Published in final edited form as:
*J Am Geriatr Soc*. 2013 September ; 61(9): 1499–1507. doi:10.1111/jgs.12419.

# Variations in Postoperative Complications across Race, Ethnicity and Sex among Older Adults

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## Abstract

**OBJECTIVES—**To explore differences in the incidence of postoperative complications among three racial/ethnic groups (white, black and Hispanic) before and after taking into account potentially confounding patient and hospital characteristics.

**DESIGN—**A cross-sectional study using 2006–2007 administrative patient discharge data from hospitals in four states (CA, PA, NJ, FL), linked to American Hospital Association Annual Survey data, and data from the U.S. Census. Risk-adjusted logistic regression models were used in the analyses.

**SETTING—**Six hundred U.S. adult nonfederal acute care hospitals.

**PARTICIPANTS—**Five hundred eighty seven thousand three hundred fourteen individuals, ages 65 and over, undergoing general, orthopedic or vascular surgeries (86% white, 6% black and 8% Hispanic).

**MEASUREMENTS—**Thirteen frequent postoperative complications.

**RESULTS—**When considered without controls, black patients had significantly higher odds than white patients of developing 12 of the 13 complications, by factors (ORs) ranging from 1.09 to 2.69. Hispanic patients had significantly higher odds than white patients on 9 of the 13 complications (ORs range from 1.11 to 1.82) and significantly lower odds than white patients on 2 of the other 4 (ORs = 0.84 in both cases).The fully adjusted models that accounted for hospital and especially patient characteristics substantially diminish the number of complications for which black and Hispanic patients had significantly higher odds than white patients. Many of the significant differences between blacks, Hispanics and white patients that persisted after controls were different for male and female patients.

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**Author Contributions**: All authors were involved in the concept and design of the study, data analysis, interpretation of results, and preparation of the manuscript.

**Conflict of Interest**

**CONCLUSION—**Older black and Hispanic patients have higher odds than white patients of developing a vast majority of postoperative complications. Differences in postoperative complication risk are largely explained by procedure type and health status, and are frequently conditional on sex.

### Keywords

Race; Ethnicity; sex; Disparities; Complications

## INTRODUCTION

Nearly 15 years ago the Institute of Medicine released its seminal report "*To Err is Human: Building a Safer Health System*."[1] Since that time reducing medical errors and improving patient safety has become a national priority and resulted in a number of initiatives to improve quality and reduce costs.[2,3] Despite efforts to address adverse events, quality gaps remain.[4–8] Black and Hispanic patients in particular are more apt to sustain a postoperative adverse event such assepsis,[9] urinary tract infection[10] and even death as compared to their white counterparts.[11] The toll that untoward postoperative events take on patients, in terms of quality of life, and healthcare systems with respect to costs, signifies a call for ongoing action to decrease their occurrence.[12]

Efforts to reduce postoperative disparities must begin with deepening the evidence base related to contributing factors. It is has been previously shown that postoperative disparities arise out of the complex interplay between patient, environmental or hospital level factors, with a number of studies concluding that complications stem from socio-demographic factors, biological predisposition, poor health status or quality differences at the institutions where minorities are served.[13–17] For example, in their study of race and gender disparities in vein graft failure, Ngyuen, et al discovered a synergistic effect between black race and female sex - such that black females were found to have notably inferior vein graft patency and limb salvage outcomes as compared to white men, white women and black men.[17] Despite these findings, analyses of the interdependent relationships between race /ethnicity, sex and postoperative adverse events are uncommon in the literature.

Poor postoperative outcomes among black and Hispanic patients have also been attributed to the fact that these patients are less likely to receive care for complex surgery at high-volume hospitals[7] and may be more likely to receive care from surgeons who complete fewer procedures and have poorer outcomes.[18,19] Higher incidence of complications among black patients has equally been attributed to longer lengths of hospital stay, severity of illness, and increased rates of medical comorbidities.[6] Taken together, the current research provides insights into individual and system level sources of postoperative disparities; however, most studies have not explored the extent to which these factors act both independently and in concert with one another.

We sought to explore the independent and joint impact of patient characteristics, including race/ethnicity and sex, as well as the structural features of hospitals on the incidence of postoperative complications among older adults using three linked data sources: 2006-07 administrative patient discharge data from 4 states (California, Pennsylvania, New Jersey and Florida), American Hospital Association (AHA) Annual Survey data and U.S. Census data. The primary outcomes were any one of a set of 39 complications among white, black and Hispanic patients over age 65, who underwent general, orthopedic, or vascular surgery.

# METHODS

## Data Sources

This study included 600adult nonfederal acute care hospitals in California, Pennsylvania, New Jersey, and Florida that (1) had at least 100 surgical discharges during the study period and (2) responded to the 2006 AHA Annual Survey. Patient discharge data were obtained from California's Office of Statewide Health Planning and Development (OSHPD), Florida's Agency for Health Care Administration (AHCA), the New Jersey Department of Health and Senior Services (NJDHSS), and the Pennsylvania Health Care Cost Containment Council (PHC4). These four states were selected because they are among the largest in the country and account for more than one-fifth of the nation's hospitalizations. Publicly available U.S. Census data were used to derive a neighborhood socioeconomic measure for each ZIP code in the four states. Data sources were merged using a unique hospital identifier.

