OSHPD Technical Note for Producing “Mortality Following Hip Fracture Repair in California Hospitals, 2012 – 2013”

Office of Statewide Health Planning and Development

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Acknowledgments

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Table of Contents

Background

This Technical Note summarizes how the 30-day risk-adjusted hospital mortality rates and quality ratings were calculated for hip fracture repair in California by the Office of Statewide Health Planning and Development (OSHPD). To make fair comparisons among different hospitals, OSHPD used a risk model to account for differences in patients' pre-operative risk of dying. Each hospital's risk-adjusted 30-day mortality rate was then compared with the statewide average, which serves as a performance benchmark. Hospitals are defined as "Better" if their risk-adjusted mortality rates were significantly lower than the statewide rate and "Worse" if their rates were higher.

Why the Mortality Outcome Was Selected

Thirty-day Risk-Adjusted Mortality Rate (RAMR) was used as the outcome because mortality can be reliably ascertained, and it is widely used in assessing the quality of provider medical care for many procedures and conditions. Providers that handle more complex cases receive a larger risk-adjustment weight in the risk model, while providers that handle less complex cases receive a smaller weight. Thus, hospitals treating sicker patients are not at a disadvantage when their performance is compared with other hospitals.

Use of 30-day mortality instead of in-hospital mortality avoids potential distortion of outcomes through hospital discharge practices and holds hospitals accountable for patients who died at home shortly after discharge or who were transferred and died in other facilities. Inpatient mortality alone may undercount deaths for hospitals that routinely transfer patients to other facilities post-surgery or discharge ill patients too early. This measure also provides a more consistent time frame given that the length of hospital stay varies across patients and types of hospitals. Deaths occurring beyond 30 days are less likely to be related to the care received in the hospital.

Data Sources

The primary data source for this report was the California Patient Discharge Data (PDD) routinely reported to OSHPD by all California-licensed hospitals. For this report, patients were selected from the 2012 and 2013 PDD using the methods described below. To identify deaths that occurred after discharge, the PDD was matched to California death certificate records (Death Statistical Master File) obtained from the California Department of Public Health using patient identifying information common to both datasets. A statistical algorithm based on social security number and other patient demographic information (birthdate, gender, ZIP code and race) was employed to identify matching patient records.

Selection of Hospitals

All state-licensed general acute care hospitals reporting patient discharge information to OSHPD were eligible for inclusion. There were 302 acute care hospitals treating hip fracture patients in the two year period of 2012-2013. Hospitals with only a small number of cases (less than 30) were included in most calculations but did not receive the performance ratings because such ratings would be less reliable. There were 55 hospitals with fewer than 30 hip fracture patients admitted to the hospital (Table 1). A total of 779 hip fracture patients were reported from these hospitals during the time period, and 42 patients died within 30 days of discharge.

In cases of hospital consolidation, name change, and change of address, the patient cases were attributed to the name of the hospital as of December 2013.

Table 1. Hospitals with Fewer than 30 Hip Fracture Repair Admissions during 2012-2013

County Name	Hospital Name	Hip Fracture Repair Cases	Hip Fracture Repair Deaths
Alameda	Alameda County Medical Center	27	1
	San Leandro Hospital	21	0
Butte	Biggs Gridley Memorial Hospital	10	2
Contra Costa	Contra Costa Regional Medical Center	14	0
Del Norte	Sutter Coast Hospital	3	0
El Dorado	Barton Memorial Hospital	27	0
Fresno	Fresno Surgical Hospital	2	0
Humboldt	Mad River Community Hospital	7	0
	Redwood Memorial Hospital	28	2
Inyo	Northern Inyo Hospital	22	2
Kern	Delano Regional Medical Center	29	0
	Kern Medical Center	27	4
	Ridgecrest Regional Hospital	25	1
Lassen	Banner Lassen Medical Center	4	0
Los Angeles	Bellflower Medical Center	6	0
	Tri-City Regional Medical Center – Hawaiian Gardens	13	1
	City of Hope Helford Clinical Research Hospital	2	0
	Community and Mission Hospital of Huntington Park – Slauson	7	0
	Los Angeles Community Hospital	7	0
	East Los Angeles Doctors Hospital	11	1
	Pacific Alliance Medical Center, Inc.	22	1
	East Valley Hospital Medical Center	7	1

County Name	Hospital Name	Hip Fracture Repair Cases	Hip Fracture Repair Deaths
Los Angeles (continued)	Southern California Hospital at Hollywood	3	0
	Memorial Hospital of Gardena	25	1
	Norwalk Community Hospital	17	0
	Pacific Hospital of Long Beach	18	1
	Silver Lake Medical Center – Downtown Campus	9	1
	Pacifica Hospital of the Valley	20	2
	Coast Plaza Hospital	14	1
	Temple Community Hospital	7	0
	Los Angeles Metropolitan Medical Center	3	0
	Los Angeles County/Rancho Los Amigos National Rehabilitation Center	1	0
	Keck Hospital of University of Southern California	14	1
Madera	Madera Community Hospital	20	3
Mendocino	Mendocino Coast District Hospital	25	3
Mono	Mammoth Hospital	13	0
Monterey	George L. Mee Memorial Hospital	10	0
	Natividad Medical Center	16	1
Orange	Chapman Medical Center	18	0
	Western Medical Center – Anaheim	6	0
	Huntington Beach Hospital	28	2
	Coastal Communities Hospital	12	1
Riverside	Temecula Valley Hospital	1	0
Sacramento	Sutter Memorial Hospital	2	0
San Benito	Hazel Hawkins Memorial Hospital	23	2
San Bernardino	Bear Valley Community Hospital	1	0
	Montclair Hospital Medical Center	9	1
	Community Hospital of San Bernardino	26	1
	Barstow Community Hospital	8	0

