.1256
PPX 4701 Laparoscopic appendectomy	0.5288	1.1877	0.4452	0.6562
PPX 4709 Other appendectomy	1.6253	1.0809	1.5037	0.1327
PPX 4849 Other pull-through resection of rectum	1.4432	1.4532	0.9931	0.3207
PPX 4863 Other anterior resection of rectum	1.5437	1.1008	1.4024	0.1608
PPX 4876 Other proctopexy	1.1848	1.4548	0.8144	0.4154
PPX 5029 Other destruction of lesion of liver	2.0090	1.2073	1.6641	0.0961
PPX 503 Lobectomy of liver	2.5060	1.3016	1.9253	0.0542
PPX 5122 Cholecystectomy	1.7448	1.0406	1.6766	0.0936
PPX 5123 Laparoscopic cholecystectomy	0.7542	1.0378	0.7268	0.4674
PPX 5132 Anastomosis of gallbladder to intestine	3.0358	1.3247	2.2917	0.0219
PPX 5136 Choledochoenterostomy	1.9538	1.1765	1.6607	0.0968
PPX 5151 Exploration of common duct	2.9166	1.6234	1.7966	0.0724
PPX 5252 Distal pancreatectomy	1.3841	1.4575	0.9497	0.3423
PPX 5259 Other partial pancreatectomy	3.4507	1.3349	2.5850	0.0097
PPX 5303 Other and open repair of direct inguinal hernia with graft or prosthesis	1.1392	1.1517	0.9892	0.3226
PPX 5304 Other and open repair of indirect inguinal hernia with graft or prosthesis	1.5932	1.1176	1.4255	0.1540
PPX 5305 Repair of inguinal hernia with graft or prosthesis, not otherwise specified	1.2178	1.1193	1.0880	0.2766
PPX 5321 Unilateral repair of femoral hernia with graft or prosthesis	1.0102	1.4631	0.6905	0.4899
PPX 5359 Repair of other hernia of anterior abdominal wall	2.5971	1.1292	2.3000	0.0214
PPX 5361 Other open incisional hernia repair with graft or prosthesis	0.4602	1.1820	0.3893	0.6970
PPX 5451 Laparoscopic lysis of peritoneal adhesions	2.0369	1.0993	1.8530	0.0639
PPX 5459 Other lysis of peritoneal adhesions	2.0646	1.0401	1.9850	0.0471
PPX 5493 Creation of cutaneoperitoneal fistula (reference)	--	--	--	--

Appendix 2b. General Surgery Probability of Death Model, Recent Era (2013 – 2015)

Variable	Estimate	Standard Error	Z	P-value
Model Intercept	-7.7623	0.8017	-9.6828	<0.0001
California	0.3315	0.1497	2.2139	0.0268
New Jersey	-0.1393	0.1756	-0.7933	0.4276
Florida	0.1251	0.1441	0.8681	0.3854
Pennsylvania (reference)	--	--	--	--
Matched in year 2013	0.1045	0.1399	0.7471	0.4550
Matched in year 2014	0.0721	0.1185	0.6089	0.5426
Matched in year 2015 (reference)	--	--	--	--
Sex (male)	-0.0090	0.1104	-0.0814	0.9351
Age	0.0416	0.0072	5.7736	<0.0001
CHF	0.2393	0.1219	1.9622	0.0497
Stroke	-0.0126	0.1395	-0.0906	0.9278
Seizure	-0.0154	0.2886	-0.0535	0.9573
Dementia	0.4284	0.1287	3.3272	0.0009
History of Alcoholism	-0.1263	0.2953	-0.4278	0.6688
History of Drug Abuse	-0.0203	0.3839	-0.0529	0.9578
Past Myocardial Infarction	0.0107	0.1495	0.0716	0.9429
Past Arrhythmia	0.0830	0.1118	0.7426	0.4577
Unstable Angina	0.2467	0.3129	0.7883	0.4305
Angina	-0.5536	0.2582	-2.1440	0.0320
Hypertension	-0.0763	0.1818	-0.4198	0.6746
Valvular Disease	0.1184	0.1120	1.0578	0.2901
Chronic Lung Disease	0.4589	0.1106	4.1506	<0.0001
Asthma	-0.1091	0.1590	-0.6860	0.4927
Liver Disease	0.5820	0.1194	4.8736	<0.0001
Renal Dysfunction	1.1303	0.1150	9.8244	<0.0001
Renal Failure	0.1711	0.1590	1.0755	0.2821
Diabetes	0.1249	0.1093	1.1428	0.2531
Paraplegia	0.0670	0.2688	0.2494	0.8030
Collagen Vascular Disease	0.2492	0.1744	1.4292	0.1530
Coagulopathy	-0.1183	0.4831	-0.2448	0.8066
Thrombocytopenia	0.0510	0.2180	0.2338	0.8151
Other Coagulopathy	0.7014	0.1542	4.5493	<0.0001
Smoking History	0.0218	0.1156	0.1886	0.8504
Post-Inflammatory Pulmonary Fibrosis	0.0723	0.2204	0.3282	0.7428
Cushings' Disease	0.3809	0.8855	0.4301	0.6671
Graves' Disease	0.0801	0.8185	0.0979	0.9220
Cancer	-0.0656	0.1134	-0.5786	0.5629
Abdominal Cancer	0.9023	0.2241	4.0261	<0.0001
Hypothyroidism	-0.0225	0.1144	-0.1963	0.8444
Chronic Peptic Ulcer	0.1119	0.6082	0.1841	0.8540
HIV and AIDS	-0.8002	1.1514	-0.6950	0.4871
Weight loss	0.4314	0.1102	3.9142	<0.0001
Major Secondary Procedure	0.0619	0.1198	0.5169	0.6052
Emergency admission	0.6757	0.1238	5.4589	<0.0001
Transfer-in status	0.3007	0.3961	0.7590	0.4479
Procedure group A	-0.2747	1.1573	-0.2374	0.8123
PPX 062 Unilateral thyroid lobectomy				
PPX 0631 Excision of lesion of thyroid				
PPX 0639 Other partial thyroidectomy				
PPX 0651 Partial substernal thyroidectomy				
PPX 0652 Complete substernal thyroidectomy				
Procedure group B	-2.3159	1.1410	-2.0297	0.0424
PPX 4642 Repair of pericolostomy hernia				