## Measures

**Patient characteristics—**The sample was composed of individuals, aged 65–99 with a Diagnosis Related Group (DRG) for general, orthopedic, or vascular surgery with a length of stay (LOS) of greater than one day. Patients admitted between January 1, 2005 and December 31, 2006 in California, New Jersey, and Pennsylvania, and between January 1, 2006 and December 31, 2007 in Florida were included. These operations were selected because they are common, are associated with well-known adverse occurrences, and are performed in most general hospitals. Patient race, ethnicity and sex data were obtained from the patient discharge records and patients categorized as non-Hispanic white, non-Hispanic black, or Hispanic of any race were included in our analytic sample. Patients of other races were excluded from these analyses. Other patient characteristics in our risk-adjustment models, included: age (years), LOS (days), primary surgical DRG, admission type (emergent orroutine), whether the admission was a transfer from another hospital, primary insurance type (Medicare, Medicaid, or private), and a set of dummy variables indicating the presence of 27 individual comorbidities.[20] Fluid and electrolyte disorders and coagulopathies were excluded from our risk adjustment models as studies have shown that these conditions may be indicators of complications rather than comorbidities, and should not be used when "present on admission" data are missing.[21,22] Finally, based on their home zip code, each patient was assigned a Neighborhood Socioeconomic Summary Index score.[23] This index includes six aggregate measures of wealth/income, education and occupation/employment that were derived from 2000 U.S. Census data. The Socioeconomic Summary Index was created by summing the z-score for each of the six measures and ranged from −14 to 32, with higher scores corresponding to higher neighborhood socioeconomic status.

**Hospital characteristics—**The 2006 AHA Annual Survey provided data on several structural characteristics of the hospitals in our sample. Teaching status was defined by the number of medical residents and fellows, and was classified as major (>1:4 trainee to bed ratio), minor (<1:4 trainee to bed ratio), or non-teaching (no medical trainees). Hospital size was classified as large (>250 beds), medium (101–250 beds), and small (<100 beds). Technology status was defined as high if the hospital had facilities for open-heart surgery, major organ transplants, or both. Core Based Statistical Area (CBSA) is a census-based measure of population density defined by the Office of Management and Budget and is divided into four categories: division (>2.5 million), metro (50,000–2.5 million), micro (10,000–49,999), and rural (<10,000).

**Outcomes:** Complications were defined using Silber and colleagues' methodology, where patients who developed any one of 39 clinical adverse events following a surgical procedure

were identified.[24] For the purpose of this analysis we selected the 13 most frequent complications, representing the top third of the set. The complications used in our analyses include: gastrointestinal bleed(GI) bleed/blood loss, respiratory compromise, renal dysfunction, delirium/psychosis, pneumothorax, shock, pneumonia, cardiac emergency, internal organ damage, postsurgical complication-not otherwise specified (NOS), wound infection, sepsis and pressure ulcer. (See Appendix for frequencies of all 39 complications in the sample.)

**Data Analysis—**We examined demographic characteristics, preoperative clinical risk factors and development of postoperative complications for white, black and Hispanic patients in our sample. Chi square ($\chi^2$) tests were used for categorical variables while ANOVA tests were used for continuous variables to evaluate differences between groups.

To determine whether the 13most commonly occurring postoperative complications were associated with race or ethnicity we employed robust logistic regression models and used Huber/White sandwich estimators to adjust the standard errors for the clustering of patients within hospitals. Models were constructed in hierarchical fashion so that each subsequent model added a variable, or set of variables sequentially to those included in the previous model. We began with bivariate models, which estimated the unadjusted main (or direct) effects of race, ethnicity, and sex, separately, without additional controls. The second model estimated the main effects of race, ethnicity, and sex, simultaneously, while controlling for patient characteristics (age, LOS, primary surgical DRG, admission type, transfer status, insurance type, medical comorbidities, and Neighborhood Socioeconomic Index). The third model added hospital characteristics (teaching status, size, technology, CBSA and state). Because of associations between race/ethnicity and sex found in the literature, we then tested each complication for the presence of sex-by-race and sex-by-ethnicity interactions. Our final model was identical to the third model except that it added the interactions between sex and race/ethnicity and we report those that were significant. All analyses were performed using Stata version 11.0 (STATA Corp, College Station, TX).

