APPENDIX

Categories of Psychiatric Comorbidity with *ICD-9* Codes

Category 1	Psychotic Conditions
294.0	Amnestic syndrome
295.00-295.95	Schizophrenic Disorders
296.90. 296.99	Other unspecified affective psychoses
297.0-297.9	Paranoid states
298.0-298.9	Other nonorganic psychoses
299.0-299.91	Psychoses with origin specific to childhood

Category 2	Major Affective Disorders
296.2-296.26	Major Depressive Disorder, single episode
296.3-296.36	Major Depressive Disorder, recurrent
300.40	Neurotic depression (dysthymic disorder)
311	Depressive disorder, not elsewhere classified

Category 3	Bipolar Disorders
296.4-296.46	Bipolar affective disorder, manic
296.5-296.56	Bipolar affective disorder, depressed
296.6-296.66	Bipolar affective disorder, mixed
296.7	Bipolar affective disorder, unspecified
296.8-296.89	Manic depressive disorder, NOS
296.0	Manic disorder, single episode
296.1	Manic disorder, recurrent

Note: Adapted from Hanrahan (2002)

Extended Methods Section

This cross-sectional study included nurse survey, patient discharge, AHA Annual Survey, and PA Department of Health Facility Questionnaire data. This study received expedited approval from the Institutional Review Board of The University of Pennsylvania. Hospitals (n=157) were included in the analysis if: 1) the hospital had $\geq$ 100 surgical discharges during the window of observation, 2) hospital characteristic data could be obtained from the AHA and PA Department of Health surveys (20,21) 3) $\geq$ 10 staff nurses responded from the hospital to create reliable staffing and education estimates (6), and 4) $\geq$ 10 patients in the hospital had a diagnosis of serious mental illness on the surgical admission or upon a hospitalization within 90 days prior to the surgical admission.

Nurse survey data were collected by the Center for Health Outcomes and Policy Research through a mail survey of half of all licensed registered nurses in PA in 1999. The final response rate for the survey was 52%, for a total of 42,329 nurses. An average of 64 nurses responded from each hospital. Respondents were included in the study if they worked as a staff nurse in direct patient care. There were 9,989 nurses in the final sample. Patients aged 20-85 years with a diagnosis related group (DRG) for general, orthopedic, or vascular surgery between April 1, 1998, to November 30, 1999 were included in the analysis. The first admission for any of the specified DRGs for each patient was analyzed. These diagnoses and parameters were chosen specifically for the use of previously established risk adjustment models for these patients (13-15, 23-25). There were 228,433 patients in the final sample.

The nurse staffing measure (6) was created for each hospital by calculating the mean number of patients that nurses reported caring for on their last shift. Nurse responses were included in the staffing measure if their patient load included at least one, but no more than twenty patients. Aiken and colleagues (6) have found this measure of staffing to be more accurate than administrative sources, as these other sources often include non-staff nurses. The nurse education measure was calculated for each hospital as the proportion of nurses who reported their highest degree in nursing as a baccalaureate or higher.

Thirty-day mortality was defined as death within 30 days of admission. Failure-to-rescue is defined as a patient death following the development of a complication after surgery (8, 9, 19, 21, 28, 29). Complications were identified by scanning the secondary diagnosis and procedure fields in the patient discharge data for any one of the ICD-9 codes indicating the presence of an adverse event as defined by Silber and colleagues (9). Failure-to-rescue in surgical patients has been tested extensively and has well-established statistical properties for assessing the effect of organizational characteristics on patient outcomes (8, 9, 19, 21).Length of stay was extracted from a variable that indicates the number of days from the admission date to the discharge date for each patient.