Variable	Estimate	Standard Error	Z	P-value
PPX 5301 Other and open repair of direct inguinal hernia				
PPX 5302 Other and open repair of indirect inguinal hernia				
PPX 5303 Other and open repair of direct inguinal hernia with graft or prosthesis				
PPX 5310 Bilateral repair of inguinal hernia, not otherwise specified				
PPX 5314 Other and open bilateral repair of direct inguinal hernia with graft or prosthesis				
PPX 5315 Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis				
PPX 5316 Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis				
PPX 5317 Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified				
PPX 5372 Other and open repair of diaphragmatic hernia, abdominal approach				
PPX 5375 Repair of diaphragmatic hernia, abdominal approach, not otherwise specified				
Procedure group C	-1.6660	1.1601	-1.4360	0.1510
PPX 4849 Other pull-through resection of rectum				
PPX 4850 Abdominoperineal resection of the rectum, not otherwise specified				
PPX 4851 Laparoscopic abdominoperineal resection of the rectum				
PPX 4852 Open abdominoperineal resection of the rectum				
PPX 4859 Other abdominoperineal resection of the rectum				
PPX 4875 Abdominal proctopexy				
PPX 4879 Other repair of rectum				
Procedure group D	-0.9970	1.2005	-0.8305	0.4063
PPX 5029 Other destruction of lesion of liver				
PPX 503 Lobectomy of liver				
Procedure group E	0.2661	0.9691	0.2745	0.7837
PPX 5132 Anastomosis of gallbladder to intestine				
PPX 5136 Choledochoenterostomy				
PPX 5137 Anastomosis of hepatic duct to gastrointestinal tract				
PPX 5141 Common duct exploration for removal of calculus				
PPX 5151 Exploration of common duct				
Procedure group F	-1.0675	0.9243	-1.1550	0.2481
PPX 5252 Distal pancreatectomy				
PPX 5253 Radical subtotal pancreatectomy				
PPX 5259 Other partial pancreatectomy				
PPX 526 Total pancreatectomy				
Procedure group G	0.2143	0.8537	0.2511	0.8018
PPX 4674 Closure of fistula of small intestine, except duodenum				
PPX 7072 Repair of colovaginal fistula				
PPX 7073 Repair of rectovaginal fistula				
Procedure group H	-1.1694	1.1822	-0.9892	0.3226

Variable	Estimate	Standard Error	Z	P-value
PPX 0681 Complete parathyroidectomy PPX 0689 Other parathyroidectomy				
Procedure group I	0.0563	1.1676	0.0482	0.9616
PPX 0722 Unilateral adrenalectomy PPX 073 Bilateral adrenalectomy				
Procedure group J	-0.5525	0.9042	-0.6110	0.5412
PPX 1711 Laparoscopic repair of direct inguinal hernia with graft or prosthesis PPX 1712 Laparoscopic repair of indirect inguinal hernia with graft or prosthesis PPX 1713 Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified PPX 1722 Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis PPX 1723 Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis PPX 1724 Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified				
Procedure group K	-0.6918	0.9045	-0.7648	0.4444
PPX 1731 Laparoscopic multiple segmental resection of large intestine PPX 1732 Laparoscopic cecectomy PPX 1734 Laparoscopic resection of transverse colon PPX 1739 Other laparoscopic partial excision of large intestine				
Procedure group L	0.1235	0.7115	0.1736	0.8622
PPX 4240 Esophagectomy, not otherwise specified PPX 4241 Partial esophagectomy PPX 4242 Total esophagectomy PPX 427 Esophagomyotomy PPX 437 Partial gastrectomy with anastomosis to jejunum				
Procedure group M	-0.1994	0.6657	-0.2995	0.7646
PPX 4342 Local excision of other lesion or tissue of stomach PPX 435 Partial gastrectomy with anastomosis to esophagus PPX 436 Partial gastrectomy with anastomosis to duodenum PPX 4439 Other gastroenterostomy without gastrectomy PPX 4466 Other procedures for creation of esophagogastric sphincteric competence PPX 4467 Laparoscopic procedures for creation of esophagogastric sphincteric competence PPX 4469 Other repair of stomach				
Procedure group N	-1.1856	0.9060	-1.3087	0.1906
PPX 4561 Multiple segmental resection of small intestine PPX 4563 Total removal of small intestine PPX 4590 Intestinal anastomosis, not otherwise specified				

Variable	Estimate	Standard Error	Z	P-value
PPX 4592 Anastomosis of small intestine to rectal stump				
PPX 4594 Large-to-large intestinal anastomosis				
PPX 4595 Anastomosis to anus				
PPX 4675 Suture of laceration of large intestine				
PPX 4679 Other repair of intestine				
Procedure group O	-1.0196	0.8944	-1.1399	0.2543
PPX 4611 Temporary colostomy				
PPX 4613 Permanent colostomy				
PPX 4623 Other permanent ileostomy				
PPX 4651 Closure of stoma of small intestine				
PPX 064 Complete thyroidectomy	-0.5763	1.1630	-0.4955	0.6202
PPX 1733 Laparoscopic right hemicolectomy	-1.1528	0.6754	-1.7069	0.0878
PPX 1735 Laparoscopic left hemicolectomy	0.6794	0.7159	0.9490	0.3426
PPX 1736 Laparoscopic sigmoidectomy	-0.9619	0.8042	-1.1961	0.2317
PPX 415 Total splenectomy	0.8942	0.6826	1.3099	0.1902
PPX 4389 Open and other partial gastrectomy	0.6574	0.7550	0.8708	0.3839
PPX 4399 Other total gastrectomy	1.0261	0.8420	1.2187	0.2229
PPX 4429 Other pyloroplasty	1.5076	0.9525	1.5828	0.1135
PPX 4438 Laparoscopic gastroenterostomy	-0.6614	1.1515	-0.5744	0.5657
PPX 4441 Suture of gastric ulcer site	0.9163	0.6697	1.3681	0.1713
PPX 4442 Suture of duodenal ulcer site	0.8538	0.6309	1.3533	0.1760
PPX 4562 Other partial resection of small intestine	0.4726	0.5455	0.8664	0.3863
PPX 4571 Open and other multiple segmental resection of large intestine	0.0111	1.2477	0.0089	0.9929
PPX 4572 Open and other cecectomy	0.7480	0.6868	1.0891	0.2761
PPX 4573 Open and other right hemicolectomy	0.1113	0.5510	0.2021	0.8399
PPX 4574 Open and other resection of transverse colon	0.7098	0.6710	1.0578	0.2901
PPX 4575 Open and other left hemicolectomy	1.0367	0.5819	1.7817	0.0748
PPX 4576 Open and other sigmoidectomy	0.4278	0.5561	0.7694	0.4417
PPX 4579 Other and unspecified partial excision of large intestine	0.8866	0.6292	1.4090	0.1588
PPX 4581 Laparoscopic total intra-abdominal colectomy	1.1386	0.9732	1.1701	0.2420
PPX 4582 Open total intra-abdominal colectomy	1.0919	0.6580	1.6596	0.0970
PPX 4583 Other and unspecified total intra-abdominal colectomy	0.7183	1.0545	0.6812	0.4958
PPX 4591 Small-to-small intestinal anastomosis	1.2047	0.9894	1.2176	0.2234
PPX 4593 Other small-to-large intestinal anastomosis	0.0224	0.8288	0.0270	0.9784
PPX 4601 Exteriorization of small intestine	1.1925	0.8477	1.4067	0.1595
PPX 4603 Exteriorization of large intestine	0.3678	0.6649	0.5532	0.5801
PPX 4610 Colostomy, not otherwise specified	0.5630	0.6561	0.8581	0.3908
PPX 4620 Ileostomy, not otherwise specified	0.9933	1.0229	0.9710	0.3315
PPX 4639 Other enterostomy	0.1309	0.8126	0.1611	0.8720
PPX 4652 Closure of stoma of large intestine	-0.9321	0.8942	-1.0424	0.2972
PPX 4673 Suture of laceration of small intestine, except duodenum	1.7739	0.9402	1.8868	0.0592
PPX 4701 Laparoscopic appendectomy	-1.3858	0.6984	-1.9841	0.0472
PPX 4709 Other appendectomy	-0.7078	0.8033	-0.8811	0.3783
PPX 4862 Anterior resection of rectum with synchronous colostomy	0.7268	0.7917	0.9180	0.3586
PPX 4863 Other anterior resection of rectum	0.4889	0.7076	0.6908	0.4897
PPX 4869 Other resection of rectum	-0.0869	0.8376	-0.1037	0.9174
PPX 4876 Other proctopexy	-0.0503	0.9261	-0.0543	0.9567
PPX 5022 Partial hepatectomy	-1.3673	1.1679	-1.1707	0.2417