## RESULTS

A total of 587,314 patients were included in the analysis (510,602 white, 32,665 black and 44,047 Hispanic).Demographic information and clinical preoperative characteristics of patients who underwent a general, orthopedic, or vascular surgery by race and ethnicity are presented in Table 1. All omnibus tests of differences across racial/ethnic groups were statistically significant at $p<0.001$—however, several differences are substantive and clinically important to note. Black patients were more likely to experience a postoperative complication as compared to Hispanic and white patients (50% vs. 43% and 42% respectively, $P=.001$). Men experienced complications more frequently than women, with 55% of black men, 48% of Hispanic men, and 44% of white men experiencing one (or more) major complications after surgery (results not shown). On average, white patients were slightly older and lived in neighborhoods with higher socioeconomic status. Notably, 9%of Hispanics had Medicaid as a primary payer as compared to 2%or less of black and white patients ($P=.001$). The most frequent co-occurring conditions, diabetes and hypertension, were more common among black and Hispanic patients as compared to white patients. Hispanic patients were most likely to be admitted for emergency surgery (46% vs. 42%of blacksand38% of whites, $P=.001$). Differences between racial/ethnic groups were also noted by surgery type, with higher percentages of black and Hispanic patients undergoing vascular and general procedures as compared to white patients. Meanwhile, 64% of white patients received an orthopedic procedure compared to about half of Hispanic (51%, $P=.001$) and black patients (47%, $P=.001$). Black patients were more likely to have

operations in larger, urban, teaching hospitals as well as hospitals with high technology procedure capability.

The frequencies of postoperative complications in white, black and Hispanic patients are demonstrated in Table 2. A higher percentage of black patients suffered 12 of the 13 individual complications included in our analyses as compared to white patients. Higher percentages of Hispanic patients suffered 10 of the 13 complications as compared to white patients.

Odds ratios for the main effects of race/ethnicity and sex are presented in Table3. The unadjusted odds ratios indicate that before taking account of other factors, black patients had significantly higher odds than white patients of developing 12 of the 13 complications (all except GI bleed/blood loss), by factors ranging from OR = 1.09, 95% CI= 1.00–1.18 (for pneumothorax) to OR= 2.69, 95% CI= 2.45–2.95(for pressure ulcer). Hispanic patients had significantly higher odds than white patients on 9 of the complications (by factors ranging from OR =1.11, 95% CI= 1.02–1.22 (for internal organ damage) to OR= 1.82, 95% CI= 1.67–1.98 (for sepsis), and significantly lower odds of developing GI bleed/blood loss and delirium/psychosis(OR = 0.84 in both cases).

After taking account of patient characteristics (in Model 2), most of the significant race/ethnicity differences that involved higher odds for black and Hispanic patients were rendered insignificant. There were, after these controls, three remaining complications where black patients had significantly higher odds than white patients (delirium/psychosis, pressure ulcer, and GI bleed/blood loss) and two where Hispanic patients had significantly higher odds (internal organ damage and sepsis). Moreover, after controlling for patient characteristics, there were five complications where black patients had significantly lower odds than white patients, and there remained two where Hispanic patients had significantly lower odds than white patients (renal dysfunction and cardiac emergency). The addition of hospital controls (Model 3) did little to alter the estimated differences of developing a postoperative complication between white, black, and Hispanic patients.

Our final set of models aimed to determine if there was a relationship between race/ethnicity, sex and the development of postoperative complications (Table 3). Before controls were added (Model 1), sex was significantly related to all 13 of the complications, and except for GI bleed/blood loss, the odds were higher for men than women (see column 1). In most cases, these differences persisted after controls for patient and hospital characteristics (Models 2 and 3). For the final six complications listed in Table 3, the effects of sex and race/ethnicity had an interactive effect. We used the odds ratios for the main effects and interactions from Model 4 in Table 3 to derive separate odds ratios to indicate how black/white patient differences and Hispanic/white patient differences varied by sex (Table 4). When we did so, we found that the higher odds of GI bleed/blood loss among black patients was more pronounced for black men than black women (OR = 1.34 vs. 1.17), while the greater odds of delirium/psychosis among black patients was more pronounced for black women than black men (OR = 1.46 vs. 1.32). The higher odds of sepsis and post-surgical complications, NOS among black patients were significant only for black women (OR = 1.14 and 1.18, respectively). And finally, the lower odds of pneumonia and pressure ulcers for Hispanic patients than white patients were significant only for Hispanic men.

## DISCUSSION

In our analysis of older adults undergoing a general, orthopedic, or vascular surgery, we found evidence that older black and Hispanic patients were more susceptible to some (but not all) potential postoperative complications. Older black patients were more likely to

suffer twelve of the thirteen most commonly occurring complications. However, after accounting for patient characteristics, such as the type of operative procedure and health status, the risk of developing a complication was significantly reduced and black patients appeared at higher risk for only GI bleed/blood loss, pressure ulcer, and psychosis/delirium. A similar pattern was evident in our attempt to examine the independent effect of ethnicity for Hispanic patients. Prior to the addition of potential confounders, Hispanic patients appeared at higher risk for two thirds of the thirteen complications, though only the risk of sepsis remained elevated after accounting for burden of illness, the type of surgical procedure, and features of the hospitals where they received care.

