Alternative Comorbidity Adjustors for the Medicare Inpatient Psychiatric Facility PPS

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The inpatient psychiatric facility prospective payment system (IPF-PPS), provides per diem payments for psychiatric hospitals and units, including 17 comorbid condition payment adjustors that cover 11 percent of patients. This study identifies an alternative set of 16 adjustors identifying three times as many high-cost patients and evaluates the improved predictive power in log per diem cost regression models. A model using the IPF-PPS adjustors achieved 8.8 percent of the feasible improvement from a no-adjustor baseline, while the alternative adjustors achieved 22.1 percent of the feasible improvement. The current adjustors may therefore be too restrictive, resulting in systematic over- or underpayment for many patients.

BACKGROUND

The Medicare acute inpatient prospective payment system (IPPS) was implemented in 1983 to pay acute care hospitals a per case payment using the diagnosis related groups (DRG). However, psychiatric hospitals and psychiatric units, known as Medicare-certified distinct part psychiatric units (DPUs), were excluded from this system, and continued to be paid under the cost-based system required by the Tax Equity and Fiscal Responsibility Act of 1982. These providers were excluded because of concerns that DRG based per case payments would result in inaccurate and unfair payments (Schweiker, 1982). Subsequent studies (English et al., 1986; Horgan and Jencks, 1987; Mitchell et al., 1987; Freiman, Mitchell, and Rosenbach, 1988) supported this concern by showing that the psychiatric and substance abuse DRGs performed poorly in explaining per case costs in psychiatric hospitals and DPUs. Nationally, these providers deliver about 75 percent of Medicare inpatient psychiatric care days.

The Balanced Budget Refinement Act of 1999, mandated the development of a per diem PPS for these IPPS excluded facilities. CMS published final regulations in November 2004 to implement the IPF-PPS to be phased-in over a 4-year period (*Federal Register*, 2004). The IPF-PPS uses existing DRGs (originally the CMS DRGs; as of October 2007, the Medicare Severity DRGs [MS-DRGs]) combined with a set of payment adjustors for comorbidities (medical and behavioral) recorded as secondary diagnoses on a Medicare claim. In addition to a set of facility, patient age, day-of-stay, electroconvulsive therapy (ECT) use, and 15 (17 as of October, 2007 using the MS-DRGs) psychiatric DRG adjustors, the IPF-PPS includes 17 comorbidity categories (CCs) to adjust payments for specific high-cost patient populations. Patients can be assigned to multiple IPF-PPS CCs. There is a separate payment multiplier for each IPF-PPS CC, and the overall comorbidity adjustment is computed as

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the product of the adjustments for the individual CCs. The payment increase for a particular CC does not depend on other diagnoses or patient characteristics (e.g., age or ECT use). Because the IPF-PPS payment rates were set to keep payments budget neutral, higher payment for some cases must result in lower payment for others. To the extent that the higher payments are focused on a relatively small number of patients, any payment reductions would presumably be small. In addition, there is also an outlier payment, after which a hospital is paid 80 percent of the costs in excess of an outlier threshold.

Several studies published before and after the IPF-PPS regulations, using data on Veterans Affairs' patients (Ashcraft et al., 1989; Sloan et al., 2006) and on Medicare patients (Cromwell et al., 2005; Drozd et al., 2006), developed hierarchical case mix classification systems for inpatient psychiatric care based on the *Diagnosis and Statistical Manual of Mental Disorders, Revised Third Edition* or *Fourth Edition* and interacting other patient characteristics within each group. Heller and Vaz (2001) estimated a model of per diem costs in IPPS-exempt psychiatric facilities similar to CMS' basic model, featuring DRGs to identify the effect on cost of the primary diagnosis and separate indicators for comorbid conditions.

There are two potential limitations to the IPF-PPS comorbidity adjustors. First, a set of adjustors specific to only a small set of patients may be insufficiently sensitive in identifying higher than average cost patients, and CMS may systematically underpay providers for such patients. About 10 percent of Medicare patients have an IPF-PPS CC (Cromwell et al., 2005). Many of the conditions are in fact quite rare (e.g., only 0.015 percent of cases were assigned the cardiac conditions IPF-PPS CC). However, a study by Heller and Vaz (2001) developed comorbidity groups for use with the existing CMS DRGs have included more patients (38 percent) whose diagnoses would trigger a payment adjustment.

Second, the 17 IPF-PPS CCs are not modeled in an interactive fashion—the payment increase for a particular category does not depend on the other diagnoses (primary or secondary) or other patient characteristics (e.g., age or ECT use) present on the claim. Their non-interactive nature may result in very large payment increases for patients with multiple comorbidities that may exceed their true cost. Alternatively, it is possible that there are economies of scale in treating patients with multiple comorbidities, in which case Medicare would overpay for their care.

This study addresses these two limitations by first exploring an alternative system of comorbidities and then developing and exploring the impact of interacting these groups. Unlike this study, the Cromwell et al. (2005) and Drozd et al. (2006) studies, though examining Medicare patients, develop inpatient case-mix classification systems that do not include DRGs. Sloan and others (2006) focused on predicting total (inpatient plus outpatient) costs among Veterans Affairs' patients (who have different demographic, and possibly different case-mix characteristics) and developed a case-mix classification scheme that assigned patients to only 1 of 48 mutually-exclusive groups using the diagnosis deemed to most affect total utilization. Heller and Vaz's (2001) study is the most similar to this one. However, our study differs from their's by using more recent data (Medicare claims from 2004 rather than from 1998) and estimating models with a structure more similar to that of the IPF-PPS, including only using the existence of comorbid conditions, not their count. The particular comorbid condition groups

are different from those used in our study, but, similarly to this study, were developed based on expert opinion.

The result of this analysis will be to demonstrate that payment accuracy can be improved by modifying the comorbid groups to include a wider set of conditions. To address these issues, we develop and present a set of comorbidity and severity adjustors that could serve as the basis of alternatives to the current adjustors.