Variable	Estimate	Standard Error	Z	P-value
PPX 5122 Cholecystectomy	-0.4858	0.5824	-0.8342	0.4042
PPX 5123 Laparoscopic cholecystectomy	-1.3210	0.5504	-2.4000	0.0164
PPX 5124 Laparoscopic partial cholecystectomy	1.1650	1.3361	0.8720	0.3832
PPX 527 Radical pancreaticoduodenectomy	-1.5958	0.8241	-1.9365	0.0528
PPX 5300 Unilateral repair of inguinal hernia, not otherwise specified	-0.5208	0.9271	-0.5617	0.5743
PPX 5304 Other and open repair of indirect inguinal hernia with graft or prosthesis	-1.6579	1.1455	-1.4473	0.1478
PPX 5305 Repair of inguinal hernia with graft or prosthesis, not otherwise specified	-1.2153	0.8939	-1.3596	0.1740
PPX 5321 Unilateral repair of femoral hernia with graft or prosthesis	0.9374	0.7410	1.2650	0.2059
PPX 5329 Other unilateral femoral herniorrhaphy	-0.3655	0.9201	-0.3972	0.6912
PPX 5341 Other and open repair of umbilical hernia with graft or prosthesis	-0.9571	1.1569	-0.8273	0.4081
PPX 5349 Other open umbilical herniorrhaphy	-0.1153	0.8207	-0.1405	0.8883
PPX 5351 Incisional hernia repair	-0.4205	0.7563	-0.5560	0.5782
PPX 5359 Repair of other hernia of anterior abdominal wall	-0.2605	0.9126	-0.2855	0.7753
PPX 5361 Other open incisional hernia repair with graft or prosthesis	-1.1610	0.7296	-1.5913	0.1115
PPX 5369 Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	-0.3512	0.8141	-0.4314	0.6662
PPX 5451 Laparoscopic lysis of peritoneal adhesions	-0.7093	0.7074	-1.0027	0.3160
PPX 5459 Other lysis of peritoneal adhesions	-0.2415	0.5658	-0.4268	0.6695
PPX 5493 Creation of cutaneoperitoneal fistula (reference)	--	--	--	--

Table 3. Complete balance table for Early Era (2003-2005)

Variable	Black Patients	Tapered Matches: Presentation + Procedure + Demographics	Tapered Matches: Procedure + Demographics	Tapered Matches: Demographics	White Patients (unmatched)
N	6,752	6,752	6,752	6,752	107,001
Age	75.99	75.84	75.98	75.99	77.48
Year of match	2005.12	2005.10	2005.12	2005.12	2005.12
Age 65-69 (%)	0.25	0.23	0.25	0.25	0.18
Age 70-74 (%)	0.24	0.25	0.25	0.24	0.21
Age 75-79 (%)	0.21	0.24	0.21	0.21	0.24
Age 80-84 (%)	0.16	0.17	0.16	0.16	0.21
Age 85 plus (%)	0.13	0.11	0.13	0.13	0.17
State- California (%)	0.23	0.23	0.23	0.23	0.25
State- New Jersey (%)	0.24	0.27	0.23	0.24	0.16
State- Florida (%)	0.34	0.34	0.34	0.34	0.35
State- Pennsylvania (%)	0.19	0.16	0.19	0.19	0.24
State- NJ/PA (%)	0.43	0.43	0.43	0.43	0.40
Male (%)	0.39	0.39	0.39	0.39	0.43
Year of match- 2004 (%)	0.22	0.23	0.22	0.22	0.22
Year of match- 2005 (%)	0.44	0.45	0.44	0.44	0.45
Year of match- 2006 (%)	0.34	0.32	0.34	0.34	0.33
Open and other cecectomy	0.01	0.01	0.01	0.01	0.01
Laparoscopic cholecystectomy	0.16	0.16	0.16	0.21	0.20
Open and other right hemicolectomy	0.14	0.14	0.14	0.11	0.12
Other anterior resection of rectum	0.01	0.01	0.01	0.02	0.02
Cholecystectomy	0.06	0.06	0.06	0.05	0.05
Open and other sigmoidectomy	0.05	0.05	0.05	0.06	0.07
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.00	0.00	0.00	0.01	0.01
Radical pancreaticoduodenectomy	0.01	0.01	0.01	0.01	0.01
Other partial resection of small intestine	0.06	0.06	0.06	0.05	0.05
Other lysis of peritoneal adhesions	0.06	0.06	0.06	0.05	0.05
Other resection of rectum	0.00	0.00	0.00	0.00	0.01
Other and open repair of indirect inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Distal pancreatectomy	0.00	0.00	0.00	0.00	0.00

Closure of stoma of small intestine	0.00	0.00	0.00	0.00	0.00
Other unilateral femoral herniorrhaphy	NR	NR	NR	0.00	0.00
Open and other left hemicolectomy	0.04	0.04	0.04	0.03	0.03
Other and unspecified partial excision of large intestine	0.01	0.01	0.01	0.01	0.01
Unilateral adrenalectomy	0.00	0.00	0.00	0.00	0.00
Abdominal proctopexy	NR	NR	NR	NR	0.00
Other gastroenterostomy without gastrectomy	0.01	0.01	0.01	0.01	0.01
Exteriorization of large intestine	0.01	0.01	0.01	0.01	0.01
Anterior resection of rectum with synchronous colostomy	0.00	0.00	0.00	0.00	0.00
Total splenectomy	0.00	0.00	0.00	0.01	0.01
Other procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	0.00	0.00
Other total gastrectomy	0.01	0.01	0.01	0.00	0.00
Other and unspecified partial excision of large intestine	0.02	0.02	0.02	0.02	0.02
Other pull-through resection of rectum	0.01	0.01	0.01	0.01	0.01
Other open umbilical herniorrhaphy	0.01	0.01	0.01	0.00	0.00
Laparoscopic appendectomy	0.01	0.01	0.01	0.02	0.02
Complete parathyroidectomy	0.00	0.00	0.00	NR	0.00
Incisional hernia repair	0.01	0.01	0.01	0.01	0.01
Temporary colostomy	0.00	0.00	0.00	NR	0.00
Repair of rectovaginal fistula	NR	NR	NR	NR	0.00
Other pull-through resection of rectum	NR	NR	NR	NR	0.00
Other destruction of lesion of liver	0.00	0.00	0.00	0.00	0.00
Small-to-small intestinal anastomosis	0.00	0.00	0.00	NR	0.00
Other open incisional hernia repair with graft or prosthesis	0.02	0.02	0.02	0.03	0.03
Partial esophagectomy	NR	NR	NR	0.00	0.00
Laparoscopic gastroenterostomy	0.00	0.00	0.00	0.00	0.00

