Preoperative Falls and Their Association with Functional Dependence and Quality of Life

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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. The surveys were collected between January 2014 and August 2015, with a response rate of 92%.

Results: In the 6 months before 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 yr) had the highest proportion of fallers (28%), recurrent fallers (13%), and severe fall-related injuries (27%) compared to younger (18 to 44 yr) and older (65+ yr) patients ($P < 0.001$ for each). A fall within 6 months was independently associated with preoperative functional dependence (odds ratio, 1.94; 99% CI, 1.68 to 2.24) and poor physical quality of life (odds ratio, 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 the assessment of preoperative functional dependence and quality of life. **(ANESTHESIOLOGY 2016; 125:322-32)**

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

What We Already Know about This Topic

- Falls are an indicator of frailty and poor health

What This Article Tells Us That Is New

- Observational study of more than 15,000 adults undergoing elective surgery found that 26% fell in the 6 months preceding surgery, and more than half of these falls caused injuries
- Even after adjustment for known confounding factors, preoperative falls were associated with a two-fold increase in both preoperative functional dependence and poor physical quality of life

Submitted for publication December 8, 2015. Accepted for publication April 13, 2016. From the Department of Anesthesiology (V.L.K., R.D.T., A.P.S., A.B.A., T.S.W., S.L.M., F.S., D.L.H., A.S., M.S.A.) and Program in Occupational Therapy (S.L.S.), Washington University School of Medicine, St. Louis, Missouri; and Department of Mathematics, Washington University, St. Louis, Missouri (N.L.).

<zdoi;10.1097/ALN.0000000000001167>

(1) describe the proportion of patients who fell, factors associated with falls, and age distribution of those falling in the 6 months before 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, Missouri (Human Research Protection Office number 201408107). All participants provided written informed consent.

Study Population

This observational investigation was a substudy of the Systematic Assessment and Targeted Improvement of Services Following Yearlong Surgical Outcomes Surveys (SATISFY-SOS) study and was conducted in compliance with the STrengthening the Reporting of OBservational Studies in Epidemiology (STROBE) guidelines.[30] SATISFY-SOS (NCT02032030) is a large, observational study that collects detailed perioperative data and data on patient-reported outcomes for adults undergoing elective surgery at Barnes Jewish Hospital in St. Louis, Missouri. 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 nonparticipation include patient refusal, lack of nurses' time or institutional review board training, or illiteracy in English. A study comparing participants to nonparticipants showed no major differences in characteristics.[31] 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, a fall was defined in the surveys as "an unexpected event where you come to rest on the ground, floor, or lower level."[32] "Recurrent fallers" were patients who experienced two or more falls in 6 months. "Severe" fall-related injury was defined as seeking medical treatment, severe pain, head injury, fracture, or change from independent to assisted living. The 6-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.[13,33] The physical component score (PCS) and mental component score of quality of life were obtained using the Veterans RAND 12-item Health Survey. With a mean of 50, the Veterans RAND 12-item Health Survey scale is standardized to the general U.S. population.[22,23] The baseline survey provided data on the history of falls, 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, USA).

Statistical Analysis

All variable selection and analytical procedures used in this study were prespecified 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 history of falls, 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 prespecified the 10 to 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 article's three main models included one or more falls within 6 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, body mass index, and age in some of the models. To resolve this issue, categorization was performed where the nonlinear relationships could not be transformed.[34,35] Because of the high ratio of events to variables, variable prespecification, and forced entry methods, overfitting was not considered to be a major concern.[36,37] Nevertheless, we performed *post hoc* bootstrapping on each model with 100 replicates for internal validation. Small differences (less than 5%) between observed and corrected c-statistics suggest that overfitting is unlikely.[38]

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 with missing data were outcomes (history of falls, Barthel index, quality of life), missing less than 1% of the data (race, Charlson comorbidity index, ASA physical status, physical activity level, perceived health status), or not missing at random (impaired mobility, incontinence). *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., USA). To calculate a crude estimate of the fall rate per 100 person-years as recommended by the Prevention of Falls Network Europe consensus group, an exponential decay curve was applied to the fall count data and extrapolated to six falls.[32] Parametric tests were performed for normally distributed data, while nonparametric tests were performed for nonnormally distributed data. All tests were two-sided. Because we conducted multiple statistical analyses, the threshold for significance was set to α less than 0.01. The threshold for clinical significance was defined *a priori* as a 20% difference in proportions or odds ratios (ORs).[39]