METHODS

Database

The data were constructed using CMS' data bases: the 2004 100 Percent National Medicare Provider Analysis and Review (MedPAR) File; the Healthcare Cost Report Information System (HCRIS) data base of Medicare Cost Reports (MCRs); and the Provider of Services (POS) File. MedPAR consists of summaries of inpatient bills submitted for Medicare payment and each record includes: selected patient demographics (age, sex, race); basic information about the stay, admission and discharge dates, admission source, and discharge status (including death); up to 10 *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnosis codes and up to 6 ICD-9-CM procedure codes; total charges for 20 ancillary departments relevant for inpatient care; and Medicare provider payments. MCRs provide data on the numbers of psychiatric unit beds, numbers of residents, and department-level costs for each hospital. This study used the most recently-available MCRs at the time of data base construction (fiscal year 2002 or 2003). Because of the longer time lag in the availability of MCR data relative to MedPAR data, we inflated these costs to 2004 dollars using the increase in the PPS-Excluded facility market basket index. The POS File gives information on each facility's location (urban or rural) and whether it has an emergency department.

Study Population

Our study sample was composed of 501,770 discharges from an IPF in calendar year 2004 with one of the 15 IPF-PPS DRGs from 2004. For purposes of calibrating weights for per diem cost models, we arbitrarily assigned each case to a 50-percent estimation sample and a 50-percent validation sample (250,885 records in each subsample).

Per Diem Cost Measure

The main variable of interest in this study is the natural log of per diem cost. We constructed this measure by first converting discharge-level ancillary department charges reported on the MedPAR record to estimated costs using facility-specific department-level cost-to-charge ratios (CCRs). CCRs outside three standard deviations of the facility type (psychiatric hospital versus DPU) mean were reset to the facility-type median department-specific CCR.

To this estimated ancillary cost was added the facility-level per diem routine cost (again applying facility type-specific ceilings and floors). We adjusted the resulting per diem cost for differences in area wages using CMS' methodology for the IPF-PPS: the portion deemed labor-related (72.828 percent) was deflated by each facility's area wage index, and the remaining non-labor related portion (21.172 percent) was added to the wage index-adjusted labor-related portion.

Standard errors of regression coefficients were computed using the Taylor linearization method assuming a clustered,

unstratified sample design (Research Triangle Institute, 2002). Because of the very large number of provider clusters, this method is equivalent to constructing robust estimates of standard errors of estimated coefficients using clustered Huber-White (Huber, 1967; White, 1980) robust standard errors (Froot, 1989).

IPF-PPS Comorbidity Categories

For each case, we constructed an indicator for each of the 17 IPF-PPS CCs using the definitions in the final regulations for the first year (2005) of IPF-PPS implementation (*Federal Register*, 2004, 2005).[1] The IPF-PPS CCs, definitions (ICD-9-CM diagnosis and procedure codes), and frequencies among patients in our analysis sample are shown in Table 1. Many of the IPF-PPS CCs are for fairly rare conditions. Only 11 percent of patients had any comorbidity category assigned, with 6.5 percent assigned only for a medical condition.

Alternative Psychiatric Comorbid Groups (PCGs)

Our primary goal in developing our alternative PCGs of secondary diagnoses was considering additional conditions that may increase per diem cost, not dropping conditions already used in the IPF-PPS CC definitions. First, we assembled a set of diagnoses drawn from the existing IPF-PPS CCs as well as from clinical review of other ICD-9-CM diagnosis codes. In total, we identified 911 diagnoses for nursing and ancillary intensity rating—772 from the IPF-PPS CCs and an additional 139 codes, including V-codes for drug-resistant infections, chronic airway obstruction not elsewhere classified, cranial trauma and other severe injuries, grand mal status, and various types of delirium.

We then rated these conditions on a 5-point Likert scale (minimal increase, low, elevated, high, and extreme) for expected nursing and ancillary costs. Diagnoses rated elevated or higher were considered candidates for grouping into our PCGs. A majority of the 772 IPF-PPS CC diagnoses were rated as inducing high nursing and ancillary service use. In contrast, most of the additional conditions were rated high for nursing use but elevated or low for ancillary service use. We felt the fact that the IPF-PPS CC diagnoses were rated high cost was sensible since the IPF-PPS CCs were identified, in part, on their ability to explain differences in per diem costs as measured using only administrative data.

One criterion usually considered for conditioning payment on diagnoses is the gamability of reporting these conditions. However, we have de-emphasized this criterion in this article for a few reasons. First, it is beyond the scope of this work to assess the gamability of the conditions underlying the IPF-PPS CCs, and these may include gamable diagnoses (e.g., ICD-9-CM 319, unspecified mental retardation). Second, assessing gamability of these diagnoses may be premature since, to our knowledge, no systematic study of actual changes in comorbidity coding under the IPF-PPS has yet been conducted. The results of such a study would inform judgment of the coding of other conditions.

Once we determined the additional candidate comorbid diagnoses, we employed several approaches to group them into PCGs:

- Combining existing IPF-PPS CCs. We took this approach when very small categories could be combined into a single group exhibiting clinical similarity.
- Splitting and recombining existing IPF-PPS CCs.

[1] MedPAR does not contain indicators for the IPF-PPS CCs.

