Predictors for Non-Home Patient Discharge Following Elective Adult Spinal Deformity Surgery

John Di Capua, MHS¹, Sulaiman Somani, BS¹, Nahyr Lugo-Fagundo, BS², Jun S. Kim, MD¹, Kevin Phan, BS³,⁴, Nathan J. Lee, BS¹, Parth Kothari, BS¹, John Shin, BS¹, and Samuel K. Cho, MD¹

Abstract

Study Design: Retrospective cohort study.

Objectives: Adult spinal deformity (ASD) surgery encompasses a wide variety of spinal disorders and is associated with a morbidity rate between 20% and 80%. The utilization of spinal surgery has increased and this trend is expected to continue. To effectively deal with an increasing patient volume, identifying variables associated with patient discharge destination can expedite placement and reduce length of stay.

Methods: The 2013-2014 American College of Surgeons National Surgical Quality Improvement Program database was queried using Current Procedural Terminology and International Classification of Diseases, Ninth Revision diagnosis codes relevant to ASD. Patients were divided based on discharge destination. Bivariate and multivariate logistic regression analyses were employed to identify predictors for patient discharge destination and hospital length of stay.

Results: A total of 4552 patients met inclusion criteria, of which 1102 (24.2%) had non-home discharge. Multivariate regression revealed total relative value unit (odds ratio [OR] = 1.01, 95% confidence interval [CI] = 1.00-1.01); female sex (OR = 1.54, 95% CI = 1.32-1.81); American Indian, Alaska Native, Asian, Native Hawaiian, or Pacific Islander versus black race (OR = 0.52, 95% CI = 0.35-0.78, P = .002); age ≥ 65 years (OR = 3.72, 95% CI = 3.19-4.35); obesity (OR = 1.18, 95% CI = 1.01-1.38, P = .034); partially/ totally functionally dependent (OR = 2.11, 95% CI = 1.49-2.99); osteotomy (OR = 1.42, 95% CI = 1.12-1.80, P = .004) pelvis fixation (OR = 2.38, 95% CI = 1.82-3.11); operation time ≥ 4 hours (OR = 1.74, 95% CI = 1.47-2.05); recent weight loss (OR = 7.66, 95% CI = 1.52-38.65; P = .014); and American Society of Anesthesiologists class ≥ 3 (OR = 1.80, 95% CI = 1.53-2.11) as predictors of non-home discharge. P values were < .001 unless otherwise noted. Additionally, multivariate regression found non-home discharge to be a significant variable in prolonged length of stay.

Conclusions: The authors suggest these results can be used to inform patients preoperatively of expected discharge destination, anticipate patient discharge needs postoperatively, and reduce health care costs and morbidity associated with prolonged LOS.

Keywords
discharge destination, ASD, adult spinal deformity, rehabilitation, home, spinal fusion, deformity, length of stay, ACS-NSQIP, patient placement planning

Introduction

With prevalence rates as high as 60% in the elderly population,¹ adult spinal deformity (ASD) has become a common pathology that has the potential to greatly affect a patient’s quality of life. Surgical treatment, which is indicated for patients with worsening neurological symptoms and sagittal malalignment, involves spinal decompression and restoration of global sagittal balance.²,³ However, postoperative...
complication and revision rates remain high. In fact, the United States Bone and Joint Initiative estimates nearly $50 billion in hospital discharge costs associated with ASD. Advances in surgical and anesthetic techniques have made the option of ASD surgery available to a greater portion of the elderly population, a growing demographic in the United States. This is evident by an increase in the annual number of discharges for spinal fusion procedures, which increased by 137% between 1998 and 2008. In order to adapt to growing surgical volume, health care providers and administrators may find themselves obligated to minimize costs by streamlining discharges and reducing length of stay (LOS) in order to minimize third-party payer pressure. Patient discharge destination is closely related to hospital LOS. Although previous studies in ASD have identified patient comorbidities and intraoperative complications as risk factors for increased LOS, ped availability at rehabilitation centers, insurance approval, and social support resources remain potential contributory factors for greater LOS. By identifying predictive factors for non-home patient discharge early, it may be possible to help mitigate associated discharge and LOS costs. Prior literature for predicting factors for non-home discharge exists, albeit sparsely, for other spinal surgeries, but to the authors’ knowledge, none have investigated this issue following ASD surgery. As such, this study seeks to identify preoperative and operative variables that are predictive of non-home discharge destination in ASD patients.