Our findings are consistent with research conducted by Vogel and colleagues (2010) who found that age (OR=2.05, 95% CI = 1.97–2.13), black race (OR=1.36, 95% CI = 1.31 – 1.41) and Hispanic ethnicity (OR= 1.33, 95% CI = 1.27 –1.39) were independent predictors for the development of postoperative sepsis following elective procedures.[9] While our research yields similar findings, our results differ in that other patient characteristics (besides race/ethnicity) appear to better explain many of the disparities seen in our unadjusted models. For example, our findings suggest that factors such as health status and multiple comorbidities significantly contribute to the development of postoperative adverse events, which if aggressively managed prior to and during the peri- and postoperative periods, may lead to improved outcomes.[25] While our risk adjustment takes into account the most commonly occurring medical comorbidities, we were unable to adjust for severity of illness or functional status coming into the operative procedure. Subsequently, physiologic health and functional status prior to a procedure may have positively or negatively affected postoperative outcomes. Future research into screening tools to weigh the risk/benefit for older minorities entering into surgery may help to identify those at greater risk for poorer outcomes.

It is also important to note that in a number of cases, black and Hispanic patients were at lower risk for developing any one of the thirteen complications. After accounting for patient and structural characteristics of the hospital, black patients experienced reduced risk for developing six complications (respiratory compromise, renal dysfunction, pneumothorax, cardiac emergency, deep wound infection, pneumonia). Older Hispanic patients experienced a similar pattern, notably experiencing lower risk of four complications. After a careful review of our data, we were unable to detect a pattern for why older black and Hispanic patients were at elevated risk for some complications but at lower risk for others. It is conceivable however, that given the literature documenting disparities, that some of the lower risk of postoperative complications may be attributed to the types of surgeries performed on black and Hispanic patients. Several studies have demonstrated that minorities disproportionately undergo less technologically sophisticated procedures.[26–28] While we were able to control for surgical type, there may have been differences in the complexity of specific surgeries that made the risk of developing complications from one procedure more likely then another. If, for example, black and Hispanic patients underwent less risky procedures, then the threat of complications may have subsequently been lower. Black and Hispanic patients may have also appeared at lower risk of postoperative complications due to our choice of comparison group. While researchers typically look to white patients as the reference category, it is possible that they may not be provided the best care in every instance; hence, such comparisons in some cases may be inappropriate.[29] Further, though a number of studies have noted that adverse outcomes among black and Hispanic patients may be due to receipt of care in lower quality hospitals.[15] It is equally plausible that minorities may be receiving care in hospitals where the overall rate of adverse events is lower. Finally other process of care differences, which are unique to hospital systems, such as differences in documentation and coding, may have led to either an underestimation of adverse events in the hospitals where minorities received care.

The fact that black and Hispanic patients were not uniformly at increased risk for developing all complications, but were at lower risk for a number of complications is consistent with several studies.[30–32] For example, Coffey, et al. (2005) examined Agency for Healthcare Research and Quality (AHRQ) patient safety events and found that non-Hispanic black patients suffered a higher occurrence of some patient safety events after controlling for socioeconomic status, while risk of other adverse events was lower for non-white Hispanics and Asians.[32] Accordingly, our findings of lower postoperative complications among black and Hispanic patients adds to this body of evidence and raises questions about potential protective factors which in some instances may lead to decreased risk of adverse events following surgery among minority patients.

Our findings also suggest that disparities in postoperative complications are in some cases associated with sex. Specifically, we found that men were more likely than women to develop nearly all of the most frequently occurring complications. In addition, we found an interactive effect between race, ethnicity and sex for six complications, which suggests that the development of complications varies by the biologic differences conferred by sex. These findings are important because they indicate the need for careful clinical assessments that not only examine differences between racial/ethnic groups, but that also consider within-group variation according to sex. Even in instances where racial and ethnic disparities are clearly noted in main (direct) effect models, the magnitude of these disparities may be underestimated when sex is not taken into consideration. An interesting example of this is seen in the case of sepsis. In our models without sex interactions, black race is associated with a twofold (OR 2.11) unadjusted risk of sepsis, which becomes insignificant once patient and hospital controls are applied (OR 1.04). However, once accounting for the moderating influence of sex, we note that black women(OR 1.18) retain significant risk for sepsis development as opposed to black men (OR 0.92) - a fact that would have been negated without the introduction of our sex interaction terms.

Taken together, our results suggest that understanding the differences in postoperative complications between white, black, and Hispanic patients is in a word— complex. The variations in our results suggest that future research should be sensitive to the multifaceted nature of complication development including the socio-cultural constructs of race/ethnicity and biological determinants such as sex.

## LIMITATIONS

We do note several limitations. Because this study relied on cross-sectional data, we were unable to determine causality. The risk of selection bias may also exist since older adults who undergo surgery may differ from those who are not. We acknowledge that the current categories used to confer racial and ethnic status are socially constructed, hence we acknowledge limitations in the reliability of the racial and ethnic designations of our sample due to our use of administrative data.[33] Data limitations also prevent us from capturing other critical elements such as immigrant status, literacy, and language status. The absence of these data elements poses additional constraints on the generalizability of our findings.