County Name	Hospital Name	Hip Fracture Repair Cases	Hip Fracture Repair Deaths
San Francisco	California Pacific Medical Center – Davies Campus	15	0
San Mateo	San Mateo Medical Center	18	1
Sonoma	Palm Drive Hospital	23	0
Stanislaus	Oak Valley District Hospital	26	1
Sutter	Sutter Surgical Hospital – North Valley	1	0
Tehama	Saint Elizabeth Community Hospital	26	3

Selection of Patients

To be included in this report, patients had to meet the following inclusion and exclusion criteria:

Inclusion Criteria

1) Admission date between January 1, 2012 and December 1, 2013
2) Age 65 years and older at admission
3) Type of care as "Acute Care"
4) Patients were included if either of two *diagnosis criteria* were met AND one *procedure criteria* was met (Table 2).
    a) *Diagnosis criteria*:
        i. Principal diagnosis of "Fracture of neck of femur (820.xx)" with secondary diagnosis not specified
        ii. Principal diagnosis of either "Other disorders of bone and cartilage (733.xx)" or "Open wound of hip and thigh (890.x)" with secondary diagnosis of "Fracture of neck of femur (820.xx)"
    b) *Procedure criteria*:
        i. Principal procedure or secondary procedure of either "Bone graft (78.xx)," "Reduction of fracture and dislocation (79.xx)," or "Joint replacement of lower extremity (81.5x)"

Exclusion Criteria

Patients were excluded if any of the following criteria were met (Table 3):

1) A principal E-code for "Late effect of Injury"
2) A principal or secondary procedure for "Revision of hip replacement"
3) A secondary diagnosis for: malignant neoplasm; late effect of musculoskeletal and connective tissue injuries; other disorders of bone and cartilage; fracture of other and unspecified parts of femur; complications peculiar to certain specified procedures; other orthopedic aftercare; fractures; intracranial injury, excluding those with skull fracture; trypanosomiasis; relapsing fever; crushing injury; injury to nerves and spinal cord; and certain traumatic complications and unspecified injuries
4) Unusable data for social security number and California residence

Table 2. Hip Fracture Repair Diagnoses and Procedures Included in the Analysis

ICD-9-CM Code	Principal Diagnosis	Secondary Diagnosis	Principal Procedure	Secondary Procedure
Diagnosis- Fracture of neck of femur (820.xx)				
820.00 Intracapsular section, unspecified	X			
820.01 Epiphysis (separation) (upper)	X			
820.02 Midcervical section	X			
820.03 Base of neck	X			
820.09 Other	X			
820.10 Intracapsular section, unspecified	X			
820.11 Epiphysis (separation) (upper)	X			
820.12 Midcervical section	X			
820.13 Base of neck	X			
820.19 Other	X			
820.20 Trochanteric section, unspecified	X			
820.21 Intertrochanteric section	X			
820.22 Subtrochanteric section	X			
820.30 Trochanteric section, unspecified	X			
820.31 Intertrochanteric section	X			
820.32 Subtrochanteric section	X			
820.8 Unspecified part of neck of femur, closed	X			
820.9 Unspecified part of neck of femur, open	X			
Diagnosis- Other disorders of bone and cartilage (733.xx)				
733.0 Osteoporosis	X			
733.00 Osteoporosis, unspecified	X			
733.01 Senile osteoporosis	X			
733.02 Idiopathic osteoporosis	X			
733.03 Disuse osteoporosis	X			
733.09 Other	X			
Diagnosis- Open wound of hip and thigh (890.x)				
890.0 Without mention of complication	X			
890.1 Complicated	X			
890.2 With tendon involvement	X			
Diagnosis- Fracture of neck of femur (820.xx)		X		
Procedure- Bone graft (78.xx) including: 78.55 Internal fixation of bone without fracture reduction (site femur)			X	X
Procedure- Reduction of fracture and dislocation (79.xx)				
79.05 Closed reduction of fracture without internal fixation (site femur)			X	X
79.15 Closed reduction of fracture with internal fixation (site femur)			X	X
79.25 Open reduction of fracture without internal fixation (site femur)			X	X
79.35 Open reduction of fracture with internal fixation (site femur)			X	X
79.45 Closed reduction of separated epiphysis (site femur)			X	X
79.55 Open reduction of separated epiphysis (site femur)			X	X
79.65 Debridement of open fracture site (site femur)			X	X
Procedure- Joint replacement of lower extremity (81.5x)				
81.51 Total hip replacement			X	X
81.52 Partial hip replacement			X	X

Table 3. Hip Fracture Repair E-Codes, Procedures and Diagnoses Excluded from Analysis

ICD-9-CM Code		Principal E-code	Secondary E-code
E929	Late effect of accidental injury	X	
E959	Late effect of self-inflicted injury	X	
E969	Late effect of injury purposely inflicted by other person	X	
E977	Late effect of injuries due to legal intervention	X	
E989	Late effect of injury, undetermined whether accidentally or purposely inflicted	X	
E999	Late effect of injury due to war operations and terrorism	X	
ICD-9-CM Code		**Principal Procedures**	**Secondary Procedures**
0.7	Revision of hip replacement, both acetabular and femoral components	X	X
0.71	Revision of hip replacement, acetabular component	X	X
0.72	Revision of hip replacement, femoral component	X	X
0.73	Revision of hip replacement, acetabular liner and/or femoral head only	X	X
81.53	Revision of hip replacement, not otherwise specified	X	X
ICD-9-CM Code		**Principal Diagnosis**	**Secondary Diagnosis**
170	Malignant neoplasm of bone and articular cartilage		X
196	Secondary and unspecified malignant neoplasm of lymph nodes		X
197	Secondary malignant neoplasm of respiratory and digestive systems		X
198	Secondary malignant neoplasm of other specified sites		X
733.4	Aseptic necrosis of bone, site unspecified		X
733.42	Head and neck of femur		X
733.8	Malunion and nonunion of fracture		X
733.81	Malunion of fracture		X
733.82	Nonunion of fracture		X
800	Fracture of vault of skull		X
801	Fracture of base of skull		X
802	Fracture of face bones		X
803	Other and unqualified skull fractures		X
804	Multiple fractures involving skull or face with other bones		X
805	Fracture of vertebral column without mention of spinal cord injury		X
806	Fracture of vertebral column with spinal cord injury		X
821	Shaft or unspecified part, closed		X
821.01	Shaft		X
821.1	Shaft or unspecified part, open		X
821.11	Shaft		X
821.2	Lower end, closed		X
821.3	Lower end, open		X
850	Concussion		X
851	Cerebral laceration and contusion		X
852	Subarachnoid, subdural, and extradural hemorrhage, following injury		X
853	Other and unspecified intracranial hemorrhage following injury		X
854	Intracranial injury of other and unspecified nature		X
86	Trypanosomiasis		X
87	Relapsing fever		X
905.3	Late effect of fracture of neck of femur		X
925	Crushing injury of face, scalp, and neck		X
926	Crushing injury of trunk		X
927	Crushing injury of upper limb		X
928	Crushing injury of lower limb		X
929	Crushing injury of multiple and unspecified sites		X