Open and other resection of transverse colon	0.01	0.01	0.01	0.01	0.01
Exteriorization of small intestine	0.00	0.00	0.00	0.00	0.00
Other enterostomy	0.01	0.01	0.01	0.00	0.00
Unilateral thyroid lobectomy	0.02	0.02	0.02	0.01	0.01
Complete thyroidectomy	0.02	0.02	0.02	0.01	0.01
Partial gastrectomy with anastomosis to duodenum	0.00	0.00	0.00	NR	0.00
Other and open repair of direct inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Other parathyroidectomy	0.02	0.02	0.02	0.01	0.01
Laparoscopic lysis of peritoneal adhesions	0.01	0.01	0.01	0.01	0.01
Lobectomy of liver	0.00	0.00	0.00	NR	0.00
Anastomosis of hepatic duct to gastrointestinal tract	NR	NR	NR	NR	0.00
Suture of laceration of large intestine	NR	NR	NR	NR	0.00
Repair of pericolostomy hernia	NR	NR	NR	0.00	0.00
Common duct exploration for removal of calculus	NR	NR	NR	NR	0.00
Total esophagectomy	NR	NR	NR	NR	0.00
Open and other partial gastrectomy	0.01	0.01	0.01	0.00	0.00
Partial hepatectomy	0.00	0.00	0.00	0.00	0.00
Esophagectomy, not otherwise specified	NR	NR	NR	0.00	0.00
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Laparoscopic procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	0.01	0.01
Closure of stoma of large intestine	0.00	0.00	0.00	0.01	0.01
Resection of vessel with replacement, other vessels of head and neck	0.00	0.00	0.00	0.00	0.00
Other repair of intestine	0.00	0.00	0.00	NR	0.00
Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00

Esophagomyotomy	0.00	0.00	0.00	NR	0.00
Other appendectomy	0.01	0.01	0.01	0.02	0.02
Local excision of other lesion or tissue of stomach	0.00	0.00	0.00	NR	0.00
Unilateral repair of femoral hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Ileostomy, not otherwise specified	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to jejunum	0.02	0.02	0.02	0.01	0.01
Other small-to-large intestinal anastomosis	0.00	0.00	0.00	NR	0.00
Other and open repair of indirect inguinal hernia	0.00	0.00	0.00	0.00	0.00
Repair of other hernia of anterior abdominal wall	0.01	0.01	0.01	0.00	0.00
Repair of inguinal hernia with graft or prosthesis, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Large-to-large intestinal anastomosis	0.00	0.00	0.00	0.00	0.00
Suture of duodenal ulcer site	0.01	0.01	0.01	0.01	0.01
Colostomy, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Creation of cutaneoperitoneal fistula	0.00	0.00	0.00	0.00	0.00
Open and other multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Closure of fistula of small intestine, except duodenum	NR	NR	NR	0.00	0.00
Multiple segmental resection of small intestine	0.00	0.00	0.00	0.00	0.00
Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Permanent colostomy	0.00	0.00	0.00	NR	0.00
Suture of gastric ulcer site	0.00	0.00	0.00	0.00	0.00
Excision of lesion of thyroid	NR	NR	NR	NR	0.00
Anastomosis of gallbladder to intestine	NR	NR	NR	NR	0.00
Other and open repair of umbilical hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Complete substernal thyroidectomy	0.00	0.00	0.00	NR	0.00

Exploration of common duct	NR	NR	NR	0.00	0.00
Other partial thyroidectomy	0.01	0.01	0.01	0.00	0.00
Suture of laceration of small intestine, except duodenum	0.01	0.01	0.01	0.01	0.00
Repair of colovaginal fistula	NR	NR	NR	NR	0.00
Other and open bilateral repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Other proctopexy	NR	NR	NR	0.00	0.00
Unilateral repair of inguinal hernia, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Other and open repair of direct inguinal hernia	0.00	0.00	0.00	0.00	0.00
Other permanent ileostomy	NR	NR	NR	0.00	0.00
Other pyloroplasty	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to esophagus	NR	NR	NR	NR	0.00
Total pancreatectomy	NR	NR	NR	NR	0.00
Choledochoenterostomy	0.00	0.00	0.00	0.00	0.00
Other partial pancreatectomy	NR	NR	NR	0.00	0.00
Bilateral repair of inguinal hernia, not otherwise specified	NR	NR	NR	0.00	NR
Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	NR	0.00
Partial substernal thyroidectomy	NR	NR	NR	NR	0.00
Other and open bilateral repair of direct inguinal hernia	NR	NR	NR	NR	0.00
Other repair of stomach	0.00	0.00	0.00	NR	0.00
Temporary ileostomy	NR	NR	NR	NR	0.00
Intestinal anastomosis, not otherwise specified	NR	NR	NR	0.00	NR
Other and open bilateral repair of inguinal hernia, one direct and one indirect	NR	NR	NR	NR	0.00
Anastomosis of small intestine to rectal stump	0.00	0.00	0.00	0.00	NR
Anastomosis to anus	NR	NR	NR	NR	0.00

Repair of other vaginoenteric fistula	NR	NR	NR	0.00	NR
Number of Comorbidities	5.81	5.67	5.27	5.14	5.27
Number of Comorbidities in Near Fine balance list of variables	0.38	0.33	0.48	0.46	0.46
Anesthesia Score	147.95	143.90	142.36	140.55	141.21
More than six comorbidities (%)	0.49	0.49	0.41	0.39	0.41
Congestive Heart Failure	0.26	0.26	0.22	0.20	0.22
Stroke	0.15	0.15	0.09	0.08	0.10
Seizure	0.02	0.02	0.01	0.01	0.01
Dementia	0.15	0.15	0.09	0.09	0.10
Alcohol abuse	0.03	0.03	0.02	0.02	0.02
Drug abuse	0.01	0.01	0.01	0.00	0.00
Past MI	0.09	0.08	0.09	0.10	0.10
Past Arrhythmia	0.25	0.25	0.29	0.28	0.30
Unstable Angina	0.05	0.03	0.04	0.04	0.04
Angina	0.08	0.06	0.08	0.08	0.08
Hypertension	0.90	0.90	0.78	0.79	0.79
Valvular Heart Disease	0.27	0.29	0.28	0.27	0.29
Chronic Lung Disease	0.27	0.27	0.30	0.29	0.30
Asthma	0.11	0.12	0.10	0.09	0.09
Liver Disease	0.16	0.15	0.14	0.13	0.13
Renal Dialysis	0.23	0.23	0.13	0.12	0.13
Renal Failure	0.16	0.15	0.08	0.07	0.08
Diabetes	0.47	0.46	0.29	0.29	0.29
Paraplegia	0.05	0.04	0.02	0.02	0.02
Collagen Vascular Disease	0.05	0.05	0.06	0.06	0.06
Coagulation disorders	0.00	NR	0.00	0.00	0.00
Thrombocytopenia	0.02	0.01	0.02	0.03	0.02
Congenital Coagulation disorder	0.06	0.05	0.06	0.06	0.06
Smoking History	0.07	0.05	0.09	0.09	0.09
Post Pulmonary Fibrosis	0.03	0.02	0.04	0.04	0.04
Cushing's disease	NR	NR	NR	NR	0.00
Graves' disease	0.01	0.01	0.01	0.01	0.01
Cancer	0.47	0.47	0.51	0.48	0.50
Abdominal Cancer	0.06	0.06	0.06	0.05	0.05
Hypothyroidism	0.15	0.12	0.23	0.22	0.22
Chronic Peptic Ulcer	0.01	0.01	0.01	0.00	0.00
AIDS	0.00	NR	NR	NR	0.00
Weight Loss	0.20	0.18	0.14	0.13	0.14
Sickle Cell Anemia	NR	NR	NR	NR	0.00