Our study of hospitals includes four of the most populous U.S. states. However, they may not be representative of hospitals in the Midwest and Deep South, which were not included in our sample; hence, our findings might have varied with their inclusion. Our sample does however, capture half of the Hispanic population, age 65 and older, who live in the U.S.[34] Further, while information related to cultural origin is not provided in the administrative record, our sample presumably contains a great deal of heterogeneity within the Hispanic population given the large proportions of Cuban (FL, NJ), Puerto Rican (FL,NJ,PA), Dominican (NJ, FL, PA), Guatemalan (CA, FL, NJ), Salvadoran (CA) and Mexican (CA)

older adults represented geographically in our sample.[34] Finally, our findings may not fully account for unmeasured confounding that might persist even after multivariable model risk adjustment, such as differences in baseline characteristics including: body mass index (BMI), smoking status, American Society of Anesthesiology (ASA) Physical Status classification (a measure of surgical survival risk),severity of comorbidities, and cognitive and/or functional impairment.[35, 36]

## CONCLUSION

Older black and Hispanic patients experience a disproportionate burden of complications, which have implications for their recovery and quality of life following operative procedures. While this finding is of clinical importance, of equal significance is the occurrence of lower risk of adverse events in some instances. Such variations have implications for future research into preoperative risk factors, some of which may be modifiable, as well as potential protective factors operating in these groups. We also note a link between postoperative outcomes and patient characteristics such as medical comorbidities and sex. Our attempt to clarify the way that patient characteristics are associated with post-surgical outcomes both within and between racial/ethnicminority groups is an important step toward addressing surgical disparities. Ongoing attention to the ways in which biologic and social determinants such as sex, race and ethnicity serve as synergistic determinants of health will aid in the future development of individualized models of care for older racial/ethnic minority patients.

## Acknowledgments

The authors would like to acknowledge Tim Cheney for his analytical assistance.

This research was supported by the National Institutes of Health, National Institute of Nursing Research (K01NR012006 [Brooks Carthon, PI], (R01-NR04513 [Aiken, principal investigator (PI)], (T32-NR007104, Linda Aiken, PI), the Agency for Healthcare Research and Quality (grant 1K08-HS018534 [Kutney-Lee, PI]) and the National Hartford Centers of Gerontological Nursing Excellence Claire M. Fagin Fellowship [Jarrín, PI].

**Sponsor's Role**: The content is solely the responsibility of the authors and does not necessarily represent the official views of the NINR, National Institutes of Health, or the AHRQ. The funding sources had no role in the study design, data collection, analysis, interpretation, or writing of the project.

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## Appendix A

Major post-surgical complications among older adults

| | White | n=510,602 | Black | n=32,665 | Hispanic | n=44,047 | Total | n=587,314 |
|---|---|---|---|---|---|---|---|---|
| Any Complication | 213,220 | 41.8% | 16,221 | 49.7% | 18,985 | 43.1% | 248,426 | 42.3% |
| GI Bleed & Blood Loss | 59,033 | 11.6% | 3,620 | 11.1% | 4,355 | 9.9% | 67,008 | 11.4% |
| Respiratory Compromise | 28,191 | 5.5% | 2,116 | 6.5% | 2,885 | 6.6% | 33,192 | 5.7% |
| Renal Dysfunction | 27,340 | 5.4% | 2,927 | 9.0% | 2,886 | 6.6% | 33,153 | 5.6% |
| (Delirium) Psychosis | 28,824 | 5.7% | 2,120 | 6.5% | 2,116 | 4.8% | 33,060 | 5.6% |
| Pneumothorax | 22,792 | 4.5% | 1,583 | 4.9% | 2,213 | 5.0% | 26,588 | 4.5% |
| Hypotension/Shock | 21,328 | 4.2% | 1,671 | 5.1% | 2,226 | 5.1% | 25,225 | 4.3% |
| Pneumonia-Other | 21,432 | 4.2% | 1,580 | 4.8% | 2,106 | 4.8% | 25,118 | 4.3% |
| Cardiac Emergency | 17,516 | 3.4% | 1,284 | 3.9% | 1,530 | 3.5% | 20,330 | 3.5% |
| Internal Organ Damage | 15,178 | 3.0% | 1,199 | 3.7% | 1,456 | 3.3% | 17,833 | 3.0% |
| Post-Surgical Complication | 15,213 | 3.0% | 1,107 | 3.4% | 1,266 | 2.9% | 17,586 | 3.0% |
| Deep Wound Infection | 14,215 | 2.8% | 1,525 | 4.7% | 1,661 | 3.8% | 17,401 | 3.0% |
| Sepsis | 12,285 | 2.4% | 1,614 | 4.9% | 1,894 | 4.3% | 15,793 | 2.7% |
| Pressure Ulcer | 10,825 | 2.1% | 1,801 | 5.5% | 1,385 | 3.1% | 14,011 | 2.4% |
| DIC[1] | 9,981 | 2.0% | 765 | 2.3% | 1,101 | 2.5% | 11,847 | 2.0% |
| Intestinal Obstruction | 9,302 | 1.8% | 611 | 1.9% | 922 | 2.1% | 10,835 | 1.8% |
| DVT[2] | 8,438 | 1.7% | 928 | 2.8% | 870 | 2.0% | 10,236 | 1.7% |
| Cardiac Event | 8,381 | 1.6% | 368 | 1.1% | 637 | 1.5% | 9,386 | 1.6% |
| Pneumonia-Aspiration | 8,006 | 1.6% | 561 | 1.7% | 695 | 1.6% | 9,262 | 1.6% |
| Seizure | 7,383 | 1.5% | 925 | 2.8% | 682 | 1.6% | 8,990 | 1.5% |
| Perforation | 7,583 | 1.5% | 551 | 1.7% | 641 | 1.5% | 8,775 | 1.5% |
| Phlebitis | 6,634 | 1.3% | 678 | 2.1% | 677 | 1.5% | 7,989 | 1.4% |
| Peritonitis | 5,786 | 1.1% | 384 | 1.2% | 643 | 1.5% | 6,813 | 1.2% |
| Gangrene/Amputation | 3,938 | 0.8% | 1,049 | 3.2% | 970 | 2.2% | 5,957 | 1.0% |
| Osteomylitis | 3,579 | 0.7% | 741 | 2.3% | 762 | 1.7% | 5,082 | 0.9% |
| Pulmonary Embolus | 3,979 | 0.8% | 417 | 1.3% | 325 | 0.7% | 4,721 | 0.8% |
| Pancreatitis | 3,405 | 0.7% | 318 | 1.0% | 562 | 1.3% | 4,285 | 0.7% |
| CHF[3] | 3,556 | 0.7% | 206 | 0.6% | 270 | 0.6% | 4,032 | 0.7% |
| CVA[4] | 3,027 | 0.6% | 291 | 0.9% | 237 | 0.5% | 3,555 | 0.6% |
| Coma | 2,937 | 0.6% | 246 | 0.8% | 353 | 0.8% | 3,536 | 0.6% |