ICD-9-CM Code		Principal Diagnosis	Secondary Diagnosis
952	Spinal cord injury without evidence of spinal bone injury		X
953	Injury to nerve roots and spinal plexus		X
954	Injury to other nerve(s) of trunk, excluding shoulder and pelvic girdles		X
958	Certain early complications of trauma		X
959	Injury, other and unspecified		X
996.42	Dislocation of prosthetic joint		X
996.43	Prosthetic joint implant failure		X
996.44	Peri-prosthetic fracture around prosthetic joint		X
V54.13	Aftercare for healing traumatic fracture of hip		X
V54.14	Aftercare for healing traumatic fracture of leg, unspecified		X
V54.23	Aftercare for healing pathologic fracture of hip		X
V54.24	Aftercare for healing pathologic fracture of leg, unspecified		X
V54.81	Aftercare following joint replacement		X
V54.89	Other orthopedic aftercare		X

How Were the 30-Day Hospital Risk-Adjusted Mortality Rates and Quality Ratings Calculated?

The Risk-Adjusted Mortality Rate (RAMR) represents the best estimate of what a hospital's mortality rate would have been if the hospital had a patient case mix identical to the statewide average. Thus, this rate is comparable among hospital providers because it accounts for differences in patient severity-of-illness.

A risk-adjustment model for estimating 30-day postoperative hip fracture mortality was originally developed by Grace Carter and colleagues at RAND[1]. A validation study, "Validation of 30-Day Mortality after Hip Fracture Repair as a Potential Quality Measure for Public Reporting" was later produced by a UC Davis research team in collaboration with OSHPD, the former AB 524 Technical Advisory Committee, and a Clinical Advisory Panel created specifically for this project. A multivariable logistic regression model was used to calculate the mortality rates adjusted for the patient's demographic and pre-operative risk factors. More detailed information, including the methodology for selecting risk factors and assessing data validity and risk model performance, can be found in the validation study.

The calculation of observed rates, expected rates, risk-adjusted rates and statistical outliers are described below to help explain the process of generating the risk-adjusted rates and quality ratings.

Calculation of Observed Rates

Numerator – The number of hip fracture repair deaths that occurred within 30 days after admission for surgery, whether in the hospital or not.

Denominator – The number of hip fracture repair cases meeting inclusion and exclusion criteria.

[1] Carter GM. A Risk Adjusted Model for Mortality Following Surgery for Hip Fracture. Los Angeles, CA: RAND; 1998. http://www.rand.org/pubs/drafts/2008/DRU1871.pdf.

Observed Rates – The number of patient deaths that occur within the patients admitted to the hospital for hip fracture repair. Observed mortality rate equals the number of hip fracture repair deaths divided by the number of hip fracture repair cases multiplied by 100.

Calculation of Expected Rates

To create risk-adjusted rates, the first step is to estimate how many people would be expected to die in a particular hospital if they had a mix of patients that was comparable to the state average hospital.

Step 1: Select Risk Factors to Predict 30-Day Death

Risk factors are patient characteristics observed at the time of admission that may influence the patient's 30-day mortality rates. Three types of risk factors were considered in the risk-adjusted model: demographic characteristics, hospitalization characteristics, and medical conditions or clinical risk factors. Table 6 shows the prevalence, parameter estimates and odds ratio (OR) estimates of risk factors included in the risk model.

Step 2: Calculate Predicted Probability of Death from Logistic Regression Model

The logistic regression model was built to predict 30-day probability of death for hip fracture patients using 2012-2013 PDD data. See the validation study for the details. The expected mortality rates of patients were obtained directly from the model output.

Calculation of Risk-Adjusted Rates

The risk-adjusted rates were calculated using observed and expected mortality rates available for each hospital. A hospital's quality of care can be assessed by comparing the difference between observed and expected rates. The RAMR at a hospital equals the State Observed Rate, multiplied by the ratio of the number of observed deaths to the number of expected deaths at that hospital (Observed Deaths/Expected Deaths or O/E ratio). The O/E ratio provides a transparent and easy-to-understand assessment of that hospital's performance. If the O/E ratio is greater than one, the hospital has a higher mortality than expected based on patient case mix. If the O/E ratio is less than one, the hospital has a lower mortality rate than expected.

Calculation of Performance Rating

The performance rating is based on a comparison of the 98% confidence interval (CI) of each hospital's RAMR to the statewide mortality rate.[1,2] OSHPD employed the exact method in calculating CIs to provide more conservative estimates for hospitals with relatively few expected deaths. If the entire 98% CI of a hospital's risk-adjusted mortality is below the state average mortality rate, indicating the hospital's RAMR is significantly lower than the state average, the performance rating is "Better." If the entire 98% CI of a hospital's RAMR is above the state average mortality rate, indicating the hospital's risk-adjusted mortality is significantly higher than

[1] The Poisson Exact Probability method is used for computing the 98% confidence interval for the risk-adjusted mortality rate (Buchan Iain, *Calculating Poisson Confidence Interval in Excel*, January 2004).