Table 1

Percent of Patients in IPFs with Each CMS IPF-PPS Comorbidity Category: 2004

IPF-PPS Comorbidity Category and Constituent ICD-9-CM Codes	Percent of Patients
Medical Comorbidities	
Artificial Openings–Digestive & Urinary 56960 - 56969, 9975, and V441 - V446	0.29
Tracheostomy 51900 - 51909 and V440	0.04
Cardiac Conditions 3910, 3911, 3912, 40201, 40403, 4160, 4210, 4211, and 4219	0.02
Coagulation Factor Deficits 2860 - 2864	0.04
Gangrene 44024 and 7854	0.03
Renal Failure–Acute 5845 - 5849, 63630, 63631, 63632, 63730, 63731, 63732, 6383, 6393, 66932, 66934, and 9585	0.37
Renal Failure–Chronic 40301, 40311, 40391, 40402, 40403, 40412, 40413, 40492, 40493, 585, 586, V451, V560, V561, and V562	1.24
Oncology Treatment 1400 - 2399; with procedure codes 9221 - 92.29 or 9925	0.01
Uncontrolled Diabetes-Mellitus 25002, 25003, 25012, 25013, 25022, 25023, 25032, 25033, 25042, 25043, 25052, 25053, 25062, 25063, 25072, 25073, 25082, 25083, 25092, and 25093	0.66
Severe Protein Calorie Malnutrition 260 - 262	0.07
Severe Musculoskeletal & Connective Tissue Disorders 6960, 7100, 73000 - 73009, 73010 - 73019, and 73020 - 73029	0.33
Infectious Disease 01000 - 04110, 042, 04500 - 05319, 05440 - 05449, 0550 - 0770, 0782 - 07889, and 07950 - 07959	2.9
Chronic Obstructive Pulmonary Disease 49121, 4941, 5100, 51883, 51884, V4611, and V4612	0.36
Poisoning 96500 - 96509, 9654, 9670 - 9699, 9770, 9800 - 9809, 9830 - 9839, 986, 9890 - 9897	0.48
Behavioral Comorbidities	
Developmental Disabilities 317, 3180, 3181, 3182, and 319	2.79
Drug and/or Alcohol Induced Mental Disorders 2910, 2920, 29212, 2922, 30300, and 30400	1.73
Eating & Conduct Disorders 3071, 30750, 31203, 31233, and 31234	0.51
Any Medical Comorbidity	6.47
Any Comorbidity	11.04

NOTES: IPF-PPS is inpatient psychiatric facility prospective payment system. ICD-9-CM is *International Classification of Diseases, Ninth Revision, Clinical Modification*.

SOURCE: Drozd, E.M., Maier, J., RTI International, Hales, J. F., Cambridge Health Alliance, and Thomas, F. G., Centers for Medicare & Medicaid Services, analysis of discharges from inpatient psychiatric units and hospitals using the 2004 100 percent MedPAR file.

- Expanding existing IPF-PPS CCs. We modified the names of these groups to reflect the broader range of conditions.
- Creating new comorbid groups. Some conditions were not logically related to those in the existing IPF-PPS CCs (e.g., dementias or deliriums).

Table 2 presents our 16 PCGs, the ICD-9-CM codes that define them, and their proportions in our analysis sample. Our PCGs comprise a much larger proportion of all patients than do the IPF-PPS CCs. Because of this, we further required that a PCG could only be assigned if the diagnosis code that would otherwise cause assignment to that PCG is not used to group that case into the case's assigned DRG (to limit triggering the PCG assignment for secondary diagnoses related to the principal diagnosis). About 13 percent of cases that would have been assigned a PCG were not assigned based on this criterion.

Table 2

Percent of Patients in IPFs with Each Alternative Comorbid Group: 2004

Alternative Comorbid Group and Constituent ICD-9-CM Codes	Percent of Patients in Comorbid Group	Percent of Patients Also in Some Comorbidity Category
Medical Comorbidities		
Artificial Openings 51900 - 51909, 56960 - 56969, 9975, and V440 - V446	0.32	100.00
Neurological Disorders 33392, 34510, 34511, 3453, 36901, 78003, and 78039	5.36	0.00
Circulatory Disorders 2860 - 2864, 3910, 3911, 3912, 40201, 40403, 4160, 4210, 4211, 4219, 4280 - 4289, 436, 44024, 7854, and V1259	6.43	6.11
Renal & Hepatic Disorders 40301, 40311, 40391, 40402, 40403, 40412, 40413, 40492, 40493, 5710 - 5728, 5845 - 586, 63630, 63631, 63632, 63730, 63731, 63732, 6383, 6393, 66932, 66934, 9585, V451, V560, V561, and V562	2.16	70.12
Neoplasms–With Radiation or Chemotherapy 1400 - 20198, 20200 - 20381, 20400 - 20491, 20500 - 20591, 20600 - 20891, 2100 - 2249, 2250 - 2279, 22800 - 2299, 2300 - 2395; with procedure codes 9221 - 9229 or 9925	0.02	100.00
Neoplasms–Without Radiation or Chemotherapy Same diagnoses as Neoplasms–With Radiation or Chemotherapy; without procedure codes 9221 - 9229 or 9925	1.35	0.00
Endocrine & Nutritional Disorders 25001 - 25003, 25011 - 25013, 25021 - 25023, 25031 - 25033, 25041 - 25043, 25051 - 25053, 25061 - 25063, 25071 - 25073, 25081 - 25083, and 25091 - 25093	1.99	36.60
Infectious Diseases 01000 - 04110, 042, 04500 - 05319, 05440 - 05449, 0550 - 0770, 0782 - 07889, 07950 - 07959, and V090 - V0991	3.01	96.58
Respiratory Diseases 49121, 4941, 496, 5100, 51883, 51884, V4611, and V4612	0.36	100.00
Severe Musculoskeletal & Connective Tissue Disorders 6960, 7100, 73000 - 73009, 73010 - 73019, and 73020 - 73029	0.33	100.00
Injury & Poisoning 80300 - 80399, 85400 - 85409, 8911, 8912, 9500 - 9509, 96500 - 96509, 9654, 9670 - 9699, 9770, 9800 - 9809, 9830 - 9839, 986, 9890 - 9899, 99883, and E9500 - E9589	0.61	78.92
Alternative Behavioral Comorbid Groups		
Psychiatric Disorders 29623, 29624, 29633, 29634, 29643, 29644, 29653, 29654, 29663, 29664, 2989, 30183, 3071, 30750, 30751, and 30981	7.65	5.75
Dementia 2900 - 29043, 2912, 29282, 29410, 29411, 33119, and 33182	9.39	0.00
Delirium 29011, 2903, 29041, 29081, 2910, 2930, 2931, and 78009	1.31	7.54
Childhood Onset 2998, 317, 3180, 3181, 3182, and 319	2.67	100.00
Substance-Related Disorders 2920, 29212, 2922, 30300, and 30400	1.21	100.00
Any Alternative Medical Comorbid Group	19.11	33.86
Any Alternative Comorbid Group	34.72	30.09

NOTES: IPF-PPS is inpatient psychiatric facility prospective payment system. ICD-9-CM is *International Classification of Diseases, Ninth Revision, Clinical Modification*.