Any Comorbidity	0.99	0.99	0.98	0.98	0.98
Cardiac with CHF	0.56	0.56	0.55	0.54	0.56
Cardiac without CHF	0.49	0.49	0.51	0.50	0.52
Stroke/Paraplegia	0.16	0.16	0.10	0.09	0.10
Any Angina	0.12	0.08	0.11	0.11	0.11
Cancer/Abdominal Cancer	0.47	0.47	0.51	0.48	0.50
Chronic Lung/Asthma	0.32	0.32	0.34	0.33	0.33
Emergency type admission (%)	0.47	0.52	0.37	0.39	0.38
Transfer-in (%)	0.01	0.01	0.01	0.01	0.01

Note. NR, Not Reportable N<11

Table 4. Complete balance table for Recent Era (2013-2015)

Variable	Black Patients	Tapered Matches			White Patients (unmatched)
		Presentation + Procedure + Demographics	Procedure + Demographics	Demographics	
N	4,964	4,964	4,964	4,964	74,108
Age	75.46	75.01	75.45	75.46	77.03
Year of match	2014.10	2014.10	2014.10	2014.10	2014.10
Age 65-69 (%)	0.27	0.28	0.27	0.27	0.22
Age 70-74 (%)	0.25	0.28	0.26	0.25	0.23
Age 75-79 (%)	0.21	0.19	0.20	0.21	0.20
Age 80-84 (%)	0.14	0.14	0.15	0.14	0.17
Age 85 plus (%)	0.12	0.11	0.12	0.12	0.18
State- California (%)	0.24	0.24	0.24	0.24	0.28
State- New Jersey (%)	0.23	0.24	0.22	0.23	0.15
State- Florida (%)	0.34	0.34	0.34	0.34	0.35
State- Pennsylvania (%)	0.19	0.17	0.19	0.19	0.21
State- NJ/PA (%)	0.42	0.42	0.42	0.42	0.37
Male (%)	0.39	0.39	0.39	0.39	0.45
Year of match- 2013 (%)	0.23	0.23	0.23	0.23	0.23
Year of match- 2014 (%)	0.44	0.44	0.44	0.44	0.45
Year of match- 2015 (%)	0.33	0.33	0.33	0.33	0.33
Procedure type (%)					
Open and other cecectomy	0.01	0.01	0.01	0.00	0.00
Laparoscopic cholecystectomy	0.19	0.19	0.19	0.21	0.22
Open and other right hemicolectomy	0.08	0.08	0.08	0.06	0.07
Other anterior resection of rectum	0.01	0.01	0.01	0.02	0.02
Cholecystectomy	0.03	0.03	0.03	0.03	0.03
Open and other sigmoidectomy	0.03	0.03	0.03	0.05	0.05
Radical pancreaticoduodenectomy	0.01	0.01	0.01	0.01	0.01
Other partial resection of small intestine	0.07	0.07	0.07	0.06	0.06
Other lysis of peritoneal adhesions	0.05	0.05	0.05	0.04	0.04
Other resection of rectum	0.00	0.00	0.00	0.01	0.01
Other and open repair of indirect inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Distal pancreatectomy	0.00	0.00	0.00	0.01	0.01
Closure of stoma of small intestine	0.01	0.01	0.01	0.01	0.01

Other unilateral femoral herniorrhaphy	NR	NR	NR	0.00	0.00
Open and other left hemicolectomy	0.02	0.02	0.02	0.02	0.02
Unilateral adrenalectomy	0.01	0.01	0.01	0.00	0.00
Abdominal proctopexy	NR	NR	NR	0.00	0.00
Other gastroenterostomy without gastrectomy	0.01	0.01	0.01	0.00	0.00
Exteriorization of large intestine	0.01	0.01	0.01	0.01	0.01
Anterior resection of rectum with synchronous colostomy	0.00	0.00	0.00	0.00	0.00
Total splenectomy	0.00	0.00	0.00	0.01	0.01
Other procedures for creation of esophagogastric sphincteric competence	NR	NR	NR	NR	0.00
Other total gastrectomy	0.00	0.00	0.00	NR	0.00
Other and unspecified partial excision of large intestine	0.01	0.01	0.01	0.01	0.01
Other open umbilical herniorrhaphy	0.00	0.00	0.00	0.00	0.00
Laparoscopic appendectomy	0.03	0.03	0.03	0.04	0.04
Complete parathyroidectomy	NR	NR	NR	NR	0.00
Incisional hernia repair	0.01	0.01	0.01	0.01	0.01
Temporary colostomy	NR	NR	NR	NR	0.00
Repair of rectovaginal fistula	NR	NR	NR	NR	0.00
Other pull-through resection of rectum	NR	NR	NR	NR	0.00
Other destruction of lesion of liver	0.00	0.00	0.00	NR	0.00
Small-to-small intestinal anastomosis	NR	NR	NR	NR	0.00
Other open incisional hernia repair with graft or prosthesis	0.02	0.02	0.02	0.03	0.03
Partial esophagectomy	NR	NR	NR	0.00	0.00
Laparoscopic gastroenterostomy	0.01	0.01	0.01	0.01	0.01
Open and other resection of transverse colon	0.01	0.01	0.01	0.01	0.01
Exteriorization of small intestine	0.00	0.00	0.00	0.00	0.00
Other enterostomy	0.00	0.00	0.00	NR	0.00