[2] Luft HS, Brown BW Jr. Calculating the probability of rare events: Why settle for an approximation? *Health Services Research.* 1993; 28:419-439.

the state average, the performance rating is “Worse.” If the state average mortality rate is within the 98% CI of a hospital’s RAMR, the performance rating is “Not Different” from the statewide average and is left blank.

Whether the hospital’s performance rating is significantly lower or higher than the state average depends on three factors: the number of hip fracture repair patients treated at the hospital, the size of the difference between the hospital’s risk-adjusted mortality rate and the statewide benchmark, and the confidence level selected for the test.

For this report, a 98% confidence interval (p=0.02) was used as a conservative benchmark to compare a hospital’s RAMR to the state average mortality rate[1]. Commonly, p-values of less than 0.05 are considered statistically significant. The smaller the p-value, the larger the confidence interval and the larger the probability it will include the state average and thus result in the hospital’s RAMR being not significantly different from the state average.

Hospital volume is important in determining statistical significance of results. For hospitals with large numbers of hip fracture repair patients the confidence interval will be narrow. As a result, moderate or even small-sized differences between the hospital’s RAMR and the statewide rate may be significant.

For hospitals with a small number of hip fracture repair cases, the confidence interval is usually much wider. This means that the difference between the hospital’s RAMR and the state average must be considerably larger for a hospital’s RAMR to be significantly different from the state average.

Patient Demographic and Hospitalization Characteristics

Approximately three out of four patients included in this analysis were female (71.51%). Most patients were White non-Hispanic (76.37%) followed by Hispanic (11.60%), Asian/Pacific Islander (6.86%), and Black (2.24%). The average age was 82.98 years, with most patients 85 to 94 years old (42.22%), followed by 75 to 84 years old (34.83%), and 65 to 74 years old (17.39%) (Table 4).

Most patients (77.74%) had no previous admissions in the previous 12 months, followed by patients who had 1 previous admission (13.66%), 2 previous admissions (4.98%), and 3 or more (3.63%) (Table 5).

The average length of stay was 5.17 days, with most patients having a length of stay of 4 to 7 days (58.94%), followed by 1 to 3 days (28.36%), up to 2 weeks (10.62%), and those more than 2 weeks (2.08%) (Table 5).

Eighty-four percent of patients were admitted from home, followed by admission from skilled nursing/intermediate care facilities (4.63%), and residential care facilities (4.39%) (Table 5). Almost all patients had an unscheduled admission (97.48%), and Medicare was the primary expected source of payment (90.94%) (Table 5).

[1] Luft HS, Brown BW Jr. Calculating the probability of rare events: Why settle for an approximation? *Health Services Research.* 1993; 28:419-439.

Table 4. Demographic Characteristics of Hip Fracture Repair Patients

Variable	Admission Year PDD					
	2012		2013		2012-2013	
	N	Percent	N	Percent	N	Percent
Total Patients	19,75	100.00	18,43	100.00	38,18	100.00
Gender						
Female	14,16	71.69	13,14	71.31	27,30	71.51
Male	5,593	28.31	5,287	28.69	10,88	28.49
Race / Ethnicity						
White	15,13	76.61	14,02	76.12	29,16	76.37
Hispanic	2,228	11.28	2,202	11.95	4,430	11.60
Asian / Pacific Islander	1,389	7.03	1,229	6.67	2,618	6.86
Black	438	2.22	418	2.27	856	2.24
Native American / Eskimo / Aleut	35	0.18	35	0.19	70	0.18
Other / Unknown	530	2.68	517	2.81	1047	2.74
Age at Admission						
Age 65-74	3,379	17.11	3260	17.69	6,639	17.39
Age 75-84	6,926	35.06	6,375	34.59	13,30	34.83
Age 85-94	8,322	42.13	7,797	42.31	16,11	42.22
Age 95 and older	1,126	5.70	998	5.42	2,124	5.56

Table 5. Hospitalization Characteristics of Hip Fracture Repair Patients

Variable	Admission Year PDD					
	2012		2013		2012-2013	
	N	Percent	N	Percent	N	Percent
Total Patients	19,753	100.00	18,430	100.00	38,18	100.00
Prior Discharges Last 12 Months						
None	16,397	83.01	13,288	72.10	29,68	77.74
One	2,196	11.12	3,021	16.39	5,217	13.66
Two	749	3.79	1,153	6.26	1,902	4.98
Three	230	1.16	510	2.77	740	1.94
Four or more	181	0.92	458	2.49	639	1.67
Length of Stay						
Zero to Three Days	5,481	27.75	5,347	29.01	10,82	28.36
Four to Seven Days	11,772	59.60	10,734	58.24	22,50	58.94
Seven to Fourteen Days	2,083	10.55	1,972	10.70	4,055	10.62
Greater than Fourteen Days	417	2.11	377	2.05	794	2.08
Source of Admission						
Home	16,642	84.25	15,561	84.43	32,20	84.34
Skilled Nursing/Intermediate Care	927	4.69	839	4.55	1,766	4.63
Residential Care Facility	899	4.55	776	4.21	1,675	4.39
Acute Inpatient Hospital Care	497	2.52	436	2.37	933	2.44
Other Inpatient Hospital Care	94	0.48	90	0.49	184	0.48
Ambulatory Surgery	43	0.22	13	0.07	56	0.15
Other / Unknown	651	3.30	715	3.88	1,366	3.58
Type of Admission						
Unscheduled	19,320	97.81	18,024	97.80	37,34	97.80
Scheduled	429	2.17	402	2.18	831	2.18
Other/Unknown	4	0.02	4	0.02	8	0.02
Expected Source of Payment						
Medicare	18,196	92.12	16,981	92.14	3,517	92.13
Private Coverage	962	4.87	877	4.76	1,839	4.82
Medi-Cal	403	2.04	382	2.07	785	2.06
Self Pay	61	0.31	46	0.25	107	0.28
Other	131	0.66	144	0.78	275	0.72

Hip Fracture Repair Risk Model

Risk factors are patient characteristics observed at the time of admission that may influence the patient's 30-day mortality outcome. Hospitals with a higher percentage of patients who have these risk factors (i.e., hospitals with a high risk case-mix) will generally have higher mortality rates, regardless of the quality of care received.