SOURCE: Drozd, E.M., Maier, J., RTI International, Hales, J. F., Cambridge Health Alliance, and Thomas, F. G., Centers for Medicare & Medicaid Services, analysis of discharges from inpatient psychiatric units and hospitals using the 2004 100 percent MedPAR file.

Five of our comorbid groups are composed only of IPF-PPS CCs: (1) Musculoskeletal and Connective Tissue Disorders; (2) Neoplasms with Radiation or Chemotherapy, nee Oncology Treatment; (3) Artificial Openings, composed of the CMS Artificial Openings–Digestive and Urinary and Tracheostomy comorbidity categories; (4) Circulatory Disorders, composed of the Cardiac Conditions, Coagulation Factor

Deficits, and Gangrene groups; and (5) Substance-Related Disorders, composed of the Drug or Alcohol Induced Mental Disorders comorbidity category except for delirium tremens, which we moved to a new delirium group.

Six PCGs are composed of CMS CCs expanded to include related conditions. We added drug-resistant infections to the IPF-PPS Infectious Diseases CC since they require much more intensive medical treatment, testing, and nursing care. We combined the IPF-PPS Renal Failure–Acute and Renal Failure–Chronic CCs and then added severe hepatic impairment, creating a Renal/Hepatic Disorders PCG. We added type II diabetes mellitus to the IPF-PPS Uncontrolled Diabetes-Mellitus CC and also added the small IPF-PPS Severe Protein Calorie Malnutrition CC to form a new PCG, Endocrine/Nutritional Disorders. We added cranial traumas, nonhealing wounds, and self-inflicted injuries to the IPF-PPS Poisonings comorbidity category, creating an Injuries and Poisonings PCG, to include many injuries that require intense nursing care.

We also created five PCGs comprised of diagnoses not in any IPF-PPS CC: (1) Neoplasms, without Radiation or Chemotherapy, including benign tumors in nervous system, endocrine, or other vital organs; (2) Delirium; (3) Neurological Disorders; (4) Dementia; and Psychiatric Disorders.

Regression Models

To maintain comparability with the IPF-PPS, the models of per diem cost that we estimated followed as closely as possible the regressions estimated by CMS to develop payment weights for the IPF-PPS. We included the following regressors:

- Five facility-level adjustors based on the model underlying the IPF-PPS payment rates: (1) rural location; (2) teaching (one plus the ratio of residents assigned to the IPF-PPS-applicable portion of the facility); (3) two occupancy-based adjustors, (4) the natural logarithm of the inpatient psychiatric occupancy rate and (5) an indicator for average occupancy rate is less than 30 percent; and whether facility reports charges on claims (In 2004, 167 IPFs, mostly psychiatric hospitals, reported zero ancillary charges on all of their submitted Medicare claims; these providers accounted for about 5 percent of Medicare days).
- Indicators for whether the patient's age falls in one of the following subgroups: under age 45, 45 to 50, 50 to 55, and so on in 5-year ranges until age 80, and 81 or over.
- Indicators for the patient's length of stay (LOS): 1 day in a facility with a 24-hour emergency department, 1 day in a facility without a 24-hour emergency department, 2 days, 3 days, and so on until 21 days, then 22 or more days.
- An indicator for whether a patient received one or more ECT treatments (ICD-9-CM procedure code 94.27) during the stay.
- A set of indicators for the DRG for the patient's stay.
- Indicators for each IPF-PPS CC or for each of our PCGs. Selected models include interactions (combinations) of PCGs to account for impacts of certain PCGs on costs that are conditional on the patient also having certain other PCGs.

Table 3 presents summary statistics among the full sample (estimation plus validation samples) for the dependent variables and the explanatory variables used in the regression analyses. Differences in the means of all variables are highly insignificant and generally within 0.05 percent for the overall sample. However, for very low-frequency indicators (overall

Table 3

Summary Statistics for IPF-PPS and Alternative Psychiatric Comorbid Group Models

Variable	μ	σ
Per Diem Cost	753.99	5391.8
log (Per Diem Cost)	6.5545	0.3672
log (Occupancy Rate)	-0.4023	0.2900
Occupancy Rate < 30%	0.0174	0.1309
All-Inclusive Rate Provider	0.0477	0.2130
Rural Facility	0.1489	0.3560
log(1 + Resident to ADC Ratio)	0.0244	0.0886
LOS = 1 & Facility Without ED	0.0065	0.0803
LOS = 1 & Facility With ED	0.0285	0.1664
LOS = 2	0.0476	0.2128
LOS = 3	0.0633	0.2435
LOS = 4	0.0683	0.2522
LOS = 5	0.0676	0.2511
LOS = 6	0.0714	0.2576
LOS = 7	0.0749	0.2632
LOS = 8	0.0607	0.2388
LOS = 9	0.0513	0.2205
LOS = 10	0.0465	0.2105
LOS = 11	0.0408	0.1977
LOS = 12	0.0371	0.1889
LOS = 13	0.0386	0.1925
LOS = 14	0.0419	0.2005
LOS = 15	0.0285	0.1663
LOS = 16	0.0216	0.1453
LOS = 17	0.0194	0.1378
LOS = 18	0.0167	0.1283
LOS = 19	0.0150	0.1215
LOS = 20	0.0146	0.1201
LOS = 21	0.0152	0.1224
LOS ≥ 22	0.1243	0.3299

Variable	μ	σ
Under 45 Years	0.3162	0.4650
45–49 Years	0.1194	0.3243
50–54 Years	0.0928	0.2901
55–59 Years	0.0660	0.2483
60–64 Years	0.0481	0.2139
65–69 Years	0.0701	0.2553
70–74 Years	0.0674	0.2507
75–79 Years	0.0733	0.2605
80 Years or Over	0.1468	0.3539
DRG 012 Degenerative Nervous System Disorders	0.0606	0.2387
DRG 023 Nontraumatic Stupor & Coma	0.0012	0.0341
DRG 424 OR Procedure with Principal Diagnosis of Mental Illness	0.0021	0.0460
DRG 425 Acute Adj. Reactions & Psychosocial Dysfunction	0.0101	0.0998
DRG 426 Depressive Neuroses	0.0363	0.1871
DRG 427 Neuroses Except Depressive	0.0117	0.1073
DRG 428 Personality & Impulse Control Disorders	0.0061	0.0779
DRG 429 Organic Disturbances & Mental Retardation	0.0796	0.2707
DRG 430 Psychoses	0.7354	0.4411
DRG 431 Childhood Mental Disorders	0.0033	0.0577
DRG 432 Other Mental Disorder Diagnoses	0.0009	0.0299
DRG 433 Alcohol/Drug Abuse or Dependence, Left Against Med. Advice	0.0027	0.0523
DRG 521 Alcohol/Drug Abuse/Dependence with CC	0.0167	0.1280
DRG 522 Alcohol/Drug Abuse/Dependence with Rehab Therapy, no CC	0.0023	0.0482
DRG 523 Alcohol/Drug Abuse/Dependence, no Rehab Therapy, no CC	0.0310	0.1732
ECT Administered During Stay	0.0206	0.1420

Refer to footnotes at the end of the table.

