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# An Evaluation of Pediatric-Modified Diagnosis-Related Groups

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*Pediatric-modified diagnosis-related groups (PM-DRGs) were designed to describe more accurately than DRGs differences in severity of illness and charges across pediatric patients. We report on an evaluation of PM-DRGs for use in prospective payment systems (PPSs). Data on pediatric discharges (i.e., patients 17 years of age or under) from 5 States and a national sample of 43 hospitals were used. PM-DRGs explained substantially more variation in resource use at the discharge level and hospital level. PM-DRGs improved classification of neonatal discharges by concentrating them into fewer categories and measuring birth weight more precisely.*

## INTRODUCTION

PM-DRGs were developed to describe variations in resource use and severity of illness across pediatric patients and the hospitals treating them more accurately than DRGs.<sup>1</sup> The development of PM-

DRGs was motivated by two concerns about DRGs. First, while the Health Care Financing Administration (HCFA) had evaluated DRGs for use as the case-mix system in the Medicare PPS, DRGs had not been tested for pediatric applications. There was evidence that the DRG system might not reflect unique clinical aspects of illness in children, particularly among severely ill newborns (National Association of Children's Hospitals and Related Institutions, 1984). Because neonates comprise 39 percent of hospital discharges among patients 14 years of age or under (excluding normal newborns) (National Center for Health Statistics, 1992), and their hospital costs are often very high (Rosenbaum, 1987; Schwartz, 1989), the sensitivity of a system to differences in resource use among neonates is critical to its performance in classifying pediatric patients. Second, few tertiary-level pediatric cases were included in the data bases used to develop DRGs (Fetter et al., 1977, 1980, 1982) or to construct payment weights for low-volume DRGs (Langenbrunner et al., 1989). Because of this, the higher costs of treating patients in these facilities may not have been adequately reflected in the DRG case-mix system or the PPS payment weights. Therefore, the DRG payment weights used in the PPS may financially penalize hospitals treating large numbers of pediatric patients (National Association of Children's Hospitals and Related Institutions, 1984; Long, Dreaschlin, and Fisher, 1986; Payne and Restuccia, 1987).

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The complete PM-DRG system consists of the pediatric categories developed by NACHRI and the original DRG categories for non-pediatric patients. Conceptually, it offers several advantages over DRGs. PM-DRGs subdivide various DRG categories and utilize several new classification variables, most notably ventilation time. Neonatal discharges are classified together instead of being dispersed into non-neonatal categories, as occurs with DRGs. PM-DRGs are potentially more sensitive to differences in birth weight, using five birth weight categories instead of the three categories used in DRGs.

PM-DRGs raise potential implementation issues, however. The PM-DRG system has 600 categories for patients of all ages, 26 percent more categories than the DRGs, contemporaneous Version 5.0. The increased number of categories could affect the "manageability" of the system (Hornbrook, 1982a; 1982b) and the stability of payment weights. The introduction of new classification variables in the PM-DRG system could increase data collection costs. In addition, the proposed use of ventilation time has raised concern among policymakers that, at the margin, it might provide an economic incentive to hospitals to increase ventilation time or record more ventilation services than were received.

There are three key components to PPSs: the case-mix system used to classify discharges; the method of determining a hospital's base or unadjusted payment; and adjustments to the base payment. The first two components use patient-level and discharge-level information, while the third component uses hospital-level information. Payment adjustments are made partially to account

for factors influencing costs that are not directly related to patient-care practice patterns (e.g., indirect teaching expenses and area wage differentials), and partially to compensate for insensitivity in the case-mix system to patient-level differences in severity of illness.

Case-mix systems which more precisely group discharges based on patient-level characteristics offer several advantages over less precise systems. Under prospective payment, more precise case-mix classification reduces the need to use hospital-level adjustments to capture patient-level differences in severity of illness and to create exceptions to the payment system, such as the exclusion of children's hospitals from the PPS. By enabling tertiary referral hospitals to classify high-risk, high-cost patients more accurately, instead of averaging their costs with other discharges, such systems reduce the chance that referral hospitals will experience certain DRGs as financial "losers" (Schwartz et al., 1989). In competitive markets, more accurate case-mix classification allows referral hospitals to describe their charges per DRG more precisely. This is advantageous for hospitals, which compete for blocks of patients through efficiency-based contracts, for payers, which need to identify the most efficient providers, and for States interested in monitoring health care expenditures.