Three types of patient risk factors were considered: demographic characteristics, hospitalization characteristics, and medical conditions or clinical risk factors.

Clinical risk factors were provided by the validation study, which included a review of the medical literature, input from a clinical advisory panel, and empirical analyses of the PDD for hip fracture repair patients. Table 6 shows prevalence, parameter estimate and standard error, odds ratio (OR), and odds ratio 95% confidence intervals for risk factors included in the 30-day mortality model.

The most prevalent clinical risk factors were pertrochanteric fracture (50.10%), followed by dementia/delirium (31.00%), chronic renal failure (23.58%), atrial fibrillation (20.78%), congestive heart failure (17.64%), and chronic obstructive pulmonary disorder (16.94%) (Table 6).

Age at admission, prior discharges (within last twelve months), and their interaction were included as categorical variables in the risk-adjusted model. There was a significant increase in risk of mortality (odds ratio) for each of three age groups. Risk of mortality also increased sharply with age from 1.65 (age 75 to 84), to 3.30 (age 85 to 94) and further to 5.19 (age 95 and older).

Risk of mortality (odds ratio) increased 60% for prior discharges (OR 1.60), yet the interaction of older age with prior discharges was generally a protective factor (Table 6). Males had a significantly increased mortality risk of 91% (OR 1.91).

For clinical risk factors, there was a significant increase in risk of mortality for dementia/delirium (OR 2.01), congestive heart failure (OR 1.78), chronic obstructive pulmonary disorder (OR 1.65), cancer (OR 1.98), fall from bed or chair (OR 1.55), chronic renal failure (OR 1.33), atrial fibrillation (OR 1.29), additional fracture (OR 1.44), valvular heart disease (OR 1.24), and pertrochanteric fracture (OR 1.17). Accident, assault, injury or fall is a protective factor (OR 0.58).

Admission from skilled nursing or intermediate care did not affect mortality risk with an odds ratio of 1.20 and a p-value of 0.042. Only 4.63% of hip fracture repair patients were admitted from skilled nursing or intermediate care. Most patients were admitted from their home (84%).

Other risk factors that did not affect risk of mortality include patients having diabetes with complications. Only 8.05% of hip fracture repair patients have diabetes with complications.

This report showed that males have a significant increase in mortality risk, which is supported by other studies. Sterling (2011) [1] recently reviewed the gender difference in hip fracture incidence and mortality. He reported that men with hip fracture were younger than women by three to six years at the time of fracture, but men had more complications than women.

[1] Sterling RS. Gender and Race/Ethnicity Differences in Hip Fracture Incidence, Morbidity, Mortality, and Function. *Clinical Orthopaedic Related Research* 2011; 469:1913-1918.

Men with hip fracture have a significantly higher mortality rate than women (OR 1.91). Sterling showed that the mortality rate within a year after hip fracture in men ranged from 9.4% to 37.1%, while women had a range of 8.2% to 12.4%.

The OSHPD hip fracture repair risk model is supported by other studies. A recent review paper[1] summarized the most common and strongest predicators for hip fracture mortality. Twelve significant risk factors were identified, which match most of the risk factors in our risk model.

Table 6. Risk Factors in Hip Fracture Repair 30-Day Mortality Model

Risk Factor	Prevalence	Parameter Estimate	Standard Error	P Value	Odds Ratio	Odds Ratio 95% CI	
Intercept		-4.8487	0.1209	<.0001			
Age 75-84	34.83%	0.4994	0.1270	<.0001	1.65	1.29	2.11
Age 85-94	42.22%	1.1943	0.1202	<.0001	3.30	2.61	4.18
Age 95 and older	5.56%	1.6476	0.1410	<.0001	5.19	3.94	6.85
Prior Discharge Last 12 Months	22.26%	0.4727	0.1801	0.0087	1.60	1.132	2.28
Age 75-84*Prior Discharges	7.97%	-0.1813	0.1940	0.3500	0.83	0.57	1.221
Age 85-94*Prior Discharges	9.20%	-0.6011	0.1843	0.0011	0.55	0.389	0.79
Age 95 and older Prior Discharges	1.02%	-0.5327	0.2434	0.0286	0.59	0.367	0.95
Male	28.49%	0.6464	0.0578	<.0001	1.91	1.70	2.14
Male Prior Discharges	7.37%	-0.2797	0.1042	0.0073	0.76	0.62	0.93
Dementia/Delirium	31.00%	0.6961	0.0484	<.0001	2.01	1.82	2.21
Congestive Heart Failure	17.64%	0.5736	0.0560	<.0001	1.78	1.59	1.98
Chronic Obstructive Pulmonary Disorder	16.94%	0.4996	0.0557	<.0001	1.65	1.48	1.84
Cancer	2.41%	0.6852	0.1114	<.0001	1.98	1.60	2.47
Fall from Bed or Chair	7.25%	0.4387	0.0721	<.0001	1.55	1.35	1.79
Chronic Renal Failure	23.58%	0.2883	0.0530	<.0001	1.33	1.20	1.48
Atrial Fibrillation	20.78%	0.2565	0.0535	<.0001	1.29	1.16	1.44
Additional Fracture	5.38%	0.3614	0.0925	<.0001	1.44	1.20	1.72
Valvular Heart Disease	11.42%	0.2149	0.0636	0.0007	1.24	1.10	1.40
Admission from Skilled Nursing / Intermediate Care	4.63%	0.1837	0.0904	0.0422	1.20	1.01	1.44

[1] Fangke H., Chengying J., Shen J., Tang P., Wang Y. Preoperative predictors for mortality following hip fracture surgery: A systematic review and meta-analysis. *Injury* 2012; 43; 676-685.