### Materials and Methods

#### Data Source

This was a retrospective study of prospectively collected data in the 2013-2014 ACS-NSQIP (American College of Surgeons National Surgical Quality Improvement Program) database. ACS-NSQIP is a large national database with risk-adjusted 30-day postoperative morbidity and mortality outcomes. Over 500 hospitals that vary in size, socioeconomic location, and academic affiliation contributed data to the database. ACS-NSQIP data is collected prospectively by dedicated clinical abstractors at each institution on more than 150 demographic, preoperative, intraoperative, and 30-day postoperative variables. The success of quality improvement initiatives based on ACS-NSQIP data have been validated in the Veterans Administration system and private sector.

#### Inclusion Criteria

The NSQIP database from 2013 to 2014 was used in this study. Adult patients (≥18 years) undergoing spinal fusion for deformity were identified based on Current Procedural Terminology (CPT) codes 22800, 22802, 22804, 22808, 22810, 22812, 22818, and 22819. CPT codes 22843, 22844, 22846, and 22847 were also included to capture long, multilevel fusion constructs. Patients with CPT codes 22842 and 22845 were included if they had an International Classification of Diseases, Ninth Revision, diagnosis for spinal deformity (including 737.1, 737.2, 737.3, 737.4, 737.8, 737.9). CPT code descriptions are included in Table 1. Cases with missing preoperative data, emergency cases, patients with a wound class of 2, 3, or 4, an open wound on their body, current seizures, current pneumonia, prior surgeries within 30 days, cases requiring cardiopulmonary resuscitation prior to surgery, any patients undergoing a nonelective procedure, or cases with diagnoses of cervical spine, trauma, or injury to spine, or neoplasm of spine were excluded in order to reduce the risk of confounding variables.

#### Variable Definition

Patient demographic variables included sex, age (≥65 years), and race (white, black, Hispanic, and other). Other race included American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander, or Unknown/Not Reported. Preoperative variables included obesity (≥30 kg/m²), diabetes (non–insulin-dependent diabetes mellitus or insulin-dependent diabetes mellitus), current smoking (within 1 year of surgery), dyspnea (≤ 30 days prior to surgery), functional status prior to surgery (independent or partially/totally dependent ≤ 30 days prior to surgery), pulmonary comorbidity (ventilator dependent ≤ 48 hours prior to surgery or history of chronic obstructive pulmonary disease ≤ 30 days prior to surgery), cardiac comorbidity (use of hypertensive medication or history of chronic heart failure ≤ 30 days prior to surgery), renal comorbidity (acute renal failure ≤ 24 hours prior to surgery or dialysis treatment ≤ 2 weeks prior to surgery), steroid use for chronic condition (≤ 30 days prior to surgery), ≥ 10% loss of body weight (in the last 6 months), bleeding disorder (chronic, active condition), preoperative transfusion of ≥ 1 unit of whole packed red blood cells (RBCs) (≤ 72 hours prior to surgery), and American Society of Anesthesiologists (ASA) physical status classification (≥ 3).

Intraoperative variables included operation year (2013-2014), fusion length (long fusion is ≥ 4 levels during an anterior approach and ≥ 7 levels during a posterior approach), surgical approach (anterior, posterior, or combined), pelvic fixation, osteotomy, intervertebral device, operative time (≥ 4 hours), and total relative value units (TRVUs).

### Table 1. Included Current Procedural Terminology (CPT) Codes With Description.

| CPT        | Description                                      |
|------------|--------------------------------------------------|
| 22800 or 22842 | Posterior fusion and instrumentation: Up to 6 levels |
| 22802 or 22843 | Posterior fusion and instrumentation: 7-12 levels |
| 22804 or 22844 | Posterior fusion and instrumentation: 13 or more levels |
| 22808 or 22845 | Anterior fusion or instrumentation: 2-3 levels |
| 22810 or 22846 | Anterior fusion or instrumentation: 4-7 levels |
| 22812 or 22847 | Anterior fusion or instrumentation: 8 or more levels |
| 22818 or 22819 | Kyphectomy 1-2 or ≥ 3 segments                   |
or vertebral column resections are at greater risk for morbidity. Thirty-day postoperative outcome variables include mortality, any postoperative complication, LOS (≥5 days), wound complication (superficial or deep surgical site infection, organ space infection, or wound dehiscence), pulmonary complication (pneumonia, unplanned reintubation, or duration of ventilator-assisted respiration ≥48 hours), venous thromboembolism (pulmonary embolism or deep vein thrombosis), renal complication (progressive renal insufficiency or acute renal failure), urinary tract infection, cardiac complication (cardiac arrest requiring cardiopulmonary resuscitation or myocardial infarction), intra-/postoperative transfusion, sepsis, reoperation (related to initial procedure), and unplanned readmission (related to initial procedure). ACS-NSQIP provides further information on variable characteristics.18

