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Preoperative falls and their association with functional dependence and quality of life

Vanessa L Kronzer, BA¹, Rose D Tang, BS¹, Allison P Schelble, BA¹, Arbi Ben Abdallah, PhD¹, Troy S Wildes, MD¹, Sherry L McKinnon, BS¹, Furqaan Sadiq, BJ¹, Nan Lin, PhD², Daniel L Helsten, MD¹, Anshuman Sharma, MD¹, Susan L Stark, PhD³, and Michael S Avidan, MBBCh¹

¹Washington University School of Medicine, Department of Anesthesiology, St. Louis, MO, USA

²Washington University, Department of Mathematics, St. Louis, MO, USA

³Washington University School of Medicine, Program in Occupational Therapy, St. Louis, MO, USA

Abstract

Background—No study has rigorously explored the characteristics of surgical patients with recent preoperative falls. Our objective was to describe the essential features of preoperative falls, and determine whether they are associated with preoperative functional dependence and poor quality of life.

Methods—This was an observational study involving 15,060 surveys from adult patients undergoing elective surgery. Surveys were collected between January 2014 and August 2015, with a response rate of 92%.

Results—In the six months prior to surgery, 26% (99% CI. 25% to 27%) of patients fell at least once, and 12% (99% CI. 11% to 13%) fell at least twice. The proportion of patients who fell was highest among patients presenting for neurosurgery (41%, 99% CI. 36% to 45%). At least one fall-related injury occurred in 58% (99% CI. 56% to 60%) of those who fell. Falls were common in all age groups, but surprisingly they did not increase monotonically with age. Middle-aged patients (45 to 64 years) had the highest proportion of fallers (28%), recurrent fallers (13%), and severe fall-related injuries (27%) compared to younger (18-44 years) and older (65+ years) patients ($p < 0.001$ for each). A fall within six months was independently associated with preoperative functional dependence (OR 1.94; 99% CI. 1.68 to 2.24) and poor physical quality of life (OR 2.18; 99% CI. 1.88 to 2.52).

Conclusions—Preoperative falls might be common and are possibly often injurious in the presurgical population, across all ages. A history of falls could enhance assessment of preoperative functional dependence and quality of life.

Corresponding Author: Michael S Avidan, avidanm@anest.wustl.edu, 660 S Euclid Ave, Campus Box 8054, Saint Louis, MO 63110, P: 314-747-4155 F: 314-747-3977.

vkleckner@go.wustl.edu, tang.r@wustl.edu, allison.schelble@wustl.edu, aba@anest.wustl.edu, wildest@anest.wustl.edu, mckinnos@anest.wustl.edu, sadiqf@anest.wustl.edu, nlin@wustl.edu, helstend@anest.wustl.edu, sharmanu@anest.wustl.edu, sstark@wustl.edu

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Introduction

Accidental falls are common, have serious mental, physical, and financial consequences, and are rising in incidence.¹⁻⁹ As a result, falls in the general community have been targeted as an area of urgent public health need.^{10,11} Presurgical patients are likely susceptible to falls due to their prevalent comorbid conditions. Falls in the preoperative period may be especially hazardous since falls render a person vulnerable to stress-related complications.^{12,13} Indeed, several studies suggest that falls among preoperative patients are more common than falls in the general community, and such falls might herald poorer surgical outcomes.¹³⁻¹⁶ Nevertheless, preoperative falls have not been rigorously studied.

Preoperative falls may reflect patient-centered metrics such as functional dependence and poor quality of life. There is a growing perception that patient-centered metrics are important, as reflected by increasing motivation to study them and incorporate them into healthcare performance evaluation.¹⁷⁻¹⁹ Current preoperative assessments rely entirely on disease-based measures, such as the American Society of Anesthesiologists (ASA) physical status score and the Charlson Comorbidity Index.^{20,21} Including patient-centered metrics into preoperative assessments might be worthwhile, considering the importance of patient-reported outcomes. However, these evaluations can be lengthy and include delicate questions.²²⁻²⁴ Research shows that falls in the general community are associated with patient-centered outcomes such as functional dependence and poor quality of life.²⁵⁻²⁹ If preoperative falls were similarly indicative of these patient-centric health markers, independent of comorbidity burden, then a history of falls could enhance preoperative assessment.

We aimed to address these two knowledge gaps regarding preoperative falls. Specifically, the aims of this study were to (1) describe the proportion of patients who fell, factors associated with falls, and age distribution of those falling in the six months prior to elective surgery and (2) determine whether a history of preoperative falls is independently associated with preoperative functional dependence and poor quality of life. For the second aim, we hypothesized that falls would be independently associated with functional dependence and poor quality of life, even after controlling for comorbidity burden.

Materials and Methods

The protocol for this study was approved by the Institutional Review Board at Washington University in St. Louis (Human Research Protection Office number 201408107). All participants provided written, informed consent.