Prospective payment for children's hospitalization is primarily a State-level issue.<sup>2</sup> Case-mix adjusted PPSs similar to

<sup>2</sup>While the Medicare population does include children, primarily eligible under the Medicare end stage renal disease (ESRD) program, the number of pediatric Medicare eligibles is quite small (approximately 3,500 persons), and the expenditures attributed to them are only about .04 percent of the Medicare budget (RAND Corporation tabulations using HCFA unpublished data for calendar year 1984).

the Medicare PPS have been adopted by 19 State Medicaid programs (Gurny, Baugh, and Reilly, 1993; Kozma, 1994) and many health maintenance organizations and Blue Cross plans, as well as the Civilian Health and Medical Program of the Uniformed Services (CHAMPUS). In some States case-mix systems are used to monitor hospital utilization and expenditures, but not for reimbursement. Five States (Massachusetts, Maine, New Jersey, New York, and Washington) have adopted the All-Patient DRG (AP-DRG) system, which incorporates PM-DRG modifications, for use in reimbursement or monitoring. However, many States continue to use the Medicare DRG case-mix classification system for prospective payment (Zimmerman and Paul, 1989). Several have followed Medicare's lead and have either excluded neonates or children's hospitals from prospective payment or given them special treatment.

We report here on the results of an evaluation of PM-DRGs that addressed the following classification and reimbursement issues:

- How do the PM-DRG and DRG systems compare in explaining variations in resource use at the discharge level?
- How much does the addition of mechanical ventilation time improve the performance of PM-DRGs in explaining variations in resource use?
- Compared with DRGs, does the larger number of categories in PM-DRGs lead to a higher proportion of categories with small numbers of discharges, which could decrease the stability of the payment weights?
- How do DRGs and PM-DRGs compare in explaining variations in resource use at the hospital level?

## DEVELOPMENT AND STRUCTURE OF PM-DRGs

Data from three sources were used to develop and refine PM-DRGs: (1) the Commission on Professional and Hospital Activities (CPHA) on 750,000 pediatric and adult hospitalizations; (2) a random stratified sample of discharges from 12 children's hospitals; and (3) routinely collected discharge data from Connecticut and Maryland.

PM-DRGs were formed by modifying several existing DRG categories based on clinical judgment and empirical analysis. Fifty-one DRGs were split or regrouped and 52 other DRGs were redefined with a pediatric emphasis. There are 600 categories in the full PM-DRG system with ventilation time and 587 categories in the PM-DRG system without ventilation time, compared with 475 categories in the DRGs, contemporaneous Version 5.0.

DRGs and PM-DRGs are similar in several respects. The goal of each is to group together discharges that are similar in clinical treatment and length of stay or charges. The classification variables in each system include age, principal diagnosis, complications and comorbidities (indicated by secondary diagnoses), operating room procedure, gender, and patient disposition (i.e., transferred, died, or other). A discharge is assigned to a major diagnostic category (MDC) in the DRG system or to a pediatric-modified MDC (PM-MDC) in the PM-DRG system to reflect the organ system and/or clinical specialty related to the principal diagnosis. The discharge is then classified into one of several hundred mutually exclusive DRG or PM-DRG categories.