Discharge destination is coded in the ACS-NSQIP database as follows: (1) skilled care, not home (eg, transitional care unit, subacute hospital, ventilator bed, skilled nursing home); (2) unskilled facility, not home (eg, nursing home or assisted facility—if not patient’s home preoperatively); (3) facility which was home (eg, return to chronic care), unskilled facility, or assisted living, which was the patient’s home preoperatively; (4) home; (5) separate acute care (eg, transfer to another acute care facility); and (6) rehab. Patients were split up as 2 cohorts: those that were discharged home and those patients that were not discharged home. Destinations other than home included skilled and non-skilled care facility (which were not patient’s home preoperatively), nursing homes, assisted living, and rehabilitation centers.

Statistical Analysis

Bivariate analyses were performed on patient demographic, preoperative, intraoperative, and postoperative characteristics using Pearson’s χ² test. Fischer’s exact test was used where appropriate. Multivariable logistic regression models were employed, adjusting for patient demographic, preoperative, and intraoperative variables, to identify risk factors for non-home patient discharge. Another multivariable logistic regression model was utilized to identify predictors for prolonged LOS. Both regression models utilized a stepwise entry and removal criteria, set to a significance level of .05. The c-statistic, which is the area under the receiver operating characteristic curve, was also retrieved from the multivariate logistic regression analysis and determined the accuracy of this model. SAS Studio Version 3.4 (SAS Institute Inc, Cary, NC) was used for all statistical analysis.

Results

Study Population

A total of 4552 patients met the inclusion criteria for the study, of which 3450 (75.8%) were discharged to home and 1102 (24.2%) were discharged to a destination other than home (Table 2). Of patients discharged to a destination other than home, 522 (47.4%) were discharged to a rehabilitation facility, 548 (49.7%) were discharged to a skilled care facility, and 32 (2.9%) were discharged to an “other” facility. Other includes an unskilled facility that was not home or separate acute care.

Patients discharged to destinations other than home were more likely to be female (66.0% vs 56.7%), of elderly age ≥65 years (64.3% vs 32.1%), obese (46.0% vs 42.2%, P = .025), diabetic (17.6% vs 14.2%, P = .005), be partially or fully functionally dependent (7.2% vs 2.5%), to use steroids (6.3% vs 4.3%, P = .010), have had recent weight loss (0.8% vs 0.1%), to have bleeding disorders (2.5% vs 1.2%, P = .002), to be ASA class ≥3 (69.6% vs 47.8%), and have cardiac (64.4% vs 52.0%) or pulmonary (7.3% vs 4.6%, P = .001) comorbidities. Operatively, these patients were also more likely to have an osteotomy (23.3% vs 10.1%), fusion to the pelvis (18.1% vs 4.3%), and operating times ≥4 hours (62.3% vs 40.5%). All P values were <.001 unless otherwise noted.

Unadjusted Analysis

There were statistically significant differences in 30-day unadjusted morbidities and mortality between these the 2 patient cohorts (Table 3). Patients discharged to a destination other than home had greater incidence of mortality (1.5% vs 0.1%), any complication (51.6% vs 21.0%), LOS ≥5 days (53.0% vs 16.6%), wound complications (3.8% vs 1.7%), pulmonary complications (5.4% vs 1.4%), venous thromboembolisms (3.5% vs 1.0%), renal complications (1.3% vs 0.1%), urinary tract infections (3.7% vs 1.3%), cardiac complications (1.5% vs 0.3%), intra-/postoperative RBC transfusion (45.2% vs 17.5%), postoperative sepsis (3.2% vs 0.9%), unplanned readmission (8.5% vs 5.0%), and reoperation (6.3% vs 2.9%). All P values were <.001 unless otherwise noted.