Study Population

This observational investigation was a sub-study of the Systematic Assessment and Targeted Improvement of Services Following Yearlong Surgical Outcomes Surveys (SATISFY-SOS) study, and was conducted in compliance with the STROBE guidelines.³⁰ SATISFY-SOS (NCT02032030) is a large, observational study that collects detailed perioperative and patient-reported outcomes data for adults undergoing elective surgery at Barnes Jewish Hospital in St. Louis. Over 70% of patients undergoing elective surgery are evaluated at the

hospital's preoperative assessment clinic before surgery. Reasons for no assessment include urgent surgery, geographical limitations, or surgeon preference. Approximately 60% of all eligible patients consent to participate in the study. Nurses at the preoperative assessment clinic recruit patients to participate and obtain written consent. The most common reason for patients not participating is that they are not approached to participate. Other reasons for non-participation include patient refusal, lack of nurse time or IRB training, or illiteracy in English. A study comparing participants to non-participants showed no major differences in characteristics (unpublished). Approximately 92% of all consented patients completed a baseline survey. The main reason for lack of survey completion was insufficient time.

Measures

Following the recommendations of the Prevention of Falls Network Europe (ProFaNE), a fall was defined in the surveys as "an unexpected event where you come to rest on the ground, floor or lower level."³¹ "Recurrent fallers" were patients who experienced two or more falls in six months. "Severe" fall-related injury was defined as seeking medical treatment, severe pain, head injury, fracture, or change from independent to assisted living. The six-month time period was chosen because it balances capturing enough falls with limiting recall bias, and it facilitates comparison with another study that used the same time period.^{13,32} The physical component score (PCS) and mental component score (MCS) of quality of life were obtained using the Veterans RAND 12-item Health Survey (VR-12). With a mean of 50, the VR-12 scale is standardized to the general U.S. population.^{22,23} The baseline survey provided falls history, quality of life, and perceived health. Nurses at the preoperative assessment clinic scored functional dependence using the Barthel Index of Activities of Daily Living. A score of 100 indicates functional independence.²⁴ Incontinence and impaired mobility were obtained from the corresponding item on the Barthel Index. Neurologic disease was defined as stroke, hemiplegia, paraplegia, quadriplegia, Parkinson Disease, or multiple sclerosis. Patients indicated their race during surgery registration using hospital-specified options. The clinic physician judged metabolic activity capability by asking the patient to describe his or her most strenuous physical activity. ASA physical status was extracted from operating room documentation. All data were extracted from the SATISFY-SOS baseline health survey and from the electronic medical record (MetaVision, iMDsoft, Needham, MA).

Statistical Analysis

All variable selection and analytical procedures used in this study were pre-specified unless specifically labeled as "post hoc." Variables were selected a priori based on rigorous studies identified through comprehensive literature review. In the falls models, variables were included if they were both associated with falls in the general population and available for collection. The models of functional dependence and quality of life compared falls history, ASA physical status, Charlson Index, and other factors that were both easily obtained and strongly associated with the outcome based on literature review. All dichotomous variables were coded "0" for lower risk of the outcome and "1" for higher risk.

This study's large dataset provided the opportunity to test interaction terms. Because including hundreds of interaction terms might result in type I error, we pre-specified the

10-20% most clinically relevant interactions for the models of falls, functional dependence, and physical quality of life (24, 19, and 11 interaction terms, respectively). Interactions of particular interest for the functional dependence and quality of life models included falls and ASA, and falls and Charlson Index. To determine which of these candidate interaction terms to include in the final model, stepwise selection with backward elimination was used. Significance to add was 0.05 and significance to remove was 0.01. Interaction terms with a p-value less than 0.05 were included in the final model.

Multivariable logistic regression was performed in all models using forced simultaneous entry of variables without variable removal. Outcome variables for the paper's three main models included one or more falls within six months, Barthel Index score less than 100, and PCS score less than 50. Of note, PCS was dichotomized due to its bimodal distribution. All models were checked for multicollinearity, influential cases, linearity of logit, and conformity to linear gradients. The only issue was conformity to linear gradients for Charlson Index, BMI, and age in some of the models. To resolve this issue, categorization was performed where the nonlinear relationships could not be transformed.^{33,34} Because of the high ratio of events to variables, variable pre-specification, and forced entry methods, overfitting was not considered to be a major concern.^{35,36} Nevertheless, we performed post hoc bootstrapping on each model with 100 replicates for internal validation. Small differences (< 5%) between observed and corrected c-statistics suggest that overfitting is unlikely.³⁷

The modeling procedure excluded any patient who was missing one or more values, removing approximately 10% of the sample in each model. Multiple imputation was not performed since the variables missing more than 1% of data were outcome variables (quality of life, Barthel Index, and fall history) or not missing at random (incontinence, mobility, and Barthel Index all come from the same assessment tool). Post hoc sensitivity analyses were performed for each model with "missing" coded as a separate category for any variable missing more than 0.5% of the data. Goodness-of-fit was assessed in the final models using the Hosmer-Lemeshow test. This test was significant ($p < 0.001$) in the original PCS model. Interaction terms between chronic pain and two variables (ASA and depression) were highly significant and resolved the overall lack of fit of the model.