PM-DRGs differ from DRGs in three ways: several new classification variables

**Table 1**  
**Overview of the Diagnosis-Related Groups (DRGs) and Pediatric-Modified DRGs (PM-DRGs)**

Classification Variables	DRGs	PM-DRGs
Adult and Pediatric Discharges	Age Gender Principal diagnosis Procedures Complications and/or comorbidities <sup>1</sup> (yes/no) Discharge status (Death)	Age Gender Principal diagnosis Procedures Complications and/or comorbidities <sup>1</sup> (yes/no) Discharge status (Death)
Neonatal Discharges	Problems divided into 3 levels, based on diagnosis: major problems, other problems, no problem  Discharge status (death, transfer)  Birth weight and gestation categories, based on ICD-9-CM codes (3 levels) Respiratory distress syndrome (yes/no)	Problems divided into 5 levels, based on diagnosis: multiple major problems, major problem, minor problem, other problem, no problem  Discharge status (early death, early transfer)  Birth weight, based on weight recorded in grams (5 levels)  Respirator time (4 levels)  Hospital of birth (yes/no) Back referral (yes/no)
First Split	Medical or surgical diagnosis	Age (Neonate or not)
Number of Categories:		
Total	475	600 or 587 <sup>3</sup>
Neonates	379 <sup>2</sup>	46 or 33 <sup>3</sup>
Definitions:		
Early Death		< 1 day of age
Early Transfer		< 4 days of stay
Respirator Use		Must be abstracted from the medical record or billing file

<sup>1</sup>Defined as a diagnosis that a panel of physicians deems would increase the length of stay by at least 1 day for 75 percent or more of the patients.

<sup>2</sup>Seven neonatal DRGs plus any of the other pediatric DRGs, depending on the principal diagnosis.

<sup>3</sup>First-listed number refers to the PM-DRG system including ventilation time; the second-listed number refers to that system without the split on ventilation time.

NOTE: ICD-9-CM is *International Classification of Diseases, 9th Revision, Clinical Modification*.

SOURCES: (Hornbrook, 1982b; Lichtig et al., 1989).

are used; age (neonate [infants aged 28 days or less] versus non-neonate) replaces principal diagnosis as the first-used classification variable; and cystic fibrosis discharges are classified into a sin-

gle category, regardless of the principal diagnosis (Table 1).<sup>3</sup> There are 46 neonatal PM-DRGs when ventilation time is included as a classification variable, and 33

<sup>3</sup>A Technical Note at the end of this article summarizes the key differences between DRGs and PM-DRGs.

when it is not. In contrast, in the DRG system neonatal discharges are grouped either into seven neonatal-specific categories or up to 372 other categories, depending on the principal diagnosis, for a total of 379 categories.

## **EMPIRICAL ANALYSIS**

### **Data Sources**

When the study began, 16 States collected and made available computerized hospital discharge abstract data. From those, we selected Maryland, New York, and Connecticut, because their data bases include birth weight in grams. There was one children's hospital in New York, one in Connecticut, and none in Maryland. Because a second objective of this study was to explore options for paying children's hospitals (Payne and Schwartz, 1991), we added California and Illinois (with 6 and 2 children's hospitals, respectively) to increase the number of children's hospitals included to 10.

Data on all discharges from general medical and surgical and children's acute care hospitals were obtained from Maryland, California, and Illinois for calendar year (CY) 1986; from Connecticut for fiscal year 1986; and from New York for CY 1987.

We also utilized national-level data from the National Perinatal Information Center (NPIC) data base. For a previous grant, 50 hospitals had been randomly selected from the universe of urban U.S. hospitals. Referral hospitals offering high-risk perinatal care in neonatal intensive care units (NICUs) were matched on bed size and teaching intensity to hospitals without NICUs. Two children's hospitals were added to the original data base, for a total of five children's hospitals. For

this study, the sample hospitals which provided data only for neonatal patients were excluded, leaving 26 hospitals with NICUs and 17 without.

One hospital was included in both the State and the national data bases, so the total number of children's hospitals in this study was 14.

Hospital discharge abstract data for 1985 were obtained from each participating hospital. NPIC supplemented routinely available data by collecting information on birth weight and ventilation time from the hospitals. Of the 43 hospitals in the NPIC data base, 35 offer ventilation services; of those, 20 provided data on ventilation time to NPIC.

Hospital-specific information on the ratio of interns and residents to beds, area wage differentials, and Medicaid disproportionate share status was obtained from the American Hospital Association (AHA) 1986 Annual Survey of Hospitals and the HCFA 1985 Medicare Provider Specific file, for use in standardizing hospital charges.