Multivariate Analysis

Multivariate logistic regression analysis (Table 4) revealed TRVU (odds ratio [OR] = 1.01, 95% confidence interval [CI] = 1.00-1.01), female sex (OR = 1.54, 95% CI = 1.32-1.81), other versus black race (OR = 0.52, 95% CI = 0.35-0.78, P = .002), age ≥65 years (OR = 3.72, 95% CI = 3.19-4.35), obesity (OR = 1.18, 95% CI = 1.01-1.38, P = .034), partially or totally dependent functional status (OR = 2.11, 95% CI = 1.49-2.99), osteotomy (OR = 1.42, 95% CI = 1.12-1.80, P = .004), fusion to pelvis (OR = 2.38, 95% CI = 1.82-3.11), operation time ≥4 hours (OR = 1.74, 95% CI = 1.47-2.05), recent weight loss (OR = 7.66, 95% CI = 1.52-38.65, P = .014), and ASA class ≥3 (OR = 1.80, 95% CI = 1.53-2.11) as predictors of non-home discharge. P values were <.001 unless otherwise noted. The c-statistic for this model was 0.77.

A second multivariate logistic regression model was fit to determine predictors for LOS ≥5 days (Table 5). The model identified diabetes (OR = 1.38, 95% CI = 1.10-1.72, P = .005), partially or totally dependent versus independent functional status (OR = 1.94, 95% CI = 1.34-2.82), long
versus short fusion length (OR = 1.67, 95% CI = 1.41-1.99), combined versus anterior surgical approach (OR = 2.53, 95% CI = 1.58-4.06), posterior versus anterior surgical approach (OR = 2.07, 95% CI = 1.68-2.54), osteotomy (OR = 1.86, 95% CI = 1.49-2.32), fusion to pelvis (OR = 2.00, 95% CI = 1.51-2.64), operation time ≥4 hours (OR = 2.89, 95% CI = 2.43-3.45), cardiac comorbidity (OR = 0.84, 95% CI = 0.71-1.00, P = .049), renal comorbidity (OR = 7.02, 95% CI = 2.17-22.69, P = .001), preoperative RBC transfusion (OR = 5.48, 95% CI = 1.39-21.65, P = .015), ASA class ≥3 (OR = 1.39, 95% CI = 1.17-1.65), and non-home discharge (OR = 3.74, 95% CI = 3.15-4.43). P values were <.001 unless otherwise noted. The c-statistic for this model was 0.82.

### Discussion

This retrospective analysis of the 2013-2014 ACS-NSQIP database identified several risk factors for patient discharge to a facility other than home following elective ASD surgery. Identified factors for non-home discharge were increasing TRVU, female sex, American Indian, Alaska Native, Asian, Native Hawaiian, or Pacific Islander versus black race, ≥65 years of age, obesity, partially or totally functionally dependent, osteotomy, pelvis fixation, operation time ≥4 hours, recent weight loss, and ASA class ≥3. ACS-NSQIP is a well-established database in the surgical literature and contains preoperative, intraoperative, and 30-day postoperative patient data from over 500 medical centers across the United States.17-20 The success

### Table 2. Bivariate Analysis of Patient Demographic, Preoperative, and Intraoperative Characteristics Following Elective ASD Surgery (N = 4552).

| Category                        | Discharge Other Than Home (n) | Discharge Home (n) | P Value |
|---------------------------------|-------------------------------|-------------------|---------|
| **Sex**                         |                               |                   |         |
| Female                          | 727                           | 1957              | <.001   |
| Male                            | 375                           | 1493              | .433    |
| **Age ≥65 years**               |                               |                   | <.001   |
| **Race**                        |                               |                   | .576    |
| White                           | 904                           | 2792              |         |
| Other                           | 67                            | 245               | 7.1%    |
| Hispanic                        | 40                            | 141               | 4.1%    |
| Black                           | 91                            | 272               | 7.9%    |
| **Obese**                       |                               |                   | .025    |
| Partially or totally dependent  | 79                            | 88                | <.001   |
| Independent                     | 1023                          | 3362              | 97.4%   |
| **Pulmonary comorbidity**       |                               |                   | .001    |
| Cardiovascular                  | 80                            | 160               | 4.6%    |
| **Cardiac comorbidity**         |                               |                   | <.001   |
| Renal comorbidity               | 7                             | 11                |        |
| **Diabetes**                    |                               |                   | .006    |
| Smoke                           | 194                           | 489               | 14.2%   |
| **Steroid use**                 |                               |                   | .010    |
| Recent weight loss              | 9                             | 2                 |        |
| **Bleeding disorder**           |                               |                   | .002    |
| Preoperative RBC transfusion    | 6                             | 7                 | .064    |
| **ASA class ≥3**                |                               |                   | <.001   |
| Operation time ≥4 hours         | 770                           | 1648              | 47.8%   |
| Operation year                  |                               |                   | <.001   |
| 2013                            | 540                           | 1573              | 45.6%   |
| 2014                            | 562                           | 1877              | 54.4%   |
| Osteotomy                       | 257                           | 348               |        |
| Intervertebral device           | 416                           | 1556              | 45.1%   |
| Fusion to Pelvis                | 199                           | 147               | 4.3%    |
| **Fusion length**               |                               |                   | <.001   |
| Long*                           | 675                           | 2001              | 58.0%   |
| Short                           | 427                           | 1449              | 42.0%   |
| **Surgical approach**           |                               |                   |         |
| Posterior                       | 882                           | 1740              | 50.4%   |
| Anterior                        | 192                           | 1622              | 47.0%   |
| Combined                        | 28                            | 88                | 2.6%    |