Risk Factor	Prevalence	Parameter Estimate	Standard Error	P Value	Odds Ratio	Odds Ratio 95% CI	
Pertrochanteric Fracture	50.10%	0.1594	0.0467	0.0006	1.17	1.07	1.29
Diabetes with Complications	8.05%	-0.0453	0.0874	0.6042	0.96	0.81	1.13
Accident, Assault, Injury or Fall	2.36%	-0.5475	0.2260	0.0154	0.58	0.37	0.90

Risk Model Validation

For this report, validity is defined as how well the risk model controls for differences in patient characteristics that would otherwise confound risk-adjusted 30-day mortality (outcome) comparisons across hospitals. Not controlling for such differences can generate biased and misleading estimates of mortality rates. Validation was assessed in two ways: discrimination using the "C" statistic, and calibration using the Hosmer and Lemeshow Goodness-of-Fit test.

Discrimination

Risk models that distinguish well between patients who die and those who survive are said to have good discrimination. A commonly used measure of discrimination is the C-statistic, also known as the area under the Receiver Operating Characteristic (ROC) curve. For all possible pairs of patients, where one dies and the other survives surgery, the C-statistic describes the proportion of pairs where the patient who died had a higher predicted risk of death than the patient who lived. C-statistics range from 0.5 to 1.0 with higher values indicating better discrimination.

The C-statistic for the 2012-2013 risk model was 0.740, which is considered very good discrimination. The C-statistic reported in the validation study was 0.716. The validation study also found that if re-abstracted ICD-9-CM codes, and clinical variables instead of originally coded OSHPD ICD-9-CM codes are used in the risk model, the C-statistic increased from 0.716 to 0.746 (Table 7). In other words, clinical data increased the percentage of randomly selected, paired hip fracture deaths and survivors who would be correctly "predicted" or classified by the model from 71.6% to 74.6%. However, the medical reporting system has improved significantly since the validation study was conducted, especially in the coding of data elements such as present-on-admission. In addition, hospitals are capturing patient information more accurately and more completely than in the past, partly due to the growth in electronic medical records. Without using additional clinical information, the C-statistic for 2012-2013 data is similar to the C-statistic of 0.746 in the validation study with clinical variables used.

Table 7. Discrimination and Calibration Statistics for Risk Model

Number of Cases	38,183
Number of Deaths	2,057
Statewide 30-Day Death Rate	5.39
<u>C-Statistic (Discrimination)</u>	
Present Study of 2012-2013 Hip Fracture Repair	0.740
Validation Study – OSHPD ICD-9-CM codes	0.716
Validation Study – Re-abstracted ICD-9-CM codes	0.698
Validation Study – Clinical Variables	0.732
Validation Study – Re-abstracted ICD-9-CM codes plus clinical variables	0.746
<u>Hosmer and Lemeshow Goodness-of-Fit Statistic (Calibration)</u>	
Estimate	40.470
P-value	<0.0001

Calibration

Calibration refers to the ability of a risk model to match predicted and observed mortality across the entire spectrum of data. A model in which the number of observed deaths matches closely with number of deaths predicted by the model demonstrates good calibration. Good calibration is essential for accurate risk adjustment.

A common measure of calibration is the Hosmer-Lemeshow Chi-Square test, which compares observed and predicted outcomes over deciles of risk. The p-value of the Hosmer-Lemeshow test statistic for 2012-2013 risk model was <0.0001 indicating a significant likelihood of poor calibration.

Another way to measure model calibration is to partition the data and compare observed deaths with predicted deaths in each of 10 risk groups (Table 8). The 10 risk groups are created by sorting all observations by predicted risk of death and then dividing the sorted observations into deciles of approximately equal size. Risk Group 1 shows patients in the lowest risk group. Among the 4,244 patients in this group, 25 died, but the model predicted 43 deaths.

Table 8. Calibration of 2012-2013 Risk Model for 30-Day Mortality

Risk Group	Hip Fracture Repair Cases (a)	Observed Deaths (b)	Predicted Deaths (c)	Difference (c) - (b)	95% CI of Predicted Deaths
1	4244	25	43.52	18.52	(30.59, 56.45)
2	3819	52	59.25	7.25	(44.16, 74.34)
3	4040	79	92.24	13.24	(73.42, 111.06)
4	3817	104	107.84	3.84	(87.49, 128.19)
5	3818	122	135.25	13.25	(112.46, 158.04)
6	3818	194	175.91	-18.09	(149.91, 201.91)
7	3819	211	215.92	4.92	(187.12, 244.72)
8	3815	340	276.91	-63.09	(244.29, 309.53)
9	3818	420	383.85	-36.15	(345.45, 422.25)
10	3175	510	566.32	56.32	(519.68, 612.96)
Total	38,183	2,057	2057.0	0	

Looking at the calibration results (Table 8) by risk group we find that the risk model over-predicts mortality risk somewhat for most of the lower risk groups (1 to 5), and under-predicts mortality risk for most of the higher risk groups (6, 8, 9), though the relative differences are not very large. This means that the risk model may over-compensate hospitals with mostly lower-risk patients and slightly under-compensate hospitals with higher risk patients. However, the amount of discrepancy between observed and predicted deaths in the highest risk patients is relatively small, and the risk model does accurately compensate hospitals for patients in the highest risk decile (10), where the actual mortality rate is quite high. Overall, the calibration results do not suggest a large bias towards hospitals with either lower or higher than average patient case mix.

Limitations of Data and Risk Model

The preferred approach to producing hospital outcome reports includes the collection of detailed clinical data to provide accurate risk adjustment.[1] Absent electronic medical records, this approach requires medical chart abstraction, which is expensive; consequently, it has not been widely implemented by public reporting agencies. Using health insurance claims or administrative data for public outcomes reporting offers several advantages, including minimal data collection costs and the ability to produce reports for a large number of procedures and conditions. However, most risk-adjusted outcome measures based on administrative data, when compared to their clinical data counterparts, are somewhat less valid measures of healthcare quality and should not be considered *de facto* gold standards.