### **Variables Used**

Age, gender, race, ZIP Code, hospital, payer, diagnoses, procedures, length of stay (LOS), and charges were available in each data base. In addition, birth weight in grams for infants born in-hospital (e.g., non-transfers) was available for Maryland, Connecticut, New York, and the NPIC data base.

In the national data base, we compared the DRG, PM-DRG\*, and PM-DRGV systems. (PM-DRGV refers here to the full PM-DRG system including ventilation time, PM-DRG\* refers to the system without ventilation time, and PM-DRG is used when the distinction between the two ver-

sions is not pertinent.) Because the State data bases did not include ventilation time, we could not group State discharges into the PM-DRGV system. In the three States with birth weight data (Connecticut, Maryland, and New York), DRGs were compared with PM-DRGs\*. In the two States without birth weight data (California and Illinois), DRGs were compared with a hybrid PM-DRG system, in which neonates were classified into DRGs and all other discharges were classified into PM-DRGs\*.

### Data Preparation

We merged information by hospital from the discharge data bases, the Medicare Provider Specific file, and the AHA data base. Eight California hospitals in the discharge data base were excluded because they could not be identified on the AHA file, probably due to name changes or mergers. The remaining hospitals were classified into four types: children's, defined as those excluded from the PPS as of 1987 or a physically separate children's facility that is part of a hospital corporation; major teaching, having an interns-and-residents-to-bed (IRB) ratio of 0.25 or greater; minor teaching, having an IRB ratio greater than 0 but less than 0.25; and community, having no interns or residents.

Nationally, 1 percent of hospitals are children's hospitals (Table 2). The percentage of children's hospitals in the States studied is also 1 percent (10/956); in the national data base it is considerably higher, due to oversampling (5/43, or 12 percent).

Teaching hospitals were also oversampled for the national data base. As a result, 30 percent of the hospitals in the na-

tional data base are involved in teaching activity, compared with 23 percent nationally. The national sample hospitals tend to have higher IRB ratios than those in the country as a whole, and the proportion with NICUs and pediatric intensive care units (PICUs) is higher than the national average.

Because the NPIC hospitals were selected using multistage stratified sampling, we weighted the observations by the sampling fractions of the hospitals in the analyses related to the discharge-level explanatory power of the case-mix systems and the percent of discharges in low-volume categories. (We did not weight the State data in these analyses, because all discharges in all relevant hospitals were used.) In the hospital-level comparison of explanatory power, the unit of observation was the hospital, with each hospital in the State and NPIC data bases weighted by the number of discharges.

We excluded discharges of patients 18 years of age or over, normal newborns, and obstetrics patients (teenaged mothers) from the analysis.

In Connecticut, 14 percent of the neonatal discharges had missing birth weight data, and for an additional 13 percent, data on neonatal diagnosis and birth weight were inconsistent. Comparable figures for Maryland were 10 percent and 6 percent. (In contrast, in New York, birth weight information was missing for only 3 percent of the neonatal discharges.) Neonates with missing birth weight data are classified by the software into PM-DRG 470 (ungroupable). Including discharges with missing birth weight data in our analysis would have resulted in a large proportion of the discharges being classified