| | White | n=510,602 | Black | n=32,665 | Hispanic | n=44,047 | Total | n=587,314 |
|---|---|---|---|---|---|---|---|---|
| Other Respiratory | 2,684 | 0.5% | 209 | 0.6% | 219 | 0.5% | 3,112 | 0.5% |
| Return to Surgery | 2,598 | 0.5% | 244 | 0.8% | 269 | 0.6% | 3,111 | 0.5% |
| Orthopedic Complication | 2,487 | 0.5% | 145 | 0.4% | 150 | 0.3% | 2,782 | 0.5% |
| Necrosis of Bone | 2,147 | 0.4% | 81 | 0.3% | 118 | 0.3% | 2,346 | 0.4% |
| Hepatitis/Jaundice | 1,331 | 0.3% | 86 | 0.3% | 161 | 0.4% | 1,578 | 0.3% |
| TIA[5] | 1,039 | 0.2% | 56 | 0.2% | 71 | 0.2% | 1,166 | 0.2% |
| Bronchospasm | 952 | 0.2% | 99 | 0.3% | 112 | 0.3% | 1,163 | 0.2% |
| Nervous System Comp | 628 | 0.1% | 87 | 0.3% | 70 | 0.2% | 785 | 0.1% |
| Pyelonephritis | 271 | 0.1% | 31 | 0.1% | 53 | 0.1% | 355 | 0.1% |
| Compartment Syndrome | 34 | 0.0% | 2 | 0.0% | 5 | 0.0% | 41 | 0.0% |

Note:

[1]Disseminated Intravascular Coagulation (DIC)

[2]Deep Vein Thrombosis (DVT)

[3]Congestive Heart Failure (CHF)

[4]Cerebral Vascular Accident (CVA)

[5]Transient Ischemic Attack (TIA)

## Table 1

Patient and Hospital Sample Characteristics by Ethnicity/Race (n=587,314)

| Patient Characteristics | | White | Black | Hispanic |
|---|---|---|---|---|
| | | 510,602 (86.9%) | 32,665 (5.6%) | 44,047 (7.5%) |
| Age mean (±SD) | | 77.2 (±7.6) | 75.0 (±7.3) | 75.4 (±7.2) |
| Male Sex *** (%) | | 38.6 | 35.2 | 38.9 |
| Primary Payer *** (%) | Medicare | 92.5 | 89.4 | 84.3 |
| | Medicaid | 0.4 | 2.1 | 8.6 |
| | Private | 7.0 | 8.5 | 7.1 |
| Socioeconomic Status *** (%) | low | 7.4 | 38.3 | 35.0 |
| | average | 47.4 | 43.4 | 40.3 |
| | above average | 28.6 | 12.6 | 17.7 |
| | high | 16.7 | 5.8 | 7.0 |
| Admission Type (%) | Emergency *** | 38.2 | 42.2 | 46.0 |
| | Transfer-Hospital *** | 1.1 | 1.3 | 1.5 |
| | Routine *** | 59.2 | 54.1 | 50.4 |
| Comorbidities (%) | COPD *** | 19.0 | 17.7 | 14.8 |
| | Diabetes *** | 19.6 | 35.3 | 35.2 |
| | Liver disease *** | 1.2 | 1.4 | 2.6 |
| | Depression *** | 7.1 | 3.8 | 6.4 |
| | Hypertension *** | 64.2 | 78.0 | 70.6 |
| Surgery Type(%) | General Surgery *** | 29.5 | 39.4 | 39.6 |
| | Orthopedic Surgery *** | 64.0 | 46.6 | 50.7 |
| | Vascular Surgery *** | 6.5 | 13.9 | 9.7 |
| Characteristics of Hospitals | | | | |
| Technology status *** (%) | High | 58.4 | 63.1 | 61.9 |
| Beds staffed *** (%) | Large >250 | 61.4 | 71.4 | 66.3 |
| | Medium 101–250 | 33.5 | 27.0 | 31.2 |
| | Small <100 | 5.1 | 1.6 | 2.5 |
| Teaching status *** (%) | Major | 10.2 | 18.0 | 6.9 |
| | Minor | 40.0 | 45.5 | 48.4 |
| | Non-teaching | 49.8 | 36.5 | 44.7 |
| Core Based Statistical Area *** | Division | 35.9 | 61.0 | 66.0 |
| | Metro | 58.7 | 38.0 | 39.5 |
| | Micro | 5.0 | 1.0 | 0.6 |
| | Rural | 0.4 | 0.0 | 0.0 |