[1] Parker JP, Li Z, Damberg CL, Danielsen B, Carlisle DM. Administrative Versus Clinical Data for Coronary Artery Bypass Graft Surgery Report Cards, The View From California. *Medical Care* 2006; 44.

Types of Data Quality Errors

Quality of care is one reason a hospital's mortality rate may be unusually high or low. However, there are additional factors that may contribute to a hospital's 30-day mortality rate. Additional factors might include known hospital data errors and unknown or not-measured data errors such as unmeasured risk and a limited outcome measure.

Hospital data errors

Hospitals that failed to report important risk factors or had other data quality problems could have received too little "credit" for their patient risk in the risk-adjustment process. Some facilities have applied for and have been granted "modifications" to standard inpatient data reporting requirements. Other facilities were unable to complete specific fields as required and were deemed "non-compliant" at the time of reporting. OSHPD provides a list of known data errors and their affected variables for facilities with approved modifications, and non-compliant facilities.

Unmeasured risk

Administrative datasets provide limited data, based on ICD-9-CM codes, to characterize a patient's risk of death. This includes data errors for both known risk factors and unknown risk factors. For known risk factors, unmeasured risk may be in the form of hospitals incorrectly reporting ICD-9-CM codes in the patient discharge data records. An empirical analysis was performed to identify hospitals who submitted extreme values of "present-on-admission" data as either 100% or 0% of their medical records. These records were reviewed for inclusion in the hip fracture repair study.

In addition, unknown risk factors *not reported* in the patient discharge data records may also account for unmeasured patient risk differences not explained by the current model.

Limited outcome measure

This report focuses on a single outcome measure: 30-day mortality. If a hospital's risk-adjusted 30-day postoperative hip fracture repair mortality rate is a valid quality of care indicator, then hospitals with low rates are managing their patients in ways that maximize the likelihood of successful outcomes. These management practices are also known as processes of care, because they describe the process by which nurses, physicians, and other health professionals provide care at the bedside. Other processes of care include a patient's quality of life after discharge, complications post-surgery, or likelihood of having subsequent hospital readmissions. Additional research is needed to obtain a more complete assessment of treatment quality that would include additional outcomes as well as important process-of-care measures.

A validation study was conducted to examine all three types of data quality errors. Highlights are presented below.

Validation Study Results

A validation study was conducted by a UC Davis research team in collaboration with OSHPD staff, the former AB 524 Technical Advisory Committee, and a Clinical Advisory Panel created specifically for this project. This study was designed to address a variety of concerns about the validity of using hospital-reported ICD-9-CM diagnosis and procedure codes in the PDD to report publicly on hospital performance. The study provided the risk-adjustment model used in this report including methodology for selecting risk factors, calculating the outcome measure, and testing the validity of risk model results.

The original methodology for estimating risk-adjusted 30-day postoperative hip fracture repair mortality was developed by Grace Carter and colleagues at RAND, using data from the PDD. This developmental work is fully described in a separate report.[1] The validation study updates the analysis performed by RAND and validates their methods using data from the PDD.

"Validation of 30-Day Postoperative Mortality after Hip Fracture Repair as a Potential Quality Measure for Public Reporting" is available on the OSHPD website: http://www.oshpd.ca.gov. Key information regarding the validation study methodology and findings is presented below.

Validation Study Methodology

The primary purpose of the validation study was to evaluate the impact of errors in hospitals' reporting of risk factors and unmeasured risk factors, on hospital risk-adjusted outcome rates.

The validation study was also designed to provide information about whether differences in process of care measures explain, in part, observed differences in risk-adjusted outcomes. To the extent that there are strong associations between process measures and risk-adjusted outcome measures, we become more confident that the outcome measures describe true quality of care.

The basic design was a retrospective cohort study of elderly patients who were admitted to acute care nonfederal hospitals in California for hip fracture, and who underwent surgical repair during that hospitalization. These patients were followed for 30 days after admission to ascertain all deaths, using OSHPD's PDD linked Vital Statistics death records. Hospitals and cases within hospitals were randomly sampled using a two-stage, stratified cluster method. To ensure sufficient statistical power to answer research questions, the study oversampled hospitals with lower or higher than expected death rates, and patients who died.

Based on a comprehensive review of the existing literature and with input from an interdisciplinary Clinical Advisory Panel, the authors developed an abstraction and recording instrument that was programmed for direct computer data entry. The clinical abstractors were either registered nurses or health professional students working under the direct supervision of a registered nurse. Clinical abstractors were tested and carefully monitored; at least 5% of the records were over-read by two abstractors to ensure more than 95% agreement throughout the project.

[1] Carter GM. A Risk Adjusted Model for Mortality Following Surgery for Hip Fracture. Los Angeles, CA: RAND; 1998. http://www.rand.org/pubs/drafts/2008/DRU1871.pdf; accessed December 1, 2008.

Validation Study Findings

Key findings of the validation study include:

1) *OSHPD's Patient Discharge Data may be used to identify acute hip fractures and treatment among elderly patients.*

   The authors received 1,007 of the 1,047 records requested from participating hospitals. Only six of these records did not meet the study's inclusion criteria because of incorrect or incomplete coding or because of the timing of the hip fracture.

2) *Risk factors in the risk adjustment models, including present-on-admission, using California patient discharge data are valid measures of patient mortality.*

   Overall, nearly a quarter of hip fractures statewide had one or more omitted (false negative) risk factors in the 30-day mortality model. Conversely, about 16% of hip fractures had one or more unconfirmed (false positive) risk factors. Most risk factors included in the model were found to be moderately sensitive (>73%) and predictive (>72%). With two exceptions (i.e., complicated diabetes, high-risk cancer), present-on-admission coding of risk factors included in the 30-day mortality model was also valid, with at least 90% agreement between original and recoded data.