Several hospital and patient characteristics were used for risk adjustment (6, 8, 10, 11). Hospital characteristics included teaching status, technology, size, and board certification

of surgeons. Patient characteristics included: age, sex, race, admission source, insurance status, surgery type and medical comorbidities (8, 10, 11). Surgery type was identified by the DRG code for the surgical admission and was indicated by a set of 48 dummy variables. Medical comorbidities were identified by ICD-9 codes in the secondary diagnosis fields as defined by Silber and colleagues (8, 9, 11, 21). The presence of a comorbidity was identified by a dummy variable. To aid in distinguishing comorbidities from complications, discharge records were examined for any hospitalizations 90 days prior to the surgical hospitalization to identify any overlapping medical comorbidities.

For this study, patients with serious mental illness (psychotic conditions, major affective disorders, and bipolar disorders) were identified through a classification system that cross-referenced ICD-9 and DSM-IV diagnoses (12). The original classification system was reviewed and validated by clinical experts. These diagnostic categories of serious mental illness were chosen based upon the limitations of discharge abstract data, in that the severity of recorded mental illnesses is not captured. Only the most chronic and disabling categories of serious mental illness according to the current literature were chosen for this study (22-24). Secondary diagnosis fields were searched for ICD-9 codes that indicated serious mental illness either on the surgical discharge record or on patients' previous discharge records 90 days prior to the surgical admission. Patient records were assigned a dummy variable indicating if any serious mental illness was present.

Frequency tables and chi-square tests were used for categorical variables and binary outcomes. Means, standard deviations and ranges were used to describe continuous variables. Patients with serious mental illness were identified and separate descriptive statistics were calculated. Interactions were tested among the independent variables. Statistical significance was set at $p<0.05$. SAS version 9.1 was used for data analyses. The effect of nurse staffing and educational levels on outcomes was examined with generalized estimating equations using PROC GENMOD to adjust for correlations among observations (25, 26). The models were adjusted for hospital and patient characteristics, as well as significant interactions. The effect of nurse staffing and educational levels on surgical patients with comorbid serious mental illness was analyzed through the creation of an interaction term between the serious mental illness dummy variable and each characteristic (serious mental illness *nurse staffing; serious mental illness *education level). Coefficients were transformed into odds ratios for each dichotomous outcome.

PROC GENMOD was used to model length of stay with the negative binomial distribution specified for the dependent variable due to its skewed form. Negative binomial regression produces more efficient estimates of coefficients and standard errors by adding a disturbance term to account for possible overdispersion, a frequent problem in clustered data (25). Estimates from the length of stay models were converted into percent changes for interpretation.

Supplemental References

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Supplemental Table

Characteristics of Surgical Patients in Sample (N=228,433)

Characteristic	SMI Patients (n=10,666) n	%	Non-SMI Patients (n=217,767) n	%
Age, mean ± SD **	60.0 ± 16.1		59.2 ± 17.0	
Men**	3,191	30.0	96,800	44.5
Race				
White**	8,601	80.6	171,228	78.6
Black**	627	5.9	15,055	6.9
Other*	1,438	13.5	31,484	14.5
Admission type				
Emergency**	3390	31.8	58,772	27.0
Transfer*	142	1.3	2,227	1.0
Insurance Type				
Public**	5799	54.4	96,236	44.2
Private **	4004	37.5	100,047	45.9
Other/Uninsured**	761	7.1	18,041	8.3
Unknown**	102	1.0	3,443	1.6
Selected Comorbidities [a]				
Stroke***	455	4.3	5,803	2.7
Hypertension***	3,812	35.7	68,225	31.3
Chronic lung disease***	1,165	10.9	17,187	7.9
Diabetes mellitus***	1,748	16.4	30,459	14.0
Hypothyroidism***	1,246	11.7	13,188	6.1
Electrolyte imbalance ***	955	9.0	14,730	6.8
Asthma***	678	6.4	7,252	3.3
Alcohol abuse ***	352	3.3	3,153	1.5
Drug abuse***	243	2.3	1,131	0.5
Dementia***	296	2.8	2,409	1.1

Note. Chi-square used to determine significance. For counts less than 5, Fisher's exact test used. T-test used for age.

[a] 28 comorbidities were measured in total.

***p<0.001 ** p <0.01 * p <0.05.