Data analysis was performed using SAS/STAT® software, Version 9.4 (SAS Institute Inc., Cary, NC). To calculate a crude estimate of the fall rate per 100 person-years as recommended by the ProFaNE consensus group, an exponential decay curve was applied to the fall count data and extrapolated to six falls.³¹ Parametric tests were performed for normally distributed data, while non-parametric tests were performed for non-normally distributed data. All tests were two-sided. Because we conducted multiple statistical analyses, the threshold for significance was set to $\alpha < 0.01$. The threshold for clinical significance was defined a priori as a 20% difference in proportions or odds ratios.³⁸

Results

Fallers and Fall-Related Injuries

A total of 15,060 baseline surveys were available between January 2014 and the time of data extraction in August, 2015. As expected, fallers and non-fallers differed for the majority of the characteristics studied (Table 1). Table 2 shows how many times patients fell, the falls according to type of surgery, and the fall-related injuries sustained. In the six months prior to surgery, 26% (99% CI. 25% to 27%) of patients had fallen at least once, and 12% (99% CI. 11% to 13%) had fallen at least twice. Overall, the fall rate was 93 per 100 person-years. Neurosurgical patients had the highest proportion of preoperative fallers (41%, 99% CI. 36% to 45%), followed by orthopedic surgery patients (36%, 99% CI. 34% to 38%). Within fallers, 58% (99% CI. 56 to 60%) reported at least one fall-related injury, and about a quarter (26%, 99% CI. 24% to 28%) reported at least one severe injury. The percent of patients seeking medical treatment for a fall ranged from 7% for general surgery (99% CI. 4% to 11%) to 20% for plastic surgery (99% CI. 15% to 27%).

Factors Associated with Preoperative Falls

Table 3 presents results from the multivariable logistic regression model of preoperative falls. Low physical activity, impaired mobility, poor perceived health, hearing impairment, dizziness, absence of cancer, osteoarthritis, rheumatoid arthritis, and incontinence were statistically and clinically significant. Regarding interactions, depression was associated with higher odds of falls only in patients older than 50, with an odds ratio of 2.11 at age 80 (99% CI. 1.60 to 2.77). In contrast, osteoarthritis was associated with an increased the odds of falls only in patients under age 65. Parkinson Disease was strongly associated with falls only when the patient's ASA physical status score was greater than or equal to three.

Preoperative Falls and Age

As illustrated by Figure 1, the distribution of falls by age was tri-modal with peaks at 18 to 24 years, 55 to 59 years, and greater than 85 years. The middle age group (45-64 years) had the highest proportion of fallers (28%), followed by the older age group (26%) and the younger age group (24%) ($p<0.001$). In addition, the middle age group had the highest proportion of recurrent fallers compared to the older and younger age groups (13% vs 11% and 12%, respectively, $p<0.001$) and the highest proportion of severe fall-related injuries (27% vs 26% and 24%, respectively, $p=0.004$). Due to the high proportion of fallers across all ages, post hoc models explored the associated factors of each age group separately (see Appendix, Table 4). For patients aged 18-44, only poor perceived health and osteoarthritis were associated with falls. More factors were significant in the middle age (45-64 years) model than the older age (65+ years) model, including female sex and incontinence. However, the association with certain variables such as impaired mobility and depression was strongest in the older age model.

Preoperative Falls and Patient-Centered Metrics

Fallers were more likely than non-fallers to have impaired function (20% vs 10%, $p<0.001$), lower physical quality of life (35 vs 41, $p<0.001$), and lower mental quality of life (49 vs 53,

$p < 0.001$). A monotonic relationship existed between the number of falls and each of these measures, as shown in Figure 2 ($p < 0.001$ for each). After controlling for known confounders, including ASA physical status and Charlson Comorbidity Index, falls history was independently associated with functional impairment (OR 1.94 99% CI. 1.68 to 2.42, see Appendix Table 5). Falls history was also independently associated with physical quality of life (OR 2.18, 99% CI. 1.88 to 2.52) after controlling for ASA physical status, Charlson Comorbidity Index, and other confounders (see Appendix, Table 6). Post hoc sensitivity analyses using individual comorbidities from the Charlson Index showed that the association between history of falls and patient-centered metrics was robust (see Appendix, Tables 7 and 8). The association between the patient-centered metrics and falls did not vary by ASA physical status or Charlson comorbidity index, as shown by the non-significant interaction terms ($p = 0.42$, $p = 0.06$, $p = 0.28$, and $p = 0.16$, respectively).

Bootstrapping showed that the differences between the observed and corrected c-statistics were very small for the main models of falls, functional dependence, and quality of life (0.0042, 0.0029, and 0.0016, respectively). The differences for the age-stratified exploratory models were also small (0.0196, 0.0066, and 0.0120). In addition, post hoc sensitivity analyses of missing data did not change odds ratio significances or produce major changes in odds ratio magnitudes. Further characterization of missing data is provided in Table 9 of the Appendix. Finally, the Hosmer-Lemeshow test did not identify any problems with model fit ($p = 0.12$, $p = 0.76$, $p = 0.29$, $p = 0.16$, $p = 0.09$, and $p = 0.39$, respectively).