Abbreviations: ASD, adult spinal deformity; RBC, red blood cell; ASA, American Society of Anesthesiologists.

*Long fusion is ≥4 levels during anterior approach and ≥7 levels during posterior approach.
Table 3. Bivariate Analysis of 30-Day Postoperative Outcomes Following Elective ASD Surgery (N = 4552).

| Category                          | Discharge Other Than Home | Discharge Home | P Value |
|-----------------------------------|---------------------------|----------------|---------|
| Mortality                         | 17                        | 2              | <.001   |
| Any complication                  | 569                       | 725            | <.001   |
| Length of stay ≥5 days            | 584                       | 572            | <.001   |
| Pulmonary complication            | 42                        | 49             | <.001   |
| Venous thromboembolism            | 59                        | 36             | <.001   |
| Renal complication                | 14                        | 5              | <.001   |
| Urinary tract infection           | 41                        | 44             | <.001   |
| Intra-/postoperative RBC transfusion | 498                    | 603            | <.001   |
| Sepsis                            | 35                        | 30             | <.001   |
| Unplanned readmission (related to initial procedure) | 94                        | 173            | <.001   |
| Reoperation (related to initial procedure) | 69                        | 101            | <.001   |

Abbreviations: ASD, adult spinal deformity; RBC, red blood cell.

Table 4. Predictors for Non-Home Discharge Following Elective ASD (N = 4555; c-statistic = 0.7714).

| Variable                                         | Odds Ratio | Lower Confidence Limit | Upper Confidence Limit | P Value |
|--------------------------------------------------|------------|-------------------------|------------------------|---------|
| Total RVU                                        | 1.01       | 1.00                    | 1.01                   | <0.001  |
| Male vs female sex                               | 1.54       | 1.32                    | 1.81                   | <0.001  |
| Race                                             |            |                         |                        |         |
| Hispanic vs Black                                | 0.73       | 0.46                    | 1.17                   | .198    |
| Other vs Black                                   | 0.52       | 0.35                    | 0.78                   | .002    |
| White vs Black                                   | 0.76       | 0.58                    | 1.01                   | .055    |
| Age ≥65 years                                    | 3.72       | 3.19                    | 4.35                   | <.001   |
| Obese                                            | 1.18       | 1.01                    | 1.38                   | .034    |
| Partially or totally dependent vs independent functional status | 2.11       | 1.49                    | 2.99                   | <.001   |
| Osteotomy                                        | 1.42       | 1.12                    | 1.80                   | .003    |
| Fusion to pelvis                                 | 2.38       | 1.82                    | 3.11                   | <.001   |
| Operation time ≥4 hours                          | 1.74       | 1.47                    | 2.05                   | <.001   |
| Recent weight loss                               | 7.66       | 5.52                    | 38.65                  | .014    |
| ASA class ≥3                                     | 1.80       | 1.53                    | 2.11                   | <.001   |

Abbreviations: ASD, adult spinal deformity; RVU, relative value unit; ASA, American Society of Anesthesiologists.