Table 3—Continued

Summary Statistics for IPF-PPS and Alternative Psychiatric Comorbid Group Models

PF-PPS Comorbidity Category	μ	σ	Alternative Comorbid Group	μ	σ
Artificial Openings–Digestive & Urinary	0.0029	0.0538	Neurological Disorders	0.0541	0.2262
Tracheostomy	0.0004	0.0189	Circulatory Disorders	0.0649	0.2464
Cardiac Conditions	0.0002	0.0123	Artificial Openings	0.0032	0.0567
Coagulation Factor Deficits	0.0004	0.0189	Renal & Hepatic Disorders	0.0218	0.1459
Gangrene	0.0003	0.0165	Neoplasms–With Radiation or Chemotherapy	0.0001	0.0114
Renal Failure–Acute	0.0037	0.0611	Neoplasms–Without Radiation or Chemotherapy	0.0136	0.1157
Renal Failure–Chronic	0.0124	0.1105	Endocrine & Nutritional Disorders	0.0195	0.1382
Oncology Treatment	0.0001	0.0116	Severe Musculoskeletal & Connective Tissue Disorders	0.0304	0.1716
Uncontrolled Diabetes–Mellitus	0.0066	0.0812	Infectious Diseases	0.0036	0.0599
Severe Protein Calorie Malnutrition	0.0007	0.0259	Respiratory Diseases	0.0033	0.0577
Severe Musculoskeletal & Connective Tissue Diseases	0.0033	0.0577	Injury & Poisoning	0.0061	0.0777
			Psychiatric Disorders	0.0771	0.2668
Infectious Disease	0.0290	0.1679	Dementia	0.0946	0.2927
Chronic Obstructive Pulmonary Disease	0.0036	0.0599	Delirium	0.0132	0.1140
Poisoning	0.0048	0.0694	Childhood Onset	0.0268	0.1615
Developmental Disabilities	0.0279	0.1648	Substance-Related Disorders	0.0122	0.1097
Drug and/or Alcohol Induced Mental Disorders	0.0173	0.1302	Psychiatric Disorders and Circulatory Disorders	0.0035	0.0594
Eating & Conduct Disorders	0.0051	0.0712	Psychiatric Disorders and Respiratory Disorders	0.0002	0.0135
			Psychiatric Disorders and Neurological Disorders	0.0057	0.0755
			Psychiatric Disorders and Dementia	0.0050	0.0707
			Dementia and Delirium	0.0050	0.0707
			Childhood Onset and Neurological Disorders	0.0051	0.0714
			Circulatory Disorders and Respiratory Disorders	0.0007	0.0259

NOTES: ADC is average daily census. ED is emergency department. LOS is length of stay. DRG is diagnosis related group. OR is operating room. CC is comorbity categories. ETC is electroconvulsive therapy.

SOURCE: Drozd, E.M., Maier, J., RTI International, Hales, J. F., Cambridge Health Alliance, and Thomas, F. G., Centers for Medicare & Medicaid Services, analysis of discharges from inpatient psychiatric units and hospitals using the 2004 100 percent MedPAR file.

sample mean less than 0.05 percent), the difference between the estimation and validation samples can be as high as 20 percent. The average case weighted total per diem cost is $754. Taking the natural logarithm of per diem cost for the regression dependent variable dramatically reduced its skewness. Nearly 43 percent of patients' lengths of stay (LOSs) were 1 week or less, and 12.43 percent of patients' LOSs exceeded 3 weeks. Nearly two thirds (64 percent) of patients were younger than age 65. DRG 430 (Psychoses) accounted for a large majority (73.54 percent) of patients; the next most frequent DRGs were 429 (Organic Disturbances and Mental Retardation; 7.01 percent) and 012 (Degenerative Nervous System Disorders; 6.06 percent). Thus, only three DRGs account for 87.56 percent of all IPF discharges. The relative weights for these DRGs ranged from 1.00 (DRG 430) to 1.05 (DRG 012) for the first year of IPF-PPS implementation (CMS, 2004), indicating that differences in payments for the vast majority of patients must be driven by facility characteristics, age, LOS, and comorbidities rather than principal diagnosis.

Two regression models used the IPF-PPS CC adjustors: one included only the medical CCs (14 adjustors), and the other included all 17 IPF-PPS CC adjustors. We estimated two similar models using our PCGs (11 medical-only groups and all 16 groups). A fifth payment model added select combinations of our PCGs (fewer than 0.01 percent of discharges in our sample had multiple CMS IPF-PPS CCs, which we deemed too infrequent for separate analysis).

We also estimated one baseline and two benchmark models. The baseline model included patient, facility, and DRG indicators, but no comorbidity adjustors to provide a lower bound on explanatory power from which the models' R^2 improvements are measured. The benchmark models used a combination of the IPF-PPS CCs, our PCGs, and either CMS hierarchical condition categories (CMS-HCCs) or CMS DxGroups. CMS-HCCs are used for Medicare managed care risk adjustment (Pope et al., 2004). DxGroups are the constituent components of CMS-HCCs; the model using these (totaling 825 adjustors) established a feasible upper bound on the comorbid-adjusted R^2.