Discussion

This study is the first to characterize preoperative falls in a large population of patients presenting for a broad range of elective surgeries. The fall rate of 93 per 100 person-years, involving 26% of patients, is twice the rate in the general population.^{2,39,40} While falls can occasion surgery, this cannot account for such a large difference since all surgeries in this sample were elective, and most fallers (86%) did not seek medical treatment. Other studies report an even higher proportion (~35%) of preoperative falls in the same time period.¹³⁻¹⁶ This higher proportion in those studies is likely attributable to the inclusion of higher risk surgical populations: patients over age 65 at a Veterans Affairs hospital,¹³ and patients presenting for ophthalmologic¹⁴ and orthopedic surgery.^{15,16}

Most established fall risk factors were also associated with preoperative falls in the present cohort. However, disease burden, as measured by ASA physical status and Charlson Comorbidity Index, was not associated with preoperative falls. Current malignancy was associated with fewer falls in our sample, which also departs from existing literature.^{41,42} Perhaps cancer patients undergoing surgery are those who are judged healthier and able to withstand the stress of surgery. Alternatively, this could be a spurious result due to testing numerous hypotheses in a large dataset. A few interaction terms were significant, suggesting that interactions are probably important to explore despite their current under-representation in falls literature.

This study is one of few to describe falls in middle age, and appears to be the first to report the distribution of falls in patients younger than 45 years. The youngest patients (age 18 to

24) had one of the highest proportions of fallers, perhaps from the corresponding peak in recreational risk-taking that occurs in this age group.⁴³ Additionally, the middle age group (45-64 years) had the highest proportion of fallers, recurrent fallers, and fall-related injuries among fallers. We found these results surprising given the common conception that falls increase monotonically with age.^{25,44-47} However, several studies support the higher proportion of fallers, recurrent fallers, and fall-related injuries in middle age.^{25,47-51} This peak in middle age might reflect a lag between onset of physical decline and development of caution. Post hoc models showed that each age group had distinct factors associated with falls. Only two variables were significantly associated with falls in the model of patients under age 45. It is possible that these falls are difficult to predict, or that risk factors selected from studies on the elderly are not prognostic in younger people. Factors specifically associated with young age and middle age falls have never been studied previously and merit further exploration.

Previous literature shows that falls in the general community are related to lower function and quality of life, but no study has examined this relationship in surgical patients.²⁵⁻²⁹ On a crude basis, the number of preoperative falls exhibited a stronger dose-response relationship with both measures than an index that incorporates the number of falls with fall injuries.⁵² After controlling for several pre-specified confounders, a history of falls was associated with reduced preoperative function and quality of life. In addition, comorbidity was not related to preoperative falls. Together, these findings suggest that a history of preoperative falls contains health-related information independent of certain commonly assessed comorbidities. A history of falls is also simple to assess. It may therefore serve as a complementary and convenient measure of preoperative health status.

Strengths of this study include its large sample and its focus on falls in presurgical patients, the age distribution of falls, and the relationship between preoperative falls and patient-centered metrics. There are also important limitations. First, we study a single population at a tertiary referral center, so our results cannot be generalized to all surgical populations and should be repeated in other populations. In addition, patients who attend the preoperative assessment clinic may be sicker or otherwise unrepresentative of other patients receiving surgery, while patients who consent to SATISFY-SOS may be a non-random sample as well. These factors could introduce selection bias and reduce generalizability. However, sampling for nonresponse bias showed that patients who consent do not differ in clinically important regards from those who do not consent, including both demographic (age, race, gender) and comorbidity (ASA, Charlson) variables.⁵³ Another limitation was the missing data. Patients missing survey questions were sicker than patients without missing data, while patients missing Barthel Index data were healthier. These findings indicate potential bias. Fortunately, the excluded sample was not large (10%), and the falls and quality of life outcome variables did not differ significantly between groups.

Validity of the data should also be considered. It is possible that variables collected from the review of systems and medical history portions of the patient's preoperative history and physical were not thorough or accurate. However, inspection of patients who had multiple independent encounters showed these data were consistent across visits. Error in recall is also a problem with survey questions, especially in older age, with a bias towards forgetting

falls.³² Nevertheless, studies where the method did not depend on long-term recall show a comparable age distribution of falls.^{2,48} The implications of more recent versus less recent falls could not be explored since we did not collect that information. Finally, use of multiple comparisons is another potential limitation. However, all investigations were pre-specified, and a significance cutoff of <0.01 (with 99 percent confidence intervals) was set to decrease bias and type I error.

Falls are probably common and might often be injurious in the preoperative population, with risk factors similar to those already identified the general population. This study challenges existing belief that falls increase monotonically with age and invites investigation of falls in middle-age and younger-age. Finally, falls may serve as a convenient and complementary tool for assessing a patient's preoperative health. A logical next step is to determine whether a history of falls can predict postoperative outcomes.