Table 5. Predictors for LOS ≥5 days in Patients Undergoing Elective ASD Surgery (N = 4552; c-statistic = 0.8249).

| Variable                                         | Odds Ratio | Lower Confidence Limit | Upper Confidence Limit | P Value |
|--------------------------------------------------|------------|-------------------------|------------------------|---------|
| Diabetes                                         | 1.38       | 1.10                    | 1.72                   | .005    |
| Partially or totally dependent vs independent functional status | 1.94       | 1.34                    | 2.82                   | <.001   |
| Long vs short fusion length                      | 1.67       | 1.41                    | 1.99                   | <.001   |
| Combined vs anterior approach                     | 2.53       | 1.58                    | 4.06                   | <.001   |
| Posterior vs anterior approach                    | 2.07       | 1.68                    | 2.54                   | <.001   |
| Osteotomy                                        | 1.86       | 1.49                    | 2.32                   | <.001   |
| Fusion to pelvis                                 | 2.00       | 1.51                    | 2.64                   | <.001   |
| Operation time ≥4 hours                          | 2.89       | 2.43                    | 3.45                   | <.001   |
| Cardiac comorbidity                              | 0.84       | 0.71                    | 1.00                   | .049    |
| Renal comorbidity                                | 7.02       | 2.17                    | 22.69                  | .001    |
| Preoperative RBC transfusion                     | 5.48       | 1.39                    | 21.65                  | .015    |
| ASA class ≥3                                     | 1.39       | 1.17                    | 1.65                   | <.001   |
| Non-home discharge                               | 3.74       | 3.15                    | 4.43                   | <.001   |

Abbreviations: LOS, length of stay; ASD, adult spinal deformity; RBC, red blood cell; ASA, American Society of Anesthesiologists.
of quality improvement initiatives based on ACS-NSQIP data has been validated in the Veterans Administration system and private sector.\textsuperscript{16,17} To our knowledge, this is the first large cohort analysis using a national database to identify predictors for patient discharge in the ASD surgery population.

Approximately 5 million adults in the United States are disabled to some degree from spine-related disorders.\textsuperscript{7} The number of surgical candidates is expected to increase as advances in surgical and anesthetic techniques make the option of surgery available to a larger population of patients. Therefore, efficient planning of patient discharge may be a contributory factor to improving patient satisfaction and hospital flow.\textsuperscript{21} Discharge to a destination other than home may also be a surrogate for higher degrees of patient illness,\textsuperscript{22} which was observed from the presence of significantly greater postoperative morbidity in these patients. On the other hand, these postoperative complications may have risen in the care facilities that were not previously the patient’s home where, for example, health care teams may not know the details of a patient’s medical history.\textsuperscript{23,24}

In an analysis of 15,092 patients undergoing lumbar spine fusion, Aldebeyan et al identified female gender, advanced age, body mass index $\geq 35$, diabetes, congestive heart failure, hypertension, ASA class $>1$, multilevel surgery, operation time $\geq 259$ minutes, postoperative morbidity, and nonelective surgery to be significant factors for requiring an inpatient admission to a facility other than home.\textsuperscript{13} The results of the present analysis support the findings of Aldebeyan et al while also contributing new factors significantly associated with discharge destination in the ASD surgery population. In the present analysis, the identified predictors for discharge destination can be separated based on their interventional capacities, for example, as modifiable or nonmodifiable variables. Modifiable patient risk factors can be actively addressed by a patient and their surgeon before surgery in order to mitigate postoperative risk, whereas nonmodifiable risk factors set a patient’s baseline predisposition and ideally can be identified by the health care team early. Potentially modifiable predictive variables for patient discharge include TRVU, body mass index, functional status, use of osteotomy, pelvic fixation, operation time, and recent weight loss. Nonmodifiable variables include sex, race, age, and possibly ASA class. Physicians should consider a patient’s constellation of modifiable and nonmodifiable factors when initiating patient placement.

There may be a relationship between patient discharge destination and hospital LOS. LOS following any surgical procedure is of great importance to health care system expenditure and a patient’s sense of well-being.\textsuperscript{12,13,25} At baseline, it costs approximately US$1000 to keep a patient in the hospital per day.\textsuperscript{12,13,25} Patients discharged to a destination other than home were more likely to experience a LOS $\geq 5$ days (53.0% vs 16.6%). A multivariate logistic regression model revealed patients discharged to a destination other than home had a 3.74 greater odds of hospital LOS $\geq 5$ days (Table 5). Unfortunately, the ACS-NSQIP database does not provide an explanation for a patient’s extended hospital stay or clinical reasoning behind patient discharge destination, making the direction of causality between LOS and discharge destination unclear. The direction of causality likely changes on a case-by-case basis, yet our results suggest that patients may experience an extended hospital LOS due to delays associated with non-home discharge. Brasel et al found that delays in discharge, which led to extended hospital stays, were predominantly linked to lack of beds in rehabilitation centers.\textsuperscript{13,26} They defined delayed discharge as a patient discharged $\geq 1$ day following medical clearance and timely discharge as a patient discharged on the same day as medical clearance.\textsuperscript{26} Additionally, their analysis showed that patients who experienced a delayed discharge incurred $\$15 000 more in hospital costs in comparison to patients who were discharged in a timely manner.\textsuperscript{26} Another plausible explanation is that patients who had more extensive surgeries (eg, osteotomies, long fusions extending to the pelvis, etc) were more likely to stay in the hospital longer and needed extra recuperation time at a monitored facility other than home later on. Furthermore, patients who had more preoperative medical comorbidities (ASA class $\geq 3$) would have required more supervision and assistance postoperatively and, therefore, would be more fitting to be discharged to a rehab or skilled nursing facility.