Unilateral thyroid lobectomy	0.01	0.01	0.01	0.00	0.00
Complete thyroidectomy	0.02	0.02	0.02	0.01	0.01
Partial gastrectomy with anastomosis to duodenum	NR	NR	NR	NR	0.00
Other and open repair of direct inguinal hernia with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Other parathyroidectomy	0.01	0.01	0.01	0.00	0.00
Laparoscopic lysis of peritoneal adhesions	0.02	0.02	0.02	0.01	0.02
Lobectomy of liver	NR	NR	NR	0.00	0.00
Anastomosis of hepatic duct to gastrointestinal tract	NR	NR	NR	NR	0.00
Suture of laceration of large intestine	NR	NR	NR	NR	0.00
Repair of pericolostomy hernia	0.00	0.00	0.00	0.00	0.00
Common duct exploration for removal of calculus	NR	NR	NR	NR	0.00
Total esophagectomy	NR	NR	NR	NR	0.00
Open and other partial gastrectomy	0.01	0.01	0.01	0.00	0.00
Partial hepatectomy	0.00	0.00	0.00	0.00	0.01
Esophagectomy, not otherwise specified	NR	NR	NR	NR	0.00
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis	0.01	0.01	0.01	0.01	0.01
Laparoscopic procedures for creation of esophagogastric sphincteric competence	0.00	0.00	0.00	0.02	0.01
Closure of stoma of large intestine	0.01	0.01	0.01	0.01	0.01
Other repair of intestine	NR	NR	NR	NR	0.00
Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00
Esophagomyotomy	0.00	0.00	0.00	0.00	0.00
Other appendectomy	0.01	0.01	0.01	0.01	0.01
Local excision of other lesion or tissue of stomach	0.01	0.01	0.01	0.00	0.00
Unilateral repair of femoral hernia with graft or prosthesis	NR	NR	NR	0.00	0.00

Ileostomy, not otherwise specified	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to jejunum	0.01	0.01	0.01	0.01	0.01
Other small-to-large intestinal anastomosis	0.00	0.00	0.00	0.00	0.00
Other and open repair of indirect inguinal hernia	NR	NR	NR	NR	0.00
Repair of other hernia of anterior abdominal wall	0.01	0.01	0.01	0.01	0.01
Repair of inguinal hernia with graft or prosthesis, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Large-to-large intestinal anastomosis	NR	NR	NR	NR	0.00
Laparoscopic sigmoidectomy	0.02	0.02	0.02	0.03	0.02
Suture of duodenal ulcer site	0.01	0.01	0.01	0.01	0.01
Laparoscopic cecectomy	0.01	0.01	0.01	0.00	0.00
Open total intra-abdominal colectomy	0.01	0.01	0.01	0.00	0.01
Laparoscopic abdominoperineal resection of the rectum	NR	NR	NR	NR	0.00
Colostomy, not otherwise specified	0.01	0.01	0.01	0.01	0.01
Creation of cutaneoperitoneal fistula	0.01	0.01	0.01	0.00	0.00
Laparoscopic total intra-abdominal colectomy	NR	NR	NR	NR	0.00
Laparoscopic right hemicolectomy	0.05	0.05	0.05	0.04	0.04
Open and other multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Open abdominoperineal resection of the rectum	0.00	0.00	0.00	0.00	0.00
Closure of fistula of small intestine, except duodenum	NR	NR	NR	NR	0.00
Multiple segmental resection of small intestine	0.00	0.00	0.00	NR	0.00
Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Internal fixation of bone without fracture reduction, tibia and fibula	0.00	0.00	0.00	0.00	0.00
Permanent colostomy	NR	NR	NR	NR	0.00

Suture of gastric ulcer site	0.01	0.01	0.01	0.01	0.00
Total removal of small intestine	NR	NR	NR	NR	0.00
Anastomosis of gallbladder to intestine	NR	NR	NR	NR	NR
Other and open repair of umbilical hernia with graft or prosthesis	0.00	0.00	0.00	0.00	0.00
Complete substernal thyroidectomy	NR	NR	NR	NR	0.00
Exploration of common duct	NR	NR	NR	0.00	NR
Other partial thyroidectomy	0.00	0.00	0.00	NR	0.00
Suture of laceration of small intestine, except duodenum	NR	NR	NR	NR	0.00
Repair of colovaginal fistula	NR	NR	NR	NR	0.00
Other proctopexy	NR	NR	NR	0.00	0.00
Unilateral repair of inguinal hernia, not otherwise specified	0.00	0.00	0.00	0.00	0.00
Other and open repair of direct inguinal hernia	NR	NR	NR	NR	0.00
Laparoscopic resection of transverse colon	0.00	0.00	0.00	0.00	0.00
Laparoscopic left hemicolectomy	0.01	0.01	0.01	0.01	0.01
Other laparoscopic partial excision of large intestine	0.00	0.00	0.00	0.00	0.00
Other permanent ileostomy	NR	NR	NR	NR	0.00
Other pyloroplasty	NR	NR	NR	NR	0.00
Partial gastrectomy with anastomosis to esophagus	NR	NR	NR	NR	0.00
Total pancreatectomy	NR	NR	NR	NR	0.00
Choledochoenterostomy	NR	NR	NR	NR	0.00
Other and open repair of diaphragmatic hernia, abdominal approach	NR	NR	NR	0.00	0.00
Abdominoperineal resection of the rectum, not otherwise specified	NR	NR	NR	NR	0.00
Other partial pancreatectomy	NR	NR	NR	NR	0.00
Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	0.00	0.00

Laparoscopic partial cholecystectomy	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	0.00	0.00
Partial substernal thyroidectomy	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified	NR	NR	NR	0.00	0.00
Laparoscopic multiple segmental resection of large intestine	NR	NR	NR	NR	0.00
Other and unspecified total intra-abdominal colectomy	NR	NR	NR	NR	0.00
Laparoscopic repair of direct inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis	NR	NR	NR	NR	0.00
Other repair of stomach	NR	NR	NR	NR	0.00
Intestinal anastomosis, not otherwise specified	NR	NR	NR	NR	0.00
Laparoscopic repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Other and open bilateral repair of inguinal hernia, one direct and one indirect	0.00	0.00	0.00	0.00	NR
Anastomosis to anus	NR	NR	NR	NR	0.00
Continent ileostomy	0.00	0.00	0.00	0.00	NR
Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified	NR	NR	NR	NR	0.00
Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis	NR	NR	NR	NR	0.00
Substernal thyroidectomy, not otherwise specified	0.00	0.00	0.00	0.00	NR
Number of Comorbidities	6.63	6.51	5.96	5.85	6.00
Number of Comorbidities in Near Fine balance list of variables	0.63	0.62	0.76	0.76	0.76
Anesthesia Score	155.01	150.37	150.15	151.78	150.71