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Appendix

Table 4

Multivariable logistic regression predicting one or more preoperative falls, stratified by age group

Factors Associated with Falls	Age 18-44 (N=2,990)			Age 45-64 (N=6,236)			Age 65+ (N=4,223)		
	Estimate	OR	99% CI	Estimate	OR	99% CI	Estimate	OR	99% CI
Age	-0.035	0.97 ^a	0.95, 0.99	-0.002	1.00 ^a	0.98, 1.01	0.008	1.01	0.99, 1.03
Female Sex	-0.137	0.87	0.68, 1.12	0.185	1.20	1.02, 1.42	-0.038	0.96	0.79, 1.18
Underweight (BMI < 18.5)	0.426	1.53	0.66, 3.54	0.197	1.22	0.59, 2.52	-0.186	0.83	0.30, 2.28
White Race	0.116	1.12	0.84, 1.50	0.038	1.04	0.85, 1.28	0.253	1.29	0.94, 1.77
Charlson Comorbidity Index (1-2)	0.070	1.07	0.82, 1.40	-0.068	0.93	0.78, 1.12	-0.089	0.92	0.72, 1.16

Factors Associated with Falls	Age 18-44 (N=2,990)			Age 45-64 (N=6,236)			Age 65+ (N=4,223)		
	Estimate	OR	99% CI	Estimate	OR	99% CI	Estimate	OR	99% CI
Charlson Comorbidity Index (3)	0.202	1.22	0.72, 2.09	-0.233	0.79	0.61, 1.03	-0.010	0.99	0.74, 1.32
ASA Physical Status (3)	-0.213	0.81	0.59, 1.11	0.075	1.08	0.90, 1.29	0.020	1.02 ^a	0.82, 1.26
Number of Home Medications, per 5	-0.457	1.15 ^a	0.62, 2.17	0.105	1.11	1.04, 1.19	0.011	1.06	0.97, 1.14
Low Physical Activity Capability	0.282	1.32 ^a	0.91, 1.93	0.357	1.43	1.19, 1.72	0.467	1.60	1.29, 1.98
Impaired Mobility	0.650	1.92	0.97, 3.79	0.332	1.39	1.04, 1.88	0.408	1.50	1.12, 2.00
Fair/Poor Perceived Health Status	0.397	1.49	1.10, 2.01	0.390	1.48	1.22, 1.79	0.115	1.12	0.86, 1.46
Visual Impairment	-0.044	0.96 ^a	0.72, 1.28	0.105	1.11	0.95, 1.30	0.133	1.14	0.95, 1.38
Hearing Impairment	-0.086	0.92	0.52, 1.62	0.281	1.32	1.05, 1.67	0.236	1.27	1.02, 1.57
Dizziness	-0.040	0.96 ^a	0.59, 1.55	0.346	1.41	1.14, 1.76	0.376	1.46	1.12, 1.88
Current Cancer	-0.315	0.73	0.42, 1.28	-0.435	0.65	0.50, 0.84	-0.307	0.74	0.55, 0.98
Osteoarthritis	0.880	2.41	1.57, 3.71	0.225	1.25	1.05, 1.49	0.086	1.09	0.89, 1.33
Rheumatoid Arthritis	0.676	1.97	0.80, 4.80	0.412	1.51	1.04, 2.20	0.016	1.02	0.61, 1.70
Depression	0.201	1.22	0.89, 1.68	-1.009	1.61^a	1.33, 1.94	0.572	1.77	1.36, 2.30
Stroke	0.197	1.22	0.53, 2.81	0.058	1.06	0.76, 1.47	-0.117	0.89 ^a	0.66, 1.20
Incontinence	0.157	1.17	0.37, 3.76	0.753	2.12	1.28, 3.51	0.221	1.25 ^a	0.71, 2.18
Parkinson Disease	^b	-	-	1.648	5.20	1.89, 14.4	-0.005	6.65^a	2.54, 17.4
Interaction Terms	Estimate	p-value		Estimate	p-value		Estimate	p-value	
Age*Home Medications	0.003	0.01							
Physical Activity*Dizziness	0.66	0.03							
Visual Impairment*Dizziness	0.718	0.01							
Age*Depression				0.027	0.04				
ASA*Parkinson Disease							1.90	0.009	
Stroke*Incontinence							1.12	0.04	

Abbreviations: OR=Odds Ratio, CI=Confidence Interval, BMI=Body Mass Index, ASA=American Society of Anesthesiologists

Age 18-44: R-squared=0.083, c=0.644, -2LL=3141; Age 45-64: R-squared=0.108, c=0.677, -2LL=6879; Age 65+ R-squared=0.091, -2LL=4606, c=0.655

^aValue depends on interaction. OR shown is based on most common scenario (ie mean age, mean number of medications, ASA 3, absence of disease)

^bOnly one patient had Parkinson Disease

Table 5

Multivariable logistic regression predicting functional impairment (Barthel Index < 100)

Characteristic	(N=13,837)		
	Estimate	OR	99% CI
Age	0.037	1.04	1.03, 1.04

Characteristic	(N=13,837)		
	Estimate	OR	99% CI
Female Sex	0.311	1.37	1.18, 1.58
Underweight (BMI < 18.5)	0.414	1.51	0.82, 2.80
Obesity (BMI 30-35)	0.175	1.19	1.00, 1.42
Morbid Obesity (BMI ≥ 35)	0.577	1.78	1.51, 2.10
History of a Fall	0.664	1.94	1.68, 2.24
Charlson Comorbidity Index (1-2)	0.099	1.10	0.93, 1.31
Charlson Comorbidity Index (≥ 3)	0.326	1.39	1.14, 1.68
ASA Physical Status (≥ 3)	0.589	1.80	1.54, 2.10
Neurologic Impairment	0.511	1.67	1.36, 2.05
Visual Impairment	0.022	1.02	0.89, 1.18
Hearing Impairment	-0.034	1.00	0.80, 1.17
Depression	0.265	1.30	1.10, 1.55