Note:

*
p≤ 0.05

**
p≤0.01

***
p≤0.001.

Percentages may not equal 100 because of rounding

**Table 2**

Most Frequent Major Postsurgical Complications Among Older Adults

| | White | n=510,602 | Black | n=32,665 | Hispanic | n=44,047 | Total | n=587,314 |
|---|---|---|---|---|---|---|---|---|
| GI Bleed & Blood Loss | 59,033 | 11.6% | 3,620 | 11.1% | 4,355 | 9.9% | 67,008 | 11.4% |
| Respiratory Compromise | 28,191 | 5.5% | 2,116 | 6.5% | 2,885 | 6.6% | 33,192 | 5.7% |
| Renal Dysfunction | 27,340 | 5.4% | 2,927 | 9.0% | 2,886 | 6.6% | 33,153 | 5.6% |
| (Delirium) Psychosis | 28,824 | 5.7% | 2,120 | 6.5% | 2,116 | 4.8% | 33,060 | 5.6% |
| Pneumothorax | 22,792 | 4.5% | 1,583 | 4.9% | 2,213 | 5.0% | 26,588 | 4.5% |
| Hypotension/Shock | 21,328 | 4.2% | 1,671 | 5.1% | 2,226 | 5.1% | 25,225 | 4.3% |
| Pneumonia-Other[1] | 21,432 | 4.2% | 1,580 | 4.8% | 2,106 | 4.8% | 25,118 | 4.3% |
| Cardiac Emergency | 17,516 | 3.4% | 1,284 | 3.9% | 1,530 | 3.5% | 20,330 | 3.5% |
| Internal Organ Damage | 15,178 | 3.0% | 1,199 | 3.7% | 1,456 | 3.3% | 17,833 | 3.0% |
| Post-surg complication, NOS[2] | 15,213 | 3.0% | 1,107 | 3.4% | 1,266 | 2.9% | 17,586 | 3.0% |
| Deep Wound Infection | 14,215 | 2.8% | 1,525 | 4.7% | 1,661 | 3.8% | 17,401 | 3.0% |
| Sepsis | 12,285 | 2.4% | 1,614 | 4.9% | 1,894 | 4.3% | 15,793 | 2.7% |
| Pressure Ulcer | 10,825 | 2.1% | 1,801 | 5.5% | 1,385 | 3.1% | 14,011 | 2.4% |

[1] Pneumonia due to causes other than aspiration

[2] Post-surgical complication, not otherwise specified

*J Am Geriatr Soc*. Author manuscript; available in PMC 2014 September 05.

**Table 3**

Logistic Regression Models for Post-Operative Complications n=587,314

| | | Unadjusted | Full Set of Patient Characteristics | Patient and Hospital Characteristics | Patient, Hospital and Race*Sex Interaction |
|---|---|---|---|---|---|
| | | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
| Respiratory Compromise | Male | 1.44*** | 1.09*** | 1.08*** | |
| | Black | 1.19*** | 0.79*** | 0.81*** | |
| | Hispanic | 1.20*** | 1.05 | 1.05 | |
| Renal Dysfunction | Male | 1.67*** | 1.27*** | 1.27*** | |
| | Black | 1.74*** | 0.94 | 0.92*** | |
| | Hispanic | 1.24*** | 0.90*** | 0.93* | |
| Pneumothorax | Male | 1.17*** | 1.00 | 0.98 | |
| | Black | 1.09* | 0.86*** | 0.90* | |
| | Hispanic | 1.13* | 1.04 | 1.05 | |
| Hypotension/ Shock | Male | 1.18*** | 1.00 | 1.00 | |
| | Black | 1.24*** | 0.98 | 0.94 | |
| | Hispanic | 1.22*** | 1.09* | 0.95 | |
| Cardiac Emergency | Male | 1.79*** | 1.36*** | 1.36*** | |
| | Black | 1.15** | 0.87*** | 0.85*** | |
| | Hispanic | 1.01 | 0.90** | 0.87*** | |
| Internal Organ Damage | Male | 1.26*** | 1.01 | 1.00 | |
| | Black | 1.24*** | 1.05 | 1.08 | |
| | Hispanic | 1.11* | 1.09* | 1.03 | |
| Deep Wound Infection | Male | 1.48*** | 1.17*** | 1.16*** | |
| | Black | 1.71*** | 0.85*** | 0.85*** | |