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 nonfallers differed for the majority of the characteristics studied (table 1). Table 2 shows how many times patients fell, the falls according to the type of surgery, and the fall-related injuries sustained. In the 6 months before 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

Table 1. Characteristics of Fallers and Nonfallers

	No. (%)*		
Characteristic	Nonfaller (N = 10,727)	Faller (N = 3,835)	OR
Age (yr), mean (SD)	55.6 (15)	56.4 (15)	—
Female sex	6,135 (57)	2,340 (61)	1.16
Underweight (BMI < 18.5 kg/m^2)	112 (1.1)	48 (1.3)	1.20
White race	8,798 (83)	3,203 (85)	1.10
Charlson comorbidity index (1–2)	4,320 (40)	1,583 (41)	1.11
Charlson comorbidity index (≥ 3)	2,021 (19)	807 (21)	1.21
ASA physical status (≥ 3)	4,145 (39)	1,778 (46)	1.37
Number of home medications, median (IQR)	6 (3–10)	8 (4–12)	—
Low physical activity level	2,622 (25)	1,547 (41)	2.10
Impaired mobility	563 (6)	434 (12)	2.30
Fair/poor perceived health status	1,813 (17)	1,095 (29)	1.96
Visual impairment	4,236 (39)	1,683 (44)	1.20
Hearing impairment	1,431 (13)	666 (17)	1.37
Dizziness	1,133 (11)	701 (18)	1.89
Current cancer	1,548 (14)	373 (10)	0.64
Osteoarthritis	2,190 (20)	1,076 (28)	1.52
Rheumatoid arthritis	272 (2.5)	165 (4.3)	1.73
Depression	1,426 (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

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

ASA = American Society of Anesthesiologists; BMI = body mass index; IQR = interquartile range; OR = odds ratio.

Table 2. Number of Falls, Falls by Surgery Type, and Fall-related Injuries

Outcome	No. (%)
Number of fallers (N = 14,562 patients)	3,835 (26)
1 fall	2,084 (14)
2 falls	1,015 (7)
≥ 3 falls	736 (5)
Number of fallers, by surgery type (N = 14,548)	
Neurosurgery	345 (41)
Orthopedic	1,253 (36)
Plastic	172 (28)
Ophthalmologic	222 (24)
General	196 (24)
Cardiac	421 (23)
Other	266 (22)
Gynecologic	320 (21)
Otolaryngology	224 (20)
Gastrointestinal/hepatobiliary	184 (20)
Urologic	227 (19)
Any fall injury (N = 3,835 fallers)	2,215 (58)
Bruising, sprain, or cut	1,621 (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)

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; and presence of 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 OR of 2.11 at age 80 (99% CI, 1.60 to 2.77). In contrast, osteoarthritis was associated with an increased 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 in figure 1, the distribution of falls by age was trimodal with peaks at 18 to 24 yr, 55 to 59 yr, and greater than 85 yr. The middle-age group (45 to 64 yr) 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 (table A1). For patients aged 18 to 44, only poor perceived health and osteoarthritis were associated with falls. More factors were significant in the middle-age (45 to 64 yr) model than the older-age (65+ yr) 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 nonfallers 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, history of falls was independently associated with functional impairment (OR, 1.94; 99% CI, 1.68 to 2.42, table A2). History of falls 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 (table A3). *Post hoc* sensitivity analyses using individual comorbidities from the Charlson index showed that the association between the history of falls and patient-centered metrics was robust (tables A4 and A5). The association between the patient-centered metrics and falls did not vary by ASA physical status or Charlson comorbidity index, as shown by the nonsignificant 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 OR significances or produce major changes in OR magnitudes. Further characterization of missing data is provided in table A6 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

Table 3. Multivariable Logistic Regression Predicting One or More Preoperative Falls

	(N = 13,449)		
Characteristic	OR	99% CI	*P* Value
Age	1.00*	0.99–1.00	0.008
Female sex	1.04	0.93–1.17	0.321
Underweight (BMI < 18.5 kg/m^2)	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)	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	1.41*	1.23–1.62	< 0.001
Rheumatoid arthritis	1.37	1.03–1.82	0.004
Depression	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	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

R^2 = 0.090; c = 0.658; −2 log likelihood = 14,711.