Abbreviations: OR=Odds Ratio, CI=Confidence Interval, BMI=Body Mass Index, ASA=American Society of Anesthesiologists

R-squared=0.144, c=0.734, -2LL=9,470

Table 6

Multivariable logistic regression predicting poor physical quality of life (PCS < 50)

Characteristic	(N=13,536)		
	Estimate	OR	99% CI
Middle age (45-64)	0.037	1.04	0.90, 1.20
Older age (65+)	-0.016	0.98	0.84, 1.16
Female Sex	0.078	1.07	0.95, 1.20
Obesity (BMI ≥ 30)	0.386	1.47	1.31, 1.65
History of a Fall	0.112	2.18	1.88, 2.52
Charlson Comorbidity Index (1-2)	0.331	1.12	0.99, 1.27
Charlson Comorbidity Index (≥ 3)	0.919	1.39	1.17, 1.67
ASA Physical Status (≥ 3)	0.777	2.51^a	2.17, 2.90
Depression	0.449	1.57^a	1.28, 1.92
Chronic Pain	2.266	9.64^a	8.10, 11.5
Interaction Terms	Estimate	p-value	
ASA*Chronic Pain	-0.696	<0.001	
Depression*Chronic Pain	-0.498	<0.001	

Abbreviations: OR=Odds Ratio, CI=Confidence Interval, BMI=Body Mass Index, ASA=American Society of Anesthesiologists

R-squared=0.281, c-statistic=0.785, -2LL=13,001

^aThis value depends on an interaction term. OR provided is based on most common scenario (ie no depression, no chronic pain, and ASA < 3)

Table 7

Multivariable logistic regression of functional impairment with individual comorbidities

Characteristic	(N=13,837)		
	Estimate	OR	99% CI
Age	0.039	1.04	1.03, 1.05
Female Sex	0.308	1.36	1.17, 1.58
Underweight (BMI < 18.5)	0.389	1.48	0.79, 2.75
Obesity (BMI 30-35)	0.154	1.17	0.98, 1.39
Morbid Obesity (BMI ≥ 35)	0.538	1.71	1.44, 2.04
History of a Fall	0.642	1.90	1.65, 2.20
Myocardial Infarction	-0.158	0.85	0.65, 1.11
Congestive Heart Failure	0.245	1.28	0.98, 1.66
Peripheral Vascular Disease	0.410	1.51	1.13, 2.02
Pulmonary Disease	0.242	1.27	1.08, 1.50
Connective Tissue Disease	0.201	1.22	0.91, 1.65
Peptic Ulcer Disease	-0.048	0.95	0.62, 1.46
Liver Disease	0.297	1.35	1.01, 1.80
Diabetes	0.171	1.19	1.01, 1.40
Renal Disease	0.441	1.55	1.13, 2.15
Malignancy	0.167	0.85	0.72, 0.99
ASA Physical Status (≥ 3)	0.549	1.73	1.48, 2.02
Neurologic Impairment	0.479	1.62	1.31, 1.99
Visual Impairment	0.018	1.02	0.88, 1.17
Hearing Impairment	-0.030	0.97	0.80, 1.17
Depression	0.262	1.30	1.09, 1.55

Abbreviations: OR=Odds Ratio, CI=Confidence Interval, BMI=Body Mass Index, ASA=American Society of Anesthesiologists

R-squared=0.081, c=0.741, -2LL=9,406

Table 8

Multivariable logistic regression of poor physical quality of life with individual comorbidities

Characteristic	(N=13,536)		
	Estimate	OR	99% CI
Middle Age (45-64)	0.089	1.09	0.95, 1.26
Older Age (65+)	0.020	1.02	0.87, 1.20
Female Sex	0.078	1.08	0.96, 1.22
Obesity (BMI ≥ 30)	0.352	1.42	1.27, 1.60
History of a Fall	0.737	2.09	1.80, 2.42
Myocardial Infarction	0.504	1.66	1.21, 2.26
Congestive Heart Failure	0.781	2.18	1.51, 3.16
Peripheral Vascular Disease	0.321	1.38	0.93, 2.04

Characteristic	(N=13,536)		
	Estimate	OR	99% CI
Cerebrovascular Disease	0.300	1.35	1.00, 1.82
Pulmonary Disease	0.432	1.54	1.31, 1.81
Connective Tissue Disease	0.832	2.30	1.52, 3.48
Peptic Ulcer Disease	0.424	1.53	0.95, 2.47
Liver Disease	0.427	1.53	1.10, 2.14
Diabetes	0.313	1.37	1.15, 1.62
Renal Disease	0.547	1.73	1.16, 2.58
Malignancy	-0.359	0.70	0.61, 0.79
ASA Physical Status (3)	0.776	*2.17	1.87, 2.52
Depression	0.420	*1.52	1.24, 1.87
Chronic Pain	2.220	*9.20	7.73, 11.0
Interaction Terms	Estimate	P -value	
ASA *Chronic Pain	-0.684	<0.001	
Depression *Chronic Pain	-0.510	<0.001	