More than six comorbidities (%)	0.61	0.61	0.51	0.51	0.53
Congestive Heart Failure	0.26	0.26	0.18	0.18	0.19
Stroke	0.21	0.21	0.13	0.13	0.14
Seizure	0.05	0.03	0.03	0.02	0.02
Dementia	0.17	0.16	0.11	0.10	0.12
Alcohol abuse	0.03	0.03	0.03	0.03	0.03
Drug abuse	0.03	0.03	0.02	0.02	0.02
Past MI	0.11	0.10	0.10	0.10	0.11
Past Arrhythmia	0.32	0.31	0.32	0.32	0.35
Unstable Angina	0.03	0.02	0.02	0.02	0.02
Angina	0.06	0.05	0.05	0.05	0.05
Hypertension	0.93	0.93	0.85	0.85	0.85
Valvular Heart Disease	0.26	0.27	0.28	0.27	0.28
Chronic Lung Disease	0.27	0.27	0.28	0.27	0.28
Asthma	0.14	0.14	0.12	0.11	0.11
Liver Disease	0.21	0.20	0.20	0.20	0.20
Renal Dialysis	0.42	0.42	0.27	0.26	0.28
Renal Failure	0.14	0.13	0.07	0.05	0.06
Diabetes	0.51	0.51	0.34	0.33	0.33
Paraplegia	0.06	0.04	0.02	0.02	0.02
Collagen Vascular Disease	0.07	0.07	0.08	0.08	0.08
Coagulation disorders	0.00	0.00	0.01	0.01	0.01
Thrombocytopenia	0.04	0.03	0.04	0.03	0.04
Congenital Coagulation disorder	0.06	0.06	0.06	0.06	0.06
Smoking History	0.23	0.23	0.28	0.28	0.28
Post Pulmonary Fibrosis	0.03	0.02	0.03	0.03	0.03
Cushing's disease	NR	NR	NR	NR	0.00
Graves' disease	0.01	0.01	0.01	0.00	0.00

Note. NR, Not Reportable N<11

Table 5. Readmission Outcomes for Black Study Population and 3 Matched White Populations: Early Era (2003-2005), Recent Era (2013, 2015), and the Difference between the Eras to Evaluate whether the Black-White Difference is Different in the Two Eras

			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	30-day readmission (or death)	24.53	23.58	20.19***	19.12***
Recent Era (2013-2015)	30-day readmission (or death)	21.70	21.68	18.19***	18.39***
Difference in Difference (Recent - Early)	30-day readmission (or death)	--	-0.93%	-0.83%	-2.10%

Notes. Black-White difference between eras is defined by the Black-White difference in Recent Era minus the Black-White difference in Early Era. Significance tests for binary variables used McNemar test (* <0.05, ** <0.01, ***<0.001). For the difference in difference across eras, Gart's test for binary outcomes was used (+ < 0.05, ++ < 0.01, +++ < 0.001). The symbols were marked in the later era if the difference in difference was significant.

Table 6. Effect of race and hospital nursing characteristics on odds of 30-day Readmission or Death, after matching patients on demographics, procedure, and presentation variables

Variables in the Model	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)
Black	1.04 (0.97-1.11)	1.05 (0.98-1.12)	1.00 (0.91-1.09)	0.99 (0.90-1.09)
Nursing Resources (High vs Low)	---	0.86 * (0.75-1.00)	0.86 * (0.75-1.00)	0.87 (0.74-1.01)
Nursing Resources (Middle vs Low)	---	0.93 (0.83-1.05)	0.93 (0.82-1.04)	0.93 (0.82-1.05)
Black*Nursing Resources (High vs Low) Interaction	---	---	0.93 (0.85-1.03)	0.94 (0.85-1.03)
Black*Nursing Resources (Middle vs Low) Interaction	---	---	0.95 (0.85-1.05)	0.95 (0.86-1.06)
Major Teaching Hospital	---	---	---	1.05 (0.90-1.22)
Minor Teaching Hospital	---	---	---	1.00 (0.89-1.13)
Large Size (>250 beds)	---	---	---	0.93 (0.83-1.05)
High Technology Hospital	---	---	---	1.07 (0.96-1.19)
General Surgery Volume	---	---	---	0.99 (0.98-1.01)
Test for improvement in fit with greater model complexity				
Chi-square	---	4.09	2.23	5.06
Degrees of Freedom	---	2	2	5
p-value	---	0.1295	0.3280	0.4085

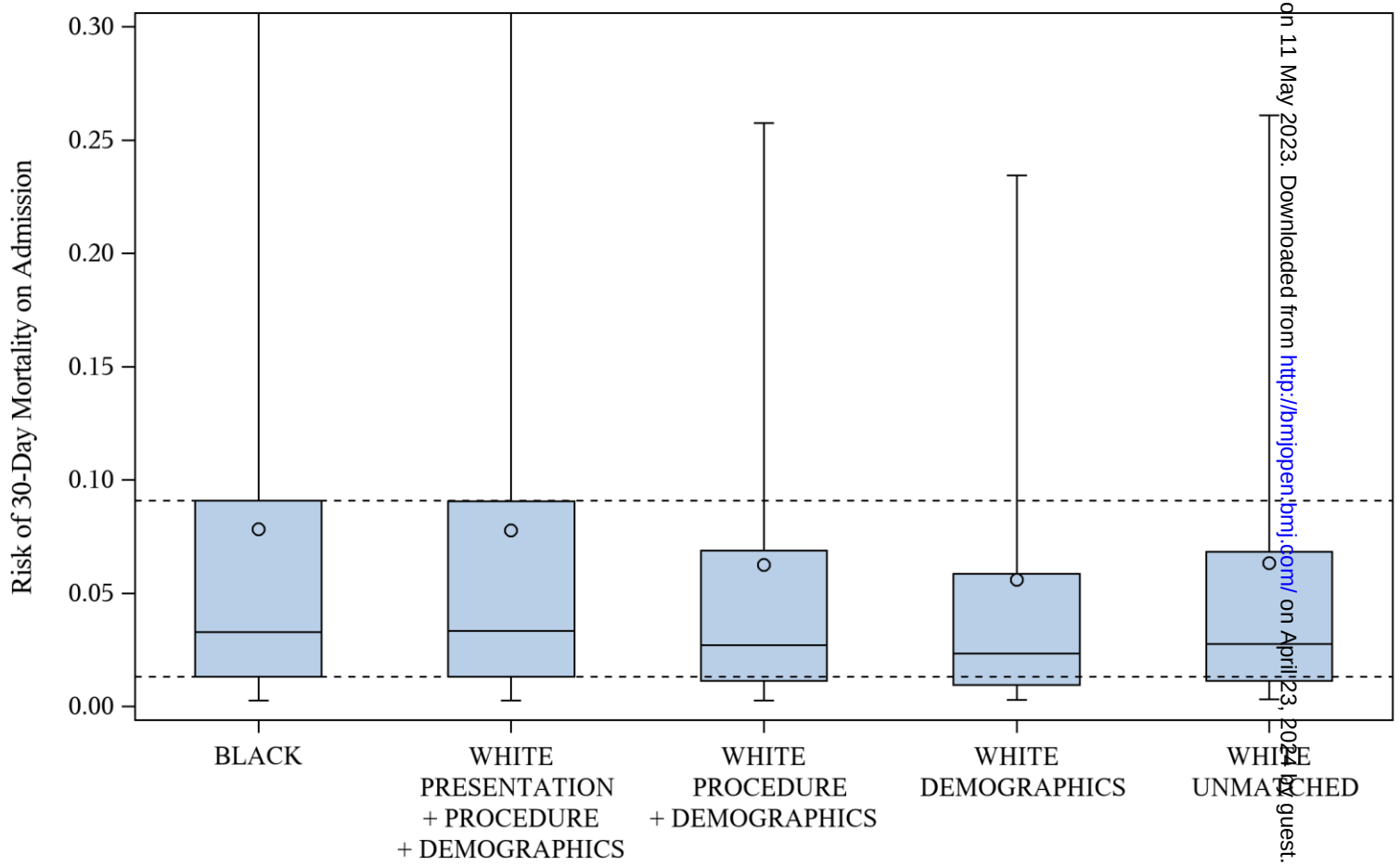
Table 7. Quality of Matches for Selected* Variables, Early Era (2003-2005)