3) *There was no significant difference in the coding of important risk factors when comparing hospitals with significantly fewer deaths than expected, hospitals with significantly more deaths than expected, and hospitals that were not outliers.*

   The validation study found several statistically significant differences in reporting of individual risk factors between hospitals with more deaths than expected and hospitals with fewer deaths than expected, but no consistent pattern. In addition, substituting recoded data for the originally submitted hospital in the multivariate model to estimate mortality risk had only a modest impact. Therefore, the authors concluded that differential reporting of risk factors in OSHPD's PDD accounts for little of the observed variation in risk-adjusted mortality rates across hospitals. Furthermore, there was little evidence of systematic under-reporting or over-reporting of coded risk factors across risk-adjusted mortality strata.

4) *Adding clinical risk factors would significantly improve the performance of risk-adjustment models for 30-day mortality after hip fracture, using either the ICD-9-CM diagnoses reported to OSHPD or recoded diagnoses.*

   Adding several clinical data elements abstracted from medical records modestly improved the predicted performance of risk-adjustment models for 30-day mortality, at both the patient and hospital levels. These clinical data elements include tachycardia (high heart rate) at admission, hypothermia (low temperature) at admission, hypokalemia (low serum potassium), leukocytosis (high white blood cell count), and compromised ambulation prior to admission. Past history of diabetes mellitus was also an independent predictor of mortality. Overall, adding information from clinical abstraction of medical records improved the discrimination of predictive models for 30-day mortality from c=0.716 to c=0.746. Adding these clinical risk factors, and substituting recoded data for OSHPD-reported ICD-9-CM codes, helped to explain higher risk-adjusted mortality at some, but not all, high-mortality outlier hospitals. However, the OSHPD model based on originally submitted hospital data did accurately identify low-mortality outlier hospitals.

5) *Meaningful differences were found in processes of care between hospitals with fewer deaths than expected and hospitals with more deaths than expected.*

   If a hospital's risk adjusted 30-day postoperative hip fracture mortality rate is a valid quality indicator, then hospitals with low rates are managing their patients in ways that maximize the likelihood of successful outcomes. These management practices are also known as processes of care, because they describe the process by which nurses, physicians, and other health professionals provide care at the bedside. Some processes of care differed across risk-adjusted mortality strata, and nearly all of these differences were in the expected direction, but none reached statistical significance. For example, prophylactic antibiotics were administered within the optimal time window (0-2 hours before start of surgery) to 54% of eligible hip fracture patients at high-mortality outlier hospitals, 65% of eligible hip fracture patients at non-outlier hospitals, and 67% of eligible patients at low-mortality outlier hospitals. Adding these measurable process factors to the risk-adjustment model for 30-day mortality improved model performance (e.g., C-statistic increased from 0.746 to 0.788) at the patient level, but did not significantly improve the model's ability to explain hospital outcomes. In other words, the observed differences in processes of care, such as use and timing of prophylactic antibiotics, across hospital mortality strata were too small to explain differences in risk-adjusted mortality.

Relationship Between Processes of Care and Outcomes

Since the validation study for this report was completed, new evidence has emerged that shows patient care can affect inpatient mortality, complications, and improve quality of life during rehabilitation. In the largest systematic review of the literature to date, the authors found that delays in surgery beyond 48 hours significantly increased the odds of both 30-day and one-year mortality in hip repair patients. In another study, surgical delays beyond 48 hours were associated with a doubling in the number of complications including pressure ulcers, pneumonia, urinary tract infections, deep vein thrombosis and pulmonary embolism.

In addition to surgical timing, recent evidence has also resulted in best practice recommendations in areas including thromboprophylaxis, anesthesia, prophylactic antibiotics, surgical fixation of fractures, and mobilization. The UK-based National Institute for Health and Care Excellence has included many of these evidence-based recommendations in their guide "Management of hip fracture in adults."[1] This report emphasizes patient-centered integrated care and timing of surgery. It recommends that services and resources should be organized to maximize their ability to ensure that patients receive surgery as soon as possible, within safe operating hours (including weekends) after presenting at a hospital with hip fracture. The Joint Commission's Surgical Care and Improvement Project's standards, aimed at preventing surgical complications such as infection, are clearly applicable to hip fracture repair and supported by

[1] National Institute for Health and Clinical Excellence. The Management of Hip Fracture in Adults: NICE Clinical guideline 124, June 2011, guidance.nice.org.uk/cg124.

evidence-based research.[1] In summary, the existing current clinical literature supports the contention that better hospital care can lead to better patient outcomes, so these outcome data appear to be actionable.

Related Hip Fracture Mortality Measures

The Agency for Healthcare Research and Quality (AHRQ) has developed two Inpatient Quality Indicators (IQIs) related to hip fracture, and these are currently reported in national publications and by a number of states. The indicators are hip fracture mortality rate and hip replacement mortality rate.

The AHRQ hip fracture inpatient mortality measure includes patients at least 65 years old, with a principal diagnosis of *fracture of neck of femur* (820.xx) and provides a risk-adjusted rate based on inpatient mortality. It is included in the Hospital Inpatient Mortality Indicators for California report published by OSHPD. Nearly 90% of the patients included in the ARHQ measure are also included in the OSHPD measure. Some of the key differences between the two measures are OSHPD's requirement that a hip surgical repair be performed, use of 30-day mortality as opposed to inpatient mortality, use of two years of data instead of one, use of a higher minimum hospital volume threshold (30 patients vs. 2) for reporting results, and a larger and more complex list of exclusion/inclusion criteria.

The ARHQ hip replacement inpatient mortality measure includes patients at least 18 years old with a diagnosis of *Osteoarthritis and allied disorders* (715.xx) or *Other and unspecified arthropathies* (716.xx), with total, partial or revised hip replacement (81.5x, 0.7x). There is no overlap between patients included in the ARHQ hip replacement mortality measure and the OSHPD Hip Fracture Repair measure. Hip replacement was not included in Hospital Inpatient Mortality Indicators for California report released by OSHPD.

[1] Centers for Medicare & Medicaid Services (CMS), The Joint Commission. Specifications manual for national hospital inpatient quality measures, version 4.1.; July 2012. various p.