Abbreviations: OR=Odds Ratio, CI=Confidence Interval, BMI=Body Mass Index, ASA=American Society of Anesthesiologists

R-squared=0.211, c-statistic=0.798, -2LL=12,721

* This value depends on an interaction term. OR provided is based on most common scenario (ie no depression, no chronic pain, and ASA < 3)

Table 9

Comparison of patients missing any variable, at least one survey variable, or at least one Barthel Index variable^a

Factor	All pts (N=15,060)	Missing any variable (N=2,429)		Missing survey variable (N=1,451)		Missing Barthel Index ^c var. (N=696)	
	No. (%)	%	p-value	%	p-value	%	p-value
Age, mean (SD)	55.9 (15)	56.7 (15)	0.005	59.3 (15)	<0.001	53.5 (13)	<0.001
Female Sex	8774 (58)	1385 (57)	0.18	839 (58)	0.74	397 (57)	0.50
Underweight (BMI < 18.5)	175 (1.2)	36 (1.5)	0.08	29 (2.0)	0.002	3 (0.4)	0.08
Obesity (BMI > 30)	7036 (47)	1076 (46)	0.16	643 (45)	0.05	319 (48)	0.69
White Race	12335 (83)	1653 (76)	<0.001	1015 (71)	<0.001	571 (83)	0.93
Charlson Comorbidity Index (1-2)	6104 (41)	999 (42)	0.03	607 (42)	0.001	266 (39)	0.09
Charlson Comorbidity Index (3)	2956 (20)	510 (21)	0.006	347 (24)	<0.001	111 (16)	0.008
ASA Physical Status (3)	6161 (41)	1071 (44)	<0.001	683 (47)	<0.001	266 (38)	0.14
Number Home Medications, median (IQR)	7 (3,11)	7 (3,11)	0.02	7 (3,11)	0.002	6 (3,10)	0.01
Low Physical Activity Capability	4373 (29)	772 (33)	<0.001	549 (38)	<0.001	182 (27)	0.21
Impaired Mobility	1066 (7)	208 (12)	<0.001	181 (13)	<0.001	-	-

Factor	All pts (N=15,060)	Missing any variable (N=2,429)		Missing survey ^b variable (N=1,451)		Missing Barthel Index ^c var. (N=696)	
	No. (%)	%	p-value	%	p-value	%	p-value
Poor/Fair Perceived Health Status	3029 (20)	545 (25)	<0.001	354 (28)	<0.001	128 (19)	0.22
Visual Impairment	6142 (41)	999 (41)	0.71	614 (42)	0.21	293 (42)	0.47
Hearing Impairment	2183 (15)	381 (16)	0.07	254 (18)	<0.001	99 (14)	0.84
Dizziness	1907 (13)	323 (13)	0.30	202 (14)	0.13	77 (11)	0.19
Current Cancer	1967 (13)	280 (12)	0.01	166 (11)	0.05	77 (11)	0.11
Osteoarthritis	3378 (22)	482 (20)	0.001	310 (21)	0.31	132 (19)	0.03
Rheumatoid Arthritis	457 (3.0)	76 (3.1)	0.77	53 (3.7)	0.15	14 (2.0)	0.11
Depression	2420 (16)	378 (16)	0.46	234 (16)	0.95	109 (16)	0.76
Stroke	1000 (7)	191 (8)	0.008	141 (10)	<0.001	36 (5)	0.11
Incontinence	300 (2.1)	40 (2.3)	0.50	34 (2.4)	0.35	-	-
Parkinson Disease	98 (0.7)	19 (0.8)	0.38	14 (1.0)	0.12	5 (0.7)	0.82
Neurological Impairment	1195 (8)	231 (10)	0.002	165 (11)	<0.001	46 (7)	0.19
Chronic Pain	6742 (45)	1061 (44)	0.24	658 (45)	0.64	290 (42)	0.09
Fall in Prior 6 Months	3835 (26)	508 (26)	0.98	275 (29)	0.07	169 (25)	0.46
Functional Impairment (<100)	1886 (13)	320 (18)	<0.001	281 (20)	<0.001	-	-
Mental Quality of Life Score, median (IQR)	56 (45,61)	55 (45,61)	0.02	54 (42,60)	0.01	55 (46,61)	0.74
Poor Physical Quality of Life (<50)	10105 (73)	932 (72)	0.50	243 (76)	0.20	468 (71)	0.25

Abbreviations: OR=Odds Ratio, CI=Confidence Interval, SD=Standard Deviation, BMI=Body Mass Index, ASA=American Society of Anesthesiologists, IQR=Interquartile Range

^aBecause of different numbers of missing values for each variable, denominator may differ from total shown

^bMissing survey variables include history of falls, quality of life, and perceived health

^cMissing Barthel Index variables include functional dependence, incontinence, and mobility issue

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Figure 1. Proportion of patients who fell in the 6 months prior to surgery, by age
error bars represent 95 percent confidence intervals

Figure 2. Relationship between number of falls and functional impairment, physical quality of life, and mental quality of life

(A) Number of falls and functional impairment (Barthel Index < 100). (B) Number of falls and quality of life score. Physical is physical quality of life. Mental is mental quality of life.