*Value depends on interaction. Odds ratio (OR) shown is based on the most common scenario (*i.e.*, mean age, mean number of medications, ASA ≥ 3, absence of disease).

ASA = American Society of Anesthesiologists; BMI = body mass index.

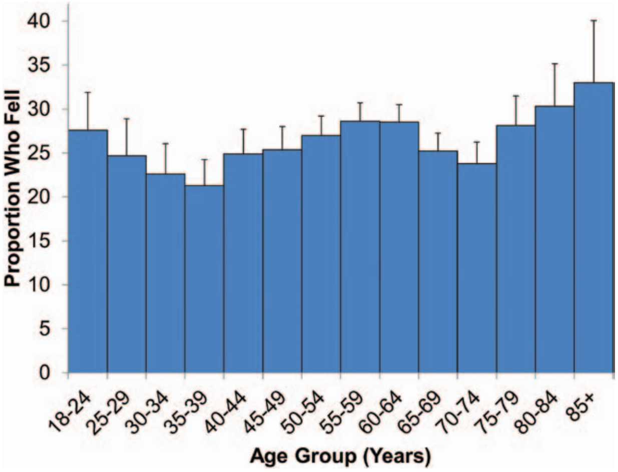

Fig. 1. Proportion of patients who fell in the 6 months before surgery, by age. *Error bars* represent 95% CIs.

elective surgeries. The fall rate of 93 per 100 person-years, involving 26% of patients, is twice the rate in the general population.[2,40,41] 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 (approximately 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 ophthalmologic[14] and orthopedic surgery.[15,16]

Most established fall risk factors were also associated with preoperative falls in the current 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.[42,43] 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 underrepresentation in the literature on falls.

This study is one of few to describe falls in middle age and appears to be the first to report the distribution of falls

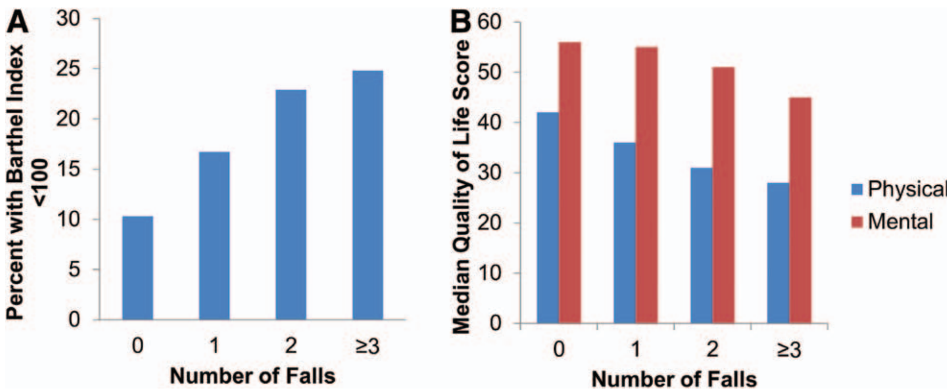

Fig. 2. Relationship between number of falls and functional impairment, physical quality of life, and mental quality of life. (*A*) Number of falls and functional impairment (Barthel index less than 100). (*B*) Number of falls and quality of life score. *Physical* = physical quality of life. *Mental* = mental quality of life.

in patients younger than 45 yr. The youngest patients (aged 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.[44] Additionally, the middle-age group (45 to 64 yr) 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.[25,45–48] However, several studies support the higher proportion of fallers, recurrent fallers, and fall-related injuries in middle age.[25,48–52] This peak in middle age might reflect a lag between the onset of physical decline and the 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 younger than 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.[53] After controlling for several prespecified 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 nonrandom 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, and gender) and comorbidity (ASA and Charlson) variables.[54] 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 that 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.[33] Nevertheless, studies where the method did not depend on long-term recall show a comparable age distribution of falls.[2,49] The implications of more recent *versus* less recent falls could not be explored since we did not collect that information. Finally, the use of multiple comparisons is another potential limitation. However, all investigations were prespecified, and a significance cutoff of less than 0.01 (with 99% CIs) 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 in the general population. This study challenges the existing belief that falls increase monotonically with age and invites investigation of falls in middle-age and younger-age groups. 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.