Regression Model Diagnostics

After estimating the regression models, we compared the models' explanatory power using the overall regression R^2 as well as subgroup R^2s for various subgroups of patients from the validation sample. The overall regression R^2 summarizes how well the regression model, on average, predicts cost by summarizing the amount of variation in per diem cost explained by each model. However, a model may predict very well for most patients (high R^2), but systematically over- or underestimate cost for a small subset of patients. To identify subgroups where a model may perform relatively well or poorly, we computed a set of subgroup R^2 statistics, which measure how much variation around the prediction for each member of the subgroup remains (Pope et al., 1998). The subgroup R^2 for subgroup S is computed as:

$$R_S^2 = 1 - \frac{\sum_{i \in S} (A_i - E_i)^2}{\sum_{i \in S} (A_i - M_S)^2},$$

where S is a patient subgroup of interest and i indexes discharges within patient subgroup S, A_i is the actual per diem cost for discharge i, E_i is the estimated cost for discharge i, and M_S is the mean per diem cost for discharges in subgroup S. Like the overall regression R^2, a subgroup R^2 cannot exceed 1.0 (where a subgroup R^2 equal

to 1.0 indicates perfect prediction for that subgroup). However, it can be negative if the average per diem cost for subgroup *S* is a better predictor than the regression model. In this analysis, the subgroups we analyze are:

- At least one IPF-PPS CC (also in at least one of our PCGs by definition).
- At least one of our PCGs, but not assigned an IPF-PPS CC.
- Not assigned to any IPF-PPS CC or any of our PCGs.
- Per diem costs in the bottom decile of all patients' per diem costs.
- Per diem costs in the top decile of all patients' per diem costs.

RESULTS

Relative Weights for Comorbidity Adjustors

Table 4 gives the relative weights for the IPF-PPS CCs computed by exponentiating the coefficient estimates from the log per diem cost regression. CMS (*Federal Register*, 2004) did not incorporate the Duan (1983) smearing adjustment for applying a nonlinear transformation—exponentiation—to log per diem cost when setting payment weights for the IPF-PPS, and for consistency we use this same approach. Most of the IPF-PPS CC weights are similar to the actual weights used in the fiscal year 2006 IPF-PPS, with the exception of

Table 4
Estimated Relative Weights for IPF-PPS Comorbidity Categories

IPF-PPS Comorbidity Category	Relative Weight	R^2 Reduction from Dropping Category
Artificial Openings–Digestive & Urinary	1.085 **	0.0002
Tracheostomy	1.076 **	< 0.0001
Cardiac Conditions	1.136 *	< 0.0001
Coagulation Factor Deficits	1.089 **	< 0.0001
Gangrene	1.047	< 0.0001
Renal Failure–Acute	1.090 **	0.0004
Renal Failure–Chronic	1.108 **	0.0010
Oncology Treatment	1.246 **	< 0.0001
Uncontrolled Diabetes-Mellitus	1.068 **	0.0002
Severe Protein Calorie Malnutrition	1.119 **	0.0001
Severe Musculoskeletal & Connective Tissue Diseases	1.097 **	0.0002
Infectious Disease	1.084 **	0.0013
Chronic Obstructive Pulmonary Disease	1.097 **	0.0002
Poisoning	1.156 **	0.0007
Developmental Disabilities	1.062 **	0.0005
Drug and/or Alcohol Induced Mental Disorders	1.041 **	0.0001
Eating & Conduct Disorders	1.057 **	0.0001
R^2	0.318	—

* Significance difference from 1.0 at the 95 percent confidence level.

** Significance at the 99 percent level.

NOTES: Relative weights computed by exponentiating estimated coefficients from a regression of the natural logarithm of per diem cost. Discharge level per diem costs were calculated using facility-specific routine per diem costs and facility- and department-level cost-to-charge ratios and department level charges for each stay, adjusted for area wage levels and updated for the Medicare Cost Report fiscal year. Relative weights for facility characteristics, length-of-stay, age group, and the electroconvulsive therapy indicator (included in the regression) are not shown. R^2 reduction computed as $\Delta R^2 = F\,(1 - R^2) / (N - k)$, where F is the F-statistic for the adjustor's regression coefficient and $N - k$ is equal to the number of observations minus the number of regressors in the model (Greene, W.H.: Econometric Analysis, 5th Ed. Prentice Hall. Upper Saddle River, NJ. 2002).

SOURCE: Drozd, E.M., Maier, J., RTI International, Hales, J. F., Cambridge Health Alliance, and Thomas, F. G., Centers for Medicare & Medicaid Services, analysis of discharges from inpatient psychiatric units and hospitals using the 2004 100 percent MedPAR file.

Table 5

Estimated Relative Weights for Alternative Psychiatric Comorbid Groups

Alternative Psychiatric Comorbid Group	Relative Weight	R^2 Reduction from Dropping Category	Relative Weight	R^2 Reduction from Dropping Category
Neurological Disorders	1.070 **	0.0011	1.077 **	0.0010
Circulatory Disorders	1.071 **	0.0013	1.075 **	0.0013
Artificial Openings	1.083 *	0.0002	1.083 *	0.0002
Renal & Hepatic Disorders	1.084 **	0.0011	1.084 **	0.0011
Neoplasms–With Radiation or Chemotherapy	1.212 **	0.0001	1.212 **	0.0001
Neoplasms–Without Radiation or Chemotherapy	1.089 **	0.0008	1.089 **	0.0008
Endocrine & Nutritional Disorders	1.067 **	0.0004	1.067 **	0.0004
Severe Musculoskeletal & Connective Tissue Disorders	1.088 **	0.0003	1.088 **	0.0003
Infectious Diseases	1.079 **	0.0007	1.079 **	0.0007
Respiratory Diseases	1.094 **	0.0002	1.104 **	0.0002
Injury & Poisoning	1.139 **	0.0008	1.138 **	0.0008
Psychiatric Disorders	1.065 **	0.0009	1.075 **	0.0009
Dementia	1.071 **	0.0006	1.074 **	0.0006
Delirium	1.055 **	0.0002	1.074 **	0.0002
Childhood Onset	1.047 **	0.0004	1.053 **	0.0004
Substance-Related Disorders	1.015	< 0.0001	1.015 **	< 0.0001
Psychiatric Disorders and Circulatory Disorders	1.097	—	0.938 **	0.0001
Psychiatric Disorders and Respiratory Disorders	1.084	—	0.930	< 0.0001
Psychiatric Disorders and Neurological Disorders	1.097	—	0.962 **	< 0.0001
Psychiatric Disorders and Dementia	1.156	—	0.938 **	0.0001
Dementia and Delirium	1.062	—	0.953 **	0.0001
Childhood Onset and Neurological Disorders	1.041	—	0.967 **	< 0.0001
Circulatory Disorders and Respiratory Disorders	1.057	—	0.965 **	< 0.0001
R^2	0.327	—	0.328	—

* Significance difference from 1.0 at the 95 percent confidence level.