Table 1

Characteristics of fallers, non-fallers, and patients missing data

	^a No. (%)		
Characteristic	Non-faller (N=10,727)	Faller (N=3,835)	OR
Age, mean (SD)	55.6 (15)	56.4 (15)	-
Female Sex	6135 (57)	2340 (61)	1.16
Underweight (BMI < 18.5)	112 (1.1)	48 (1.3)	1.20
White Race	8798 (83)	3203 (85)	1.10
Charlson Comorbidity Index (1-2)	4320 (40)	1583 (41)	1.11
Charlson Comorbidity Index (3)	2021 (19)	807 (21)	1.21
ASA Physical Status (3)	4145 (39)	1778 (46)	1.37
Number of Home Medications, median (IQR)	6 (3,10)	8 (4,12)	-
Low Physical Activity Level	2622 (25)	1547 (41)	2.10
Impaired Mobility	563 (6)	434 (12)	2.30
Fair/Poor Perceived Health Status	1813 (17)	1095 (29)	1.96
Visual Impairment	4236 (39)	1683 (44)	1.20
Hearing Impairment	1431 (13)	666 (17)	1.37
Dizziness	1133 (11)	701 (18)	1.89
Current Cancer	1548 (14)	373 (10)	0.64
Osteoarthritis	2190 (20)	1076 (28)	1.52
Rheumatoid Arthritis	272 (2.5)	165 (4.3)	1.73
Depression	1426 (13)	904 (24)	2.01
Stroke	634 (6)	311 (8)	1.41
Incontinence	155 (1.5)	128 (3.5)	2.35
Parkinson Disease	31 (0.3)	65 (1.7)	5.95

Abbreviations: OR=Odds Ratio, SD=Standard Deviation, BMI=Body Mass Index, ASA=American Society of Anesthesiologists, IQR=Interquartile Range

^a Because of slightly different numbers of missing values for each variable, denominator may differ from this total.

Table 2

Number of falls, falls by surgery type, and fall-related injuries

Outcome	Number (%)
Number of fallers (N=14,562 patients)	3835 (26)
1 fall	2084 (14)
2 falls	1015 (7)
3 falls	736 (5)
Number of fallers, by surgery type (N=14,548)	
Neurosurgery	345 (41)
Orthopedic	1253 (36)
Plastic	172 (28)
Ophthalmologic	222 (24)
General	196 (24)
Cardiac	421 (23)
Other	266 (22)
Gynecologic	320 (21)
Otolaryngology	224 (20)
GI/Hepatobiliary	184 (20)
Urologic	227 (19)
Any fall-injury (N=3,835 fallers)	2215 (58)
Bruising, sprain, or cut	1621 (42)
Severe pain	568 (15)
Sought medical treatment	560 (15)
Reduced mobility	476 (12)
Fracture	290 (8)
Head injury	121 (3)
Independent to assisted living	52 (1)
Prefer not to answer	5 (0.03)

Table 3

Multivariable logistic regression predicting one or more preoperative falls

	(N=13,449)		
Characteristic	OR	99% CI	p-value
Age	^a 1.00	0.99, 1.00	0.008
Female Sex	1.04	0.93, 1.17	0.321
Underweight (BMI < 18.5)	1.19	0.74, 1.91	0.358
White Race	1.11	0.96, 1.29	0.060
Charlson Comorbidity Index (1-2)	0.97	0.85, 1.10	0.468
Charlson Comorbidity Index (3)	0.92	0.77, 1.10	0.251
ASA Physical Status (3)	^a 1.01	0.89, 1.14	0.820
Number of Home Medications, per 5	1.09	1.04, 1.15	<0.001
Low Physical Activity Capability	1.49	1.31, 1.69	<0.001
Impaired Mobility	1.50	1.24, 1.82	<0.001
Fair/Poor Perceived Health Status	1.37	1.19, 1.56	<0.001
Visual Impairment	1.11	1.00, 1.24	0.014
Hearing Impairment	1.29	1.11, 1.50	<0.001
Dizziness	1.44	1.24, 1.67	<0.001
Current Cancer	0.69	0.57, 0.82	<0.001
Osteoarthritis	^a 1.41	1.23, 1.62	<0.001
Rheumatoid Arthritis	1.37	1.03, 1.82	0.004
Depression	^a 1.57	1.37, 1.80	0.402
Stroke	1.02	0.83, 1.26	0.798
Incontinence	1.72	1.23, 2.40	<0.001
Parkinson Disease	^a 7.19	3.28, 15.8	0.293
Interaction Terms	Estimate		p-value
Age*Depression	0.012		0.003
Age*Osteoarthritis	-0.020		<0.001
ASA*Parkinson Disease	1.521		0.004

Abbreviations: OR=Odds Ratio, CI=Confidence Interval, ASA=American Society of Anesthesiologists, BMI=Body Mass Index

R-squared=0.090, c=0.658, -2LL=14,711

^aValue depends on interaction. OR shown is based on most common scenario (ie mean age, mean number of medications, ASA 3, absence of disease)