There are several limitations that must be addressed in this work. Because the ACS-NSQIP database classifies cases based on CPT codes, differences between procedural techniques cannot be accounted for in this study. Adjustment for more surgery-specific variables, such as type of osteotomy used and type of spinal deformity, were unable to be performed. TRVU was used as a loose surrogate for surgical complexity in an attempt to control for those cases where patients underwent technically demanding osteotomies such as pedicle subtraction or vertebral column resections. Although it offers a large patient size, ACS-NSQIP overrepresents academic medical centers and therefore is less able to fully represent all US hospitals. The ACS-NSQIP database does not include non-US hospitals, thus potentially limiting the applicability of the findings to non-US centers. However, the variables identified in the analysis are commonly used variables that can be assessed in any patient. Contributing hospital is kept anonymous, limiting the ability to adjust for institution size, patient volume, academic affiliation, and surgeon experience. Additionally, long-term complications are not captured in the NSQIP database, leading to a potential underestimation of risk. Finally, a major limitation of this study is due to its retrospective nature, which limits the ability to determine the direction of causality. For example, it is unclear whether a postoperative complication occurred in the hospital following surgery or at the patient’s final destination. The authors are unable to include the occurrence of postoperative complications in the multivariate logistic regression models, which could potentially influence a patient’s overall LOS and disposition, thus introducing a potential confounding bias.

Despite these limitations, this is the first national study of predictors for patient discharge to a facility other than home following elective ASD surgery. Identified predictors include
increasing TRVU, female sex, American Indian, Alaska Native, Asian, Native Hawaiian, or Pacific Islander versus black race, ≥65 years of age, obesity, partially or totally functionally dependent, osteotomy, pelvis fixation, operation time ≥4 hours, recent weight loss, and ASA class ≥3. Additionally, the study evaluated predictive factors for prolonged hospital LOS and found discharge destination to be a significant variable. The authors suggest there is a potential for the results of this study be used by health care teams to inform patients preoperatively of expected discharge disposition, anticipate patient discharge needs postoperatively, and reduce health care costs and morbidity associated with prolonged LOS.

**Authors' Note**

This study was qualified as exempt by the Mount Sinai Hospital Institutional Review Board.