** Significance at the 99 percent level.

NOTES: Relative weights computed by exponentiating estimated coefficients from a regression of the natural logarithm of per diem cost. Discharge level per diem costs were calculated using facility-specific routine per diem costs and facility- and department-level cost-to-charge ratios and department level charges for each stay, adjusted for area wage levels and updated for the Medicare Cost Report fiscal year. Relative weights for facility characteristics, length-of-stay, age group, and the electroconvulsive therapy indicator (included in the regression) are not shown. R^2 reduction computed as $\Delta R^2 = F\,(1 - R^2)\,/\,(N - k)$, where F is the F-statistic for the adjustor's regression coefficient and $N - k$ is equal to the number of observations minus the number of regressors in the model (Greene, W.H.: Econometric Analysis, 5th Ed. Prentice Hall. Upper Saddle River, NJ. 2002).

SOURCE: Drozd, E.M., Maier, J., RTI International, Hales, J. F., Cambridge Health Alliance, and Thomas, F. G., Centers for Medicare & Medicaid Services, analysis of discharges from inpatient psychiatric units and hospitals using the 2004 100 percent MedPAR file.

oncology treatment. The estimated weight based on this regression is 1.256, significantly different from the IPF-PPS weight of 1.07. This anomaly may be due to the very low frequency (0.01 percent) of this CC, which may result in instability of this relative weight as different years' data (2004 versus 2002) are used to calibrate it. Also noteworthy is the fact that, with the exception of Gangrene, our estimates of the relative weights of the IPF-PPS CCs are statistically significantly greater than 1.0, while their contributions to the model R^2 are quite minor. This is due to the very low frequencies of the IPF-PPS CCs.

Table 5 give the relative weights for our PCGs. The range of relative weights (1.07 to 1.26) is approximately the same as the range of our estimated IPF-PPS CC weights (1.08 to 1.26). The Artificial Openings PCG, composed of the Digestive and Urinary Artificial Openings and Tracheostomy IPF-PPS CCs, has a relative weight of 1.083, closer to that of the former CC (1.086) than the latter (1.076). The relative weight of our Circulatory Disorders

PCG (1.071) is somewhat lower than that of the IPF-PPS CCs it contains (Cardiac Conditions and Coagulation Factor Deficits) likely due to adding a substantial number of additional cases with above average, but not extremely high costs. Our Renal/Hepatic PCG has a somewhat lower weight than the two IPF-PPS Renal Failure CCs (1.084 versus 1.090 and 1.108) due to adding the relatively lower-cost liver failure patients. The weight for oncology patients actively receiving radiation or chemotherapy is similar across models, but our oncology PCG includes cancer patients not actively receiving oncology treatment, whose relative weight of 1.089 is relatively high compared to patients with other comorbidities. With the exception of the Substance-Related Disorders PCG, our behavioral condition PCGs' relative weights are generally similar in magnitude to those of the behavioral disorder IPF-PPS CCs. Since the number of patients who would be assigned to one of our PCGs is significantly higher than would be assigned to a behavioral IPF-PPS CC, this suggests that a substantial portion of the 0.009 increase in R^2 from the IPF-PPS to our model is due to expanding the number of patients identified as having a behavioral comorbidity.

Dropping individual indicators for our PCGs from a per diem cost model generally has a greater impact on the model's explanatory power than dropping IPF-PPS CCs. For only one of the 17 IPF-PPS CCs (Infectious Diseases) would dropping from the model reduce the model R^2 by more than 0.1 percentage points. In contrast, three of our 16 PCGs (Neurological, Circulatory, and Renal/Hepatic Disorders) have R^2 impacts greater than 0.1 percentage points.

Table 5 also shows relative weights and R^2 impacts for a model that includes the seven interactions of our PCGs with more than 0.5 percent of cases (2,500 patients). All but one of the weights are less than 1.0 and statistically significant, indicating that the per diem cost impact of multiple PCGs is less than the product of the weights for the individual PCGs considered separately. Not controlling for the attenuating effect of these interactions would bias upward the estimate of per diem cost. For example, the estimated combined effect on per diem cost of a psychiatric and a dementia comorbidity using the purely additive model is 1.141 (1.065 × 1.071), a 14.1-percent increase in per diem cost. However, when adjusting for interaction effects, the estimated combined effect of these conditions is 1.083 (1.075 × 1.074 × 0.938), an 8.3 percent increase in per diem cost. Ignoring this interaction effect would, therefore, result in a 5.8-percent overpayment for patients with both psychiatric and dementia comorbidities. Thus the effect of omitting the comorbid group interaction terms is to slightly underpay for patients with a single comorbid condition and significantly overpay for the quite small number of patients with multiple comorbidities.

Comparing Overall Model Explanatory Power

The difference in R^2 of 0.9 percentage points between our alternative comorbid group model and the IPF-PPS comorbidity model may seem small. Estimating the benchmark models without any comorbidity indicators (but including facility, LOS, age, ECT use, and DRG indicators) and ones using CMS-HCC and DxGroup indicators can put this R^2 difference in perspective. The CMS-HCCs, with 210 comorbidity adjustors, increases the adjusted R^2 by only 1.4 percentage points (from 0.327 to 0.341) beyond our PCG model with select interactions.