**Table 2**  
**Descriptive Information on U.S. Hospitals, State Data Bases, and the National Hospital Sample**

Hospital Characteristics	Total United States		States										National Hospital Sample	
			Connecticut		Maryland		New York		California		Illinois			
<b>Number (Percent of Hospitals)</b>														
Total	7,064	(100)	33	(100)	49	(100)	237	(100)	427	(100)	210	(100)	43	(100)
Children's <sup>1</sup>	61	(1)	1	(3)	0	(0)	1	(0)	6	(1)	2	(1)	5	(12)
Major Teaching <sup>2</sup>	266	(4)	2	(6)	4	(8)	38	(16)	19	(4)	12	(6)	13	(30)
Minor Teaching <sup>3</sup>	1,330	(19)	17	(52)	16	(33)	71	(30)	64	(15)	44	(21)	12	(28)
Community <sup>4</sup>	5,412	(76)	13	(39)	29	(59)	127	(54)	338	(79)	152	(72)	13	(30)
<b>Average Number of Beds per Hospital (Percent of Beds)</b>														
Total	174	(100)	280	(100)	273	(100)	294	(100)	166	(100)	211	(100)	472	(100)
Children's	163	(1)	98	(1)	—	NA	313	(0)	155	(1)	166	(1)	212	(5)
Major Teaching	486	(10)	635	(14)	641	(19)	709	(38)	449	(12)	582	(16)	677	(43)
Minor Teaching	333	(36)	345	(64)	328	(39)	342	(35)	262	(24)	352	(35)	423	(25)
Community	120	(53)	155	(22)	191	(42)	143	(26)	132	(63)	142	(49)	413	(27)
<b>Average Number of Pediatric Discharges per Hospital in the Study Data Set (Percent of Discharges from the Hospital Type)</b>														
Total	5,046	(100)	1,140	(100)	1,211	(100)	755	(100)	2,011	(100)	772	(100)	3,181	(100)
Children's	5,910	(1)	1,803	(5)	—	NA	6,318	(4)	2,189	(10)	5,883	(7)	10,173	(37)
Major Teaching	17,032	(13)	3,070	(16)	3,623	(24)	2,209	(47)	2,711	(20)	1,936	(14)	3,050	(29)
Minor Teaching	9,636	(36)	1,292	(58)	1,396	(38)	738	(29)	1,995	(22)	1,099	(30)	1,919	(17)
Community	3,320	(50)	593	(21)	777	(38)	285	(20)	1,971	(48)	518	(49)	1,787	(17)
<b>Average Ratio of FTE Interns and Residents to Beds</b>														
Total		.03		.09		.07		.09		.04		.04		.15
Children's		.16		.12		NA		.36		.16		.16		.18
Major Teaching		.43		.42		.41		.39		.53		.44		.34
Minor Teaching		.07		.12		.12		.10		.07		.08		.11
Community		.00		.00		.00		.00		.00		.00		.00

See footnotes at end of table.

**Table 2—Continued**  
**Descriptive Information on U.S. Hospitals, State Data Bases, and the National Hospital Sample**

Hospital Characteristics	Total United States	States					National Hospital Sample
		Connecticut	Maryland	New York	California	Illinois	
<b>Percent of Hospitals with NICUs</b>							
Total	10	21	16	17	18	12	60
Children's	64	0	NA	100	83	50	100
Major Teaching	58	50	100	63	82	75	75
Minor Teaching	22	35	21	18	32	24	64
Community	3	0	0	1	10	3	31
<b>Percent of Hospitals with PICUs</b>							
Total	5	12	9	8	8	9	36
Children's	71	0	NA	100	83	50	100
Major Teaching	38	50	50	37	76	58	42
Minor Teaching	9	18	7	6	12	19	36
Community	1	0	4	0	1	1	8
<b>Percent of Patient Days Attributed to Medicaid Patients, Hospitalwide</b>							
Total	15	8	10	16	15	13	17
Children's	29	26	NA	36	47	25	31
Major Teaching	20	10	22	28	28	24	24
Minor Teaching	19	8	10	15	14	12	10
Community	13	7	9	14	14	12	11

<sup>1</sup>Defined as hospitals that were excluded from the Medicare prospective payment system as children's hospitals in 1987 or physically separate children's facilities that are part of a hospital corporation.

<sup>2</sup>Defined as general acute-care hospitals with a ratio of interns and residents to beds of > 0.25.

<sup>3</sup>Defined as general acute-care hospitals with a ratio of interns and residents to beds of between 0.0 and 0.25.

<sup>4</sup>Defined as general acute-care hospitals with a ratio of interns and residents to beds of 0.0.

NOTES: NA is not applicable. FTE is full-time equivalent. NICU is neonatal intensive care unit. PICU is pediatric intensive care unit.