| | | Unadjusted | Full Set of Patient Characteristics | Patient and Hospital Characteristics | Patient, Hospital and Race*Sex Interaction |
|---|---|---|---|---|---|
| | | Model 1 | Model 2 | Model 3 | Model 4 |
| | Hispanic | 1.37*** | 1.00 | 0.95 | |
| GI Bleed & Blood Loss | Male | 0.78*** | 0.83*** | 0.82*** | 0.82*** |
| | Black | 0.95 | 1.10 | 1.23*** | 1.17*** |
| | Hispanic | 0.84*** | 1.00 | 1.02 | 1.02 |
| | Black*Male | | | | 1.15** |
| (Delirium) Psychosis | Male | 0.80*** | 1.07*** | 1.05*** | 1.05*** |
| | Black | 1.16*** | 1.34*** | 1.41*** | 1.46*** |
| | Hispanic | 0.84*** | 0.95 | 0.89*** | 0.89*** |
| | Black*Male | | | | 0.90* |
| Pneumonia-(other than aspiration) | Male | 1.37*** | 1.20*** | 1.20*** | 1.21*** |
| | Black | 1.16*** | 0.83*** | 0.90* | 0.90* |
| | Hispanic | 1.15** | 1.02 | 0.98 | 1.05 |
| | Hispanic*Male | | | | 0.87** |
| Post-surg Comp, not classified elsewhere | Male | 1.52*** | 1.37*** | 1.39*** | 1.40*** |
| | Black | 1.14* | 1.12* | 1.09 | 1.18** |
| | Hispanic | 0.96 | 0.98 | 1.04 | 1.04 |
| | Black*Male | | | | 0.84** |
| Sepsis | Male | 1.62*** | 1.21*** | 1.20*** | 1.22*** |
| | Black | 2.11*** | 1.06 | 1.04 | 1.14** |
| | Hispanic | 1.82*** | 1.31*** | 1.16*** | 1.16*** |
| | Black*Male | | | | 0.81*** |
| Pressure Ulcer | Male | 1.22*** | 0.97 | 0.98 | 1.00 |
| | Black | 2.69*** | 1.20*** | 1.12* | 1.12* |

| | | Unadjusted | Full Set of Patient Characteristics | Patient and Hospital Characteristics | Patient, Hospital and Race*Sex Interaction |
|---|---|---|---|---|---|
| | | Model 1 | Model 2 | Model 3 | Model 4 |
| | Hispanic | 1.50*** | 0.98 | 0.87** | 0.96 |
| | Hispanic*Male | | | | 0.80*** |

NOTE:

*p≤ 0.05

**p≤0.01

***p≤0.001

Models are presented in step-wise fashion so that each subsequent model includes the variables in the prior model. Coefficients for patient and hospital characteristics were suppressed due to space. Model 1 includes separate un-adjusted models for sex and race/ethnicity. Model 2 includes all patient characteristics: age, surgical Diagnosis Related Groups (DRGs), 27 Elixhauser comorbidity dummies, insurance type, transfer status, Neighborhood Socioeconomic Index. Model 3 adds hospital characteristics: bed size, teaching status, technology status, Core Based Statistical Area (CBSA), and state. Model 4 adds significant interaction term (race/ethnicity*sex). Reference group is non-Hispanic white women.

## Table 4

Odds Ratios of Race/Ethnicity-by Sex Interactions for Postoperative Complications

| GI Bleed and Blood Loss | Main Effect | Interaction Effect | Implied Effect |
|---|---|---|---|
| *Effect of being black* | | | |
| for females | 1.172** | | 1.172** |
| for males | 1.172** | 1.147** | 1.344*** |
| (Delirium) Psychosis | Main Effect | Interaction Effect | Implied Effect |
| *Effect of being black* | | | |
| for females | 1.456*** | | 1.456*** |
| for males | 1.456*** | 0.905* | 1.317*** |
| Sepsis | Main Effect | Interaction Effect | Implied Effect |
| *Effect of being black* | | | |
| for females | 1.144** | | 1.144** |
| for males | 1.144** | 0.810*** | 0.927 |
| Post-surgical Complication, NOS | Main Effect | Interaction Effect | Implied Effect |
| *Effect of being black* | | | |
| for females | 1.180** | | 1.180** |
| for males | 1.180** | 0.838** | 0.989 |
| Pneumonia, not due to aspiration | Main Effect | Interaction Effect | Implied Effect |
| *Effect of being Hispanic* | | | |
| for females | 1.050 | | 1.050 |
| for males | 1.050 | 0.866** | 0.909* |
| Pressure Ulcer | Main Effect | Interaction Effect | Implied Effect |
| *Effect of being Hispanic* | | | |
| for females | 0.957 | | 0.957 |
| for males | 0.957 | 0.798*** | 0.764*** |

Note: reference group is non-Hispanic white women,

* p< 0.05

** p<0.01

*** p<0.001