Acknowledgments

The authors thank Will Godfrey, M.A., Department of Anesthesiology, Washington University School of Medicine, St. Louis, Missouri; Bradley Fritz, M.D., Department of Anesthesiology, Washington University School of Medicine, St. Louis, Missouri; Lewis Kazis, Sc.D., Departments of Health Services, School of Public Health, Boston University, Boston, Massachusetts; Michelle Jerry, M.S., Biostatistics Department, University of Michigan, Ann Arbor, Michigan; Center for Preoperative Assessment and Planning, Department of Anesthesiology, Barnes Jewish Hospital, St. Louis, Missouri; and Institute of Quality Improvement, Research and Informatics, Department of Anesthesiology, Washington University School of Medicine, St. Louis, Missouri.

Research Support

This study was supported by the Washington University Institute of Clinical and Translational Sciences grant UL1TR000448 from the National Center for Advancing Translational Sciences, along with grant 1UH2AG050312-01 from the National Institute on Aging, of the National Institutes of Health (NIH; Bethesda, Maryland). The content is solely the responsibility of the authors and does not necessarily represent the official view of the NIH. It was also supported by grant BJHF#7937–77 from the Barnes-Jewish Hospital Foundation and the Washington University Department of Anesthesiology (St. Louis, Missouri). The funding sources provided infrastructure and financial support but had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

Competing Interests

The authors declare no competing interests.

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Table A1. Multivariable Logistic Regression Predicting One or More Preoperative Falls, Stratified by Age Group

	Age 18–44 Yr (N = 2,990)			Age 45–64 Yr (N = 6,236)			Age 65+ Yr (N = 4,223)		
Factors Associated with Falls	Estimate	OR	99% CI	Estimate	OR	99% CI	Estimate	OR	99% CI
Age	−0.035	0.97*	0.95–0.99	−0.002	1.00*	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 kg/m^2)	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
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*	0.82–1.26
Number of home medications, per 5	−0.457	1.15*	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*	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*	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*	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*	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*	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*	0.71–2.18
Parkinson disease	—†	—	—	1.648	5.20	1.89–14.4	−0.005	6.65*	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	

Age 18–44 yr: R^2 = 0.083, c = 0.644, −2 log likelihood (−2LL) = 3,141; age 45–64: R^2 = 0.108, c = 0.677, −2LL = 6,879; age 65+: R^2 = 0.091, c = 0.655, −2LL = 4,606.

*Value depends on interaction. Odds ratio (OR) shown is based on the most common scenario (*i.e.*, mean age, mean number of medications, ASA ≥ 3, absence of disease). †Only one patient had Parkinson disease.

ASA = American Society of Anesthesiologists; BMI = body mass index.

Table A2. Multivariable Logistic Regression Predicting Functional Impairment (Barthel Index < 100)

	(N = 13,837)		
Characteristic	Estimate	OR	99% CI
Age	0.037	1.04	1.03–1.04
Female sex	0.311	1.37	1.18–1.58
Underweight (BMI < 18.5 kg/m^2)	0.414	1.51	0.82–2.80
Obesity (BMI, 30–35 kg/m^2)	0.175	1.19	1.00–1.42
Morbid obesity (BMI ≥ 35 kg/m^2)	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

R^2 = 0.144; c = 0.734; −2 log likelihood = 9,470.

ASA = American Society of Anesthesiologists; BMI = body mass index; OR = odds ratio.

Table A3. Multivariable Logistic Regression Predicting Poor Physical Quality of Life (PCS < 50)

	(N = 13,536)		
Characteristic	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 kg/m^2)	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*	2.17–2.90
Depression	0.449	1.57*	1.28–1.92
Chronic pain	2.266	9.64*	8.10–11.5
Interaction terms	Estimate	*P* Value	
ASA × chronic pain	−0.696	< 0.001	
Depression × chronic pain	−0.498	< 0.001	

R^2 = 0.281; c = 0.785; −2 log likelihood = 13,001.