SOURCES: Payne, S.M.C., Boston University, School of Medicine, and Schwartz, R.M., National Perinatal Information Center, 1993; American Hospital Association, 1987-88.

into PM-DRG 470, distorting our assessment of the potential performance of the new system, especially in Maryland and Connecticut. We therefore deleted from study the neonatal discharges that lacked birth weight data.

The deleted discharges most likely had higher charges and longer stays than the average non-neonatal discharge,<sup>4</sup> so the deletions were probably not random, and most likely reduced the variability left to be explained in the Connecticut data base.

Charges in the State data bases for 1986 (e.g., all States except New York) were inflated to 1987 levels using a hospital-industry-specific factor obtained from the AHA (1987-88).

The total charge for each discharge was standardized to adjust for factors not directly related to patient care practice patterns, such as indirect medical education costs and area wage differentials. PPS definitions and policies for standardizing charges in effect in 1986 and 1987 were identified and followed with minor exceptions (*Federal Register*, 1983; 1987; May 27, 1988; and September 1, 1988). We used standardized charges to compare charges across hospitals, calculate standardized base payments, and calculate case-mix indexes (described later).<sup>5</sup>

## METHODS

Data from the State and NPIC samples were always analyzed separately. Each

<sup>4</sup>As evidenced by the relative charge weights for many of the non-normal neonatal DRGs (data available upon request from the authors).

<sup>5</sup>In the national data base, charges were also converted using cost-to-charge ratios in order to estimate costs (Cotterill, Bobula, and Connerton, 1986). Results using ratio of costs to charges (RCC)-adjusted charges were the same as those using LOS and charges, and so are not presented here.

analysis was conducted separately for each State, with one exception. In the hospital-level regression, we merged data from Connecticut, Maryland, and New York to increase the number of hospitals analyzed.

We conducted the analyses under two conditions: (1) excluding statistical outliers (defined as discharges with charges above or below 3.0 standard deviations of the geometric mean charge for each DRG [*Federal Register*, 1985]) and (2) including statistical outliers (i.e., using all discharges). The PM-DRG system was designed to classify outliers more sensitively, so deleting them from the analysis removes the cases that PM-DRGs are expected to explain especially well. In order to demonstrate the power of the PM-DRG system to explain resource use for all cases, we present here the results including statistical outliers.

### Explanatory Power, Discharge-Level Analysis

Ordinary least squares regression (the General Linear Models Procedure in Statistical Analysis System [SAS]) was used to assess the explanatory power of the case-mix systems, as measured by the *R*-square. One regression was run for each dependent variable: LOS; the natural log value of LOS (LNLOS); total charge (TOTCH); standardized charge (STCH); and the log value of the standardized charge (LNSTCH). The independent variables were the DRG, the PM-DRG\*, and the PM-DRGV (national data set only). The national data were weighted as previously described. Adjusted *R*-squares were calculated to account for any increase in explanatory power due to the larger number of categories in PM-DRGs\* and PM-

DRGVs compared with DRGs (Feldman, 1992; Johnson and Wichern, 1982).

We calculated the relative or percent difference in adjusted *R*-squares between the PM-DRG\* system and the DRG system as follows:

$$\frac{(R\text{-square using PM-DRGs}^*) - (R\text{-square using DRGs})}{R\text{-square using DRGs.}}$$

### *Contribution of Ventilation Time*

In this analysis we used a subset of the NPIC data base, the 28 hospitals which either: (1) provided ventilation services and provided ventilation time data to NPIC; or (2) did not provide such services. The weighting and the analysis were similar to the discharge-level analysis previously described.

### *Low-Volume Categories*

For each State and for the national data base, we calculated the number and percent of discharges in each DRG and in each PM-DRG\*. We then calculated: (1) the proportion of low-volume categories (i.e., those with small numbers of discharges) in each case-mix system; and (2) the percentage of discharges in those categories. We used 3 definitions of low volume: (1) 100 discharges or fewer; (2) 50 discharges or fewer, the minimum number used by HCFA to set payment weights using standard methods; and (3) 30 discharges or fewer, the minimum number we felt could be used to establish stable payment weights, because assumptions about normality become more problematic when the number of cases is much less than 30. In this analysis, the national data were weighted as previously described.