When we include all 792 DxGroups (for a total of 825 adjustors), we find a feasible

R^2 of 0.381, compared to a baseline of 0.313 (for a model with no comorbidity indicators). Therefore, any feasible set of comorbidity adjustors is unlikely to achieve more than a 6.8-percentage point (100 × [0.381 – 0.313]) R^2 improvement. Stated this way, our PCGs achieve about 21 percent of the feasible R^2 improvement over no comorbidity indicators (100 × [0.327 – 0.313] ÷ [0.381 – 0.313]), whereas the IPF-PPS CCs achieve less than 9 percent of the feasible maximum.

Subgroup Analysis

Subgroup R^2s are presented in Table 6. Each column containing the subgroup R^2 for a specific model, and the rows correspond to the subgroups (the first row presents the R^2 for each model for the entire population—in other words, the overall model R^2).

As expected, adding comorbidity adjustors improves the subgroup R^2s for all three comorbidity-based subgroups. Regardless of the set of comorbidity adjustors used, the patients with a comorbid condition identified as both an IPF-PPS CC and one of our PCGs have the least well-explained per diem costs among the three comorbidity-based groups. These patients tend to have the highest per diem costs and the highest variance of per diem costs. In contrast, the patients with the highest overall subgroup R^2s are those with one or more of our PCGs, but not an IPF-PPS CC. These 30 percent of all patients have the best-predicted per diem costs using all models; however, since our PCGs target these patients, our models provide significant explanatory power improvements over the IPF-PPS models.

Table 6 also indicates that the improved predictive power of our PCGs over the IPF-PPS CCs operates more at the low-cost end of the per diem cost distribution than at the top. This result is due to the improved identification of the lowest-cost patients when the set of comorbid conditions identified for payment adjustment is expanded. Rather than combine the low and medium cost patients, our groups separate them, which results in more accurate payment for both.

DISCUSSION

This article develops an alternative set of comorbidity adjustors for the Medicare IPF-PPS that improves the explanatory power of the payment model by identifying additional patients whose case mix and cost may warrant additional payment. Although other studies have shown that

Table 6

Subgroup R^2 Comparisons Between IPF-PPS and Alternative Psychiatric Comorbid Group Models

Subgroup	Percent of Cases	No Comorbidity Adjustors	IPF-PPS CCs	ACGs Without Interactions	ACGs With Interactions
All Cases	100	0.314	0.319	0.324	0.327
Has IPF-PPS CC	11.0	0.252	0.299	0.295	0.299
Has ACG, no IPF-PPS CC	30.0	0.325	0.318	0.336	0.348
No ACG or IPF-PPS CC	58.9	0.318	0.321	0.323	0.324
Bottom Per Diem Cost Decile	10.0	0.462	0.472	0.48	0.488
Top Per Diem Cost Decile	10.0	0.386	0.389	0.392	0.392

NOTES: IPF-PPS CC is inpatient psychiatric facility prospective payment system comorbidity category. Subgroup R^2 values are equal to one minus the ratio of the sum of squared residuals to the sum of squared deviations from the subgroup mean, using only observations in each subgroup.

SOURCE: Drozd, E.M., Maier, J., RTI International, Hales, J. F., Cambridge Health Alliance, and Thomas, F. G., Centers for Medicare & Medicaid Services, analysis of discharges from inpatient psychiatric units and hospitals using the 2004 100 percent MedPAR file.

interacting age, principal diagnosis, secondary diagnosis, and other characteristics can improve case mix adjustment performance (Ashcraft et al., 1989; Cromwell et al., 2005; Drozd et al., 2006; and Sloan et al., 2006), we restricted only to models that were consistent with the existing system, with separate adjustments for age, length/day of stay, principal, and secondary diagnoses.

We found that the existing IPF-PPS comorbidity adjustors do identify especially high cost patients, but may be too restrictive and ignore many other patients with significantly higher-than-average costs. By reducing systematic variance in providers' margins based on patient case mix, providers would have less incentive to avoid certain types of patients or to not provide services needed by certain classes of patients. In addition, we found that patients with multiple comorbidities are less costly to treat than would be predicted from per diem cost models that treat each comorbidity's extra cost as independent. It is important to note that increased payments for certain higher-cost patients would result in lower payments for lower-cost patients in order to maintain budget neutrality.

However, the limited increase in the models' predictive power, even when an extraordinary number of adjustors are included, suggests that no set of comorbidity adjustors will purge the payment system of over- and underestimates of per diem cost. The resulting systematic positive profitability of some patients and negative profitability of others may induce facilities to engage in favorable selection for profitable patients, resulting in reduced access for the unprofitable. Significant unexplained within- and across-facility variation in costs increases the likelihood for favorable selection (e.g., closing some types of units to avoid unprofitable patients). However, identifying the true cost differences would require improvements in coding (including differentiation of unit types such as geriatric, med-psych, intensive psych) or extensive studies that still cannot be comprehensive of all facilities.

In broadening the number of secondary comorbid diagnoses, CMS must also consider the potential for unjustified code creep. Many diagnoses can be reported that are not under active care during psychiatric admission and would not justify additional payments, hence, CMS' narrow list of very serious illnesses and conditions. Since the ICD-9-CM coding scheme does not indicate whether a diagnosis is under active treatment, this is a potentially serious limitation. Excluding secondary diagnoses from consideration for determining comorbidity adjustment, as we have done, could reduce some scope for gaming. Although we have attempted to identify only more serious conditions, further research is needed on these and the current IPF-PPS CC conditions.

Finally, it should be noted that, since October 2007, the IPF-PPS has used the MS-DRGs. In general, the MS-DRGs have made DRG-based payment systems more conditional on comorbid condition severity, only five DRGs (012, Degenerative Nervous System Disorders; 023, Nontraumatic Stupor & Coma; and 521–523, Alcohol/Drug Abuse or Dependence) have been divided based on whether the patient has a major CC (MCC). These five DRGs account for about 11 percent of IPF cases (Table 3), and the number of these with an MCC are presumably much less common. Therefore, according to CMS (*Federal Register*, 2008), "…the impact of the new MS–DRGs on the IPF PPS is negligible." However, it could be possible that the MS-DRGs relevant to the IPF-PPS could be split further based on CCs and MCCs, or even reorganized, to incorporate both the DRGs and the IPF-PPS

CCs into a single set of MS-DRGs. Further research, of course, would be necessary to evaluate such a refinement.

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