Variable	**Black Patients** (n = 6,752)	**Tapered Matches** Presentation + Procedure + Demographics (n = 6,752)	Procedure + Demographics (n = 6,752)	Demographics (n = 6,752)	White Patients (unmatched) (n = 107,001)
State (%)					
California	23.2	23.2	23.2	23.2	**24.9**[c]
Florida	34.0	34.0	34.0	34.0	**35.5**[a]
New Jersey / Pennsylvania	42.8	42.8	42.8	42.8	**39.6**[c]
Year of Procedure (%)					
2004	21.7	22.7	21.7	21.7	21.6
2005	44.5	44.9	44.5	44.5	45.1
2006	33.8	32.4	33.8	33.8	33.3
Age at Procedure	76.0	75.8	76.0	76.0	**77.5**[c]
% Male	38.6	38.6	38.6	38.6	**43.1**[c]
Procedures (%)					
Laparoscopic cholecystectomy (5123)	15.8	15.8	15.8	**21.0**[c]	**19.9**[c]
Open right hemicolectomy (4573)	13.6	13.6	13.6	**11.3**[c]	**12.1**[c]
Lysis of peritoneal adhesion (5459)	6.2	6.2	6.2	**4.6**[c]	**4.6**[c]
Partial resection of small intestine (4562)	5.7	5.7	5.7	**4.6**[b]	**4.9**[b]
Open cholecystectomy (5122)	5.6	5.6	5.6	5.5	5.4
Selected Comorbidities (%)					
Hypertension	89.8	90.0	**78.3**[c]	**79.3**[c]	**79.5**[c]
Diabetes	46.5	46.5	**28.5**[c]	**29.3**[c]	**28.5**[c]
Congestive heart failure	25.8	25.7	**21.6**[c]	**20.3**[c]	**21.6**[c]
Renal dialysis	23.2	23.0	**13.1**[c]	**12.4**[c]	**13.4**[c]
Renal failure	15.6	15.4	**7.7**[c]	**7.1**[c]	**7.7**[c]
Paraplegia	4.8	**3.6**[c]	**1.8**[c]	**1.7**[c]	**1.9**[c]
Mortality Risk Score (prob)	0.078	0.078	**0.062**[c]	**0.056**[c]	**0.063**[c]
Emergency admission (%)	47.3	**51.6**[c]	**37.5**[c]	**38.6**[c]	**37.9**[c]
Transfer status (%)	0.9	1.0	0.9	**0.6**[a]	0.7
Anesthesia time (minutes)	148	**144**[c]	**142**[c]	**141**[c]	**141**[c]
Dual-eligible (%)	38.8	**12.0**[c]	**10.0**[c]	**9.7**[c]	**9.3**[c]
Neighborhood median household income ($)	23,658	**31,844**[c]	**32,359**[c]	**32,182**[c]	**31,729**[c]
Neighborhood high school graduate (%)	82.2	**88.6**[c]	**88.9**[c]	**88.9**[c]	**88.7**[c]
Neighborhood college graduate (%)	32.2	**39.7**[c]	**40.0**[c]	**40.0**[c]	**39.6**[c]

Notes. Bolded numbers represent significant differences [a]<0.005; [b]<0.01; [c]<0.001. *Complete balance tables with all variables are available in Appendix Table 2 for Early Era (2003-2005) patient matches. Dual-eligible is a beneficiary of both Medicare and Medicaid. Measures of patient socioeconomic status were obtained through the American Community Survey and are based on

neighborhood-level characteristics: median household income, percentage of high school graduates and percentage of college graduates.

Figure 1. Distribution of Mortality Risk Score for the Black Study Population, the Total White Study Population, and 3 Matched White Populations, Early Era (2003-2005)



Note. The tails of each box plot represent the lower 5% and upper 95% of the distribution. The mortality risk estimates presented here are based on risk at the time of admission.

Table 8. Exterior Match to Compare Mortality Differences in White Control Groups

			Tapered Matches of White Controls		
		Black Patients	Presentation + Procedure + Demographics	Procedure + Demographics	Demographics
Early Era (2003-2005)	1-year mortality	21.45%	20.51%	17.54%***	15.52%***
	30-day mortality	6.71%	7.81%**	6.47%	5.60%**
	Exterior match	**Pvalue**			
	Demo vs. Proc 1-year	0.0009		x	x
	Proc vs. Pres 1-year	< 0.0001	x	x	
	Demo vs. Pres 1-year	< 0.0001	x		x
	Demo vs. Proc 30-day	0.0261		x	x
	Proc vs. Pres 30-day	0.0012	x	x	
	Demo vs. Pres 30-day	< 0.0001	x		x
Recent Era (2013-2015)	1-year mortality	15.87%	16.16%	12.99%***	12.29%***
	30-day mortality	5.70%	7.88%***	5.74%	5.42%
	Exterior match	**Pvalue**			
	Demo vs. Proc 1-year	0.2752		x	x
	Proc vs. Pres 1-year	< 0.0001	x	x	
	Demo vs. Pres 1-year	< 0.0001	x		x
	Demo vs. Proc 30-day	0.4615		x	x
	Proc vs. Pres 30-day	< 0.0001	x	x	
	Demo vs. Pres 30-day	< 0.0001	x		x
Difference between Eras (Recent - Early)	1-year mortality	--	-1.23%	-1.03%	-2.35%
	30-day mortality	--	-1.08%	-0.28%	-0.83%

Note. The two White control groups being compared are marked with an ‘x’. P-values test the equality of the mortality in the two White controls groups being compared. Summary: The White control groups are significantly different in all cases except the Demographics vs Demographics+Procedure groups in the Recent Era for both 1-year and 30-day mortality. This suggests that Black patients were having higher risk procedures than White patients in the Early Era, but not the Recent Era.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1
Objectives	3	State specific objectives, including any prespecified hypotheses	1
Methods			
Study design	4	Present key elements of study design early in the paper	2-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2-4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	2 & 3
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3 & 4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	2
2Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	2 & 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	3 & 4
Statistical methods5	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	5

(e) Describe any sensitivity analyses

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	2
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	2
		(b) Indicate number of participants with missing data for each variable of interest	n/a
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*n/a*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*n/a*
		Cross-sectional study—Report numbers of outcome events or summary measures	*Tables 1 & 2*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 3
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	9 & 10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11 & 12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Title page, cover letter

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.