### *Explanatory Power, Hospital-Level Analysis*

We compared the performance of the systems in explaining variations in the average wage-adjusted charge per hospital, measured by *R*-squares. The independent variables were the natural log of the case-mix index (CMI) under each system for each hospital (abbreviated as *ln* CMIPMDRG\* and *ln* CMIDRG).

The CMI is a discharge-weighted measure of the relative costliness of the patients treated in a hospital. We calculated the case-mix index for each hospital as follows: First, for each data base we calculated the average standardized charge for each DRG by dividing the total standardized charges for the DRG by the number of discharges in that DRG. The relative charge weight (RCW) for each DRG (designated by DRGi) was then computed as follows:

$$\text{RCW for DRGi} = \frac{\text{Average standardized charge for DRGi}}{\text{Average standardized charge for all DRGs}}$$

The process was then repeated using PM-DRGs\* and PM-DRGVs (national data base only).

The case-mix index for each hospital was calculated by: (1) assigning the calculated RCW to each discharge, based on the DRG into which the discharge was classified; (2) summing the relative charge weights for all discharges treated in the hospital; and (3) dividing by the number of discharges treated in the hospital. As per HCFA procedures, discharges classified as statistical outliers were excluded in calculating relative cost

weights to avoid distortion of the weights by extreme values; they were included in calculating the hospital's case-mix index. For each hospital we calculated separate case-mix indexes using DRGs and PM-DRGs\*.

Ordinary least squares regression was used. Two separate analyses were conducted, the first using pooled data from the three States (Connecticut, Maryland, and New York) that include birth weight and the second using the national data base. In each analysis, the unit of observation was the hospital, weighted by the number of discharges from each hospital. There were 319 hospitals in the State data base and 43 in the NPIC data base.

## FINDINGS

### Explanatory Power, Discharge-Level Analysis

The amount of variability explained using DRGs was relatively low across the data bases (Table 3). For example, for LOS the highest *R*-square was .3125, and for standardized charges (STCH) the highest *R*-square was .2700 (both in Connecticut).

Marked improvements in the *R*-square values using PM-DRGs\* were apparent for each data set. The greatest improvements occurred in Maryland and the NPIC data sets, where the *R*-squares for LOS increased by 62 percent and 70 percent, respectively, when PM-DRGs\* were used. Improvements were even higher for STCH (75 percent in Maryland and 98 percent in the NPIC data set). Improvements in New York were somewhat lower but still appreciable (46 percent for LOS and 41 percent for STCH). Improvements in Connecticut (25 percent for LOS and 49 percent for STCH) were lower than in Maryland and

the NPIC data base. This may be due to the problems previously discussed with birth weight data in Connecticut. As noted previously, the deleted discharges most likely had higher average charges than non-neonatal discharges, so deleting them reduced the variability left to be explained by the PM-DRG\* system. In California and Illinois, the improvements were much smaller, probably because DRGs were used for newborns due to lack of birth weight data.

The improvement from using PM-DRGs\* was not as dramatic for log-transformed as for untransformed variables. This was expected, because log transformation reduces the impact of extreme values. In the PM-DRG\* system, extremely long LOSs or high charges are handled by the grouper specifically and, as a result, there is much less impact from using a log transformed value.

### *Contribution of Ventilation Time*

In the 28 hospitals from the NPIC data set for which we had information on mechanical ventilation time, only 8 percent of the discharges studied (8,066/97,604) were in PM-DRGs involving ventilation time. Of those, only 1 percent (999) of the discharges were classified into a different category when the full PM-DRGV system (i.e., with ventilation time) was used instead of PM-DRGs\*. Discharges involving mechanical ventilation had significantly longer average LOS and cost ( $p < .0001$ ) than discharges not involving ventilation. However, adding ventilation time as a classification variable to PM-DRGs resulted in only marginal improvements in *R*-squares across all the discharges, from .3602 to .3738 for LOS (a 4-percent increase) and from .3170 to

**Table 3**  
**