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

ASA = American Society of Anesthesiologists; BMI = body mass index; PCS = physical component score.

Table A4. Multivariable Logistic Regression of Functional Impairment with Individual Comorbidities

	(N = 13,837)		
Characteristic	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 kg/m^2)	0.389	1.48	0.79–2.75
Obesity (BMI, 30–35 kg/m^2)	0.154	1.17	0.98–1.39
Morbid obesity (BMI ≥ 35 kg/m^2)	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

R^2 = 0.081; c = 0.741; −2 log likelihood = 9,406.

ASA = American Society of Anesthesiologists; BMI = body mass index; OR = odds ratio.

Table A5. Multivariable Logistic Regression of Poor Physical Quality of Life with Individual Comorbidities

	(N = 13,536)		
Characteristic	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 kg/m^2)	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
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	

R^2 = 0.211; c = 0.798; −2 log likelihood = 12,721.

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

ASA = American Society of Anesthesiologists; BMI = body mass index.

Table A6. Comparison of Patients Missing Any Variable, at Least One Survey Variable, or at Least One Barthel Index Variable*

	All Patients (N = 15,060)	Missing Any Variable (N = 2,429)		Missing Survey Variable† (N = 1,451)		Missing Barthel Index Variable‡ (N = 696)	
Factor	No. (%)	%	*P* Value	%	*P* Value	%	*P* Value
Age (yr), mean (SD)	55.9 (15)	56.7 (15)	0.005	59.3 (15)	< 0.001	53.5 (13)	< 0.001
Female sex	8,774 (58)	1,385 (57)	0.18	839 (58)	0.74	397 (57)	0.50
Underweight (BMI < 18.5 kg/m^2)	175 (1.2)	36 (1.5)	0.08	29 (2.0)	0.002	3 (0.4)	0.08
Obesity (BMI > 30 kg/m^2)	7,036 (47)	1,076 (46)	0.16	643 (45)	0.05	319 (48)	0.69
White race	12,335 (83)	1,653 (76)	< 0.001	1,015 (71)	< 0.001	571 (83)	0.93
Charlson comorbidity index (1–2)	6,104 (41)	999 (42)	0.03	607 (42)	0.001	266 (39)	0.09
Charlson comorbidity index (≥ 3)	2,956 (20)	510 (21)	0.006	347 (24)	< 0.001	111 (16)	0.008
ASA physical status (≥ 3)	6,161 (41)	1,071 (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	4,373 (29)	772 (33)	< 0.001	549 (38)	< 0.001	182 (27)	0.21
Impaired mobility	1,066 (7)	208 (12)	< 0.001	181 (13)	< 0.001	—	—
Poor/fair perceived health status	3,029 (20)	545 (25)	< 0.001	354 (28)	< 0.001	128 (19)	0.22
Visual impairment	6,142 (41)	999 (41)	0.71	614 (42)	0.21	293 (42)	0.47
Hearing impairment	2,183 (15)	381 (16)	0.07	254 (18)	< 0.001	99 (14)	0.84
Dizziness	1,907 (13)	323 (13)	0.30	202 (14)	0.13	77 (11)	0.19
Current cancer	1,967 (13)	280 (12)	0.01	166 (11)	0.05	77 (11)	0.11
Osteoarthritis	3,378 (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	2,420 (16)	378 (16)	0.46	234 (16)	0.95	109 (16)	0.76
Stroke	1,000 (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
Neurologic impairment	1,195 (8)	231 (10)	0.002	165 (11)	< 0.001	46 (7)	0.19
Chronic pain	6,742 (45)	1,061 (44)	0.24	658 (45)	0.64	290 (42)	0.09
Fall before 6 mo	3,835 (26)	508 (26)	0.98	275 (29)	0.07	169 (25)	0.46
Functional impairment (< 100)	1,886 (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)	10,105 (73)	932 (72)	0.50	243 (76)	0.20	468 (71)	0.25

*Because of the different numbers of missing values for each variable, the denominator may differ from total shown. †Missing survey variables include history of falls, quality of life, and perceived health. ‡Missing Barthel index variables include functional dependence, incontinence, and mobility issue.

ASA = American Society of Anesthesiologists; BMI = body mass index; IQR = interquartile range.