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

**References**

1. Schwab F, Dubey A, Gamez L, et al. Adult scoliosis: prevalence, SF-36, and nutritional parameters in an elderly volunteer population. *Spine (Phila Pa 1976).* 2005;30:1082-1085.
2. Youssef JA, Orndorff DO, Patty CA, et al. Current status of adult spinal deformity. *Global Spine J.* 2013;3:51-62.
3. Good CR, Auerbach JD, O’Leary PT, Schuler TC. Adult spine deformity. *Curr Rev Musculoskelet Med.* 2011;4:159-167.
4. Iorio JA, Reid P, Kim HJ. Neurological complications in adult spinal deformity surgery. *Curr Rev Musculoskelet Med.* 2016;9:290-298. doi:10.1007/s12178-016-9350-y.
5. United States Bone and Joint Initiative. The Burden of Musculoskeletal Diseases in the United States: Prevalence, Societal and Economic Costs. 3rd ed. Rosemont, IL: United States Bone and Joint Initiative; 2015.
6. Ambler GK, Brooks DE, Al Zuhir N, et al. Effect of frailty on short- and mid-term outcomes in vascular surgical patients. *Br J Surg.* 2015;102:638-645.
7. Cowman JA Jr, Dimick JB, Wainess R, Upchurch GR Jr, Chandler WF, La Marca F. Changes in the utilization of spinal fusion in the United States. *Neurosurgery.* 2006;59:15-20.
8. Mentsoudis SG, Hughes A, Ma Y, ChiuYL, Sama AA, Girardi FP. Increased in-hospital complications after primary posterior versus primary anterior cervical fusion. *Clin Orthop Relat Res.* 2011;469:649-657.
9. Rajae SS, Bae HW, Kanim LE, Delamarter RB. Spinal fusion in the United States: analysis of trends from 1998 to 2008. *Spine (Phila Pa 1976).* 2012;37:67-76.
10. Sheer JK, Ailon TT, Smith JS, et al. 166 predictive modeling of length of hospital stay following adult spinal deformity correction: analysis of 653 patients with an accuracy of 75% within 2 days. *Neurosurgery.* 2016;63(suppl 1):166-167.
11. Klineberg EO, Passias PG, Jalai CM, et al. Predicting extended length of hospital stay in an adult spinal deformity surgical population. *Spine (Phila Pa 1976).* 2016;41:E798-E805.
12. Gruskay JA, Fu M, Bohl DD, Webb ML, Grauer JN. Factors affecting length of stay after elective posterior lumbar spine surgery: a multivariate analysis. *Spine J.* 2015;15:1188-1195.
13. Aldebeian S, Aoude A, Fortin M, et al. Predictors of discharge destination after lumbar spine fusion surgery. *Spine (Phila Pa 1976).* 2016;41:1535-1541.
14. Gulati A, Yeo CJ, Cooney AD, McLean AN, Fraser MH, Allan DB. Functional outcome and discharge destination in elderly patients with spinal cord injuries. *Spinal Cord.* 2011;49:215-218.
15. American College of Surgeons National Surgical Quality Improvement Program. Participants. https://www.facs.org/quality-programs/acs-nsqip/participants. Accessed April 1, 2016.
16. Fink AS, Campbell DA Jr, Mentzer RM Jr, et al. The National Surgical Quality Improvement Program in non-veterans administration hospitals: initial demonstration of feasibility. *Ann Surg.* 2002;236:344-353.
17. Molina CS, Thakore RV, Blumer A, Obremeksey WT, Sethi MK. Use of the National Surgical Quality Improvement Program in orthopaedic surgery. *Clin Orthop Relat Res.* 2015;473:1574-1581.
18. American College of Surgeon National Surgical Quality Improvement Program. ACS-NSQIP User Guide for the 2014 Participant Data Use File. https://www.facs.org/~/media/files/quality programs/NSQIP/NSQIP_puf_userguide_2014.shtml. Accessed February 10, 2016.
19. Schoenfeld AJ, Carey PA, Cleveland AW 3rd, Bader JO, Bono CM. Patient factors, comorbidities, and surgical characteristics that increase mortality and complication risk after spinal arthrodesis: a prognostic study based on 5,887 patients. *Spine J.* 2013;13:1171-1179.
20. Aynardi M, Jacobides CL, Huang R, Mortazavi SM, Parvizi J. Risk factors for early mortality following modern total hip arthroplasty. *J Arthroplasty.* 2013;28:517-520.
21. Keswani A, Tasi MC, Fields A, Lovy AJ, Moucha CS, Bozic KJ. Discharge destination after total joint arthroplasty: an analysis of postdischarge outcomes, placement risk factors, and recent trends. *J Arthroplasty.* 2016;31:1155-1162.
22. Legner VJ, Massarweh NN, Symons RG, McCormick WC, Flum DR. The significance of discharge to skilled care after abdominopelvic surgery in older adults. *Ann Surg.* 2009;249:250-255.
23. Shen Q, Cordato D, Chan DK, Hung WT, Karr M. Identifying the determinants of 1-year post-stroke outcomes in elderly patients. *Acta Neurologica Scand.* 2006;113:114-120.
24. Marcantonio ER, Kiely DK, Simon SE, et al. Outcomes of older people admitted to postacute facilities with delirium. *J Am Geriatrics Soc.* 2005;53:963-969.
25. Yeom JS, Buchowski JM, Shen HX, Liu G, Bunnaprasert T, Riew KD. Effect of fibrin sealant on drain output and duration of hospitalization after multilevel anterior cervical fusion a retrospective matched pair analysis. *Spine (Phila Pa 1976).* 2008;33:E543-E547.
26. Brasel KJ, Rasmussen J, Cauley C, Weigelt JA. Reasons for delayed discharge of trauma patients. *J Surg Res.* 2002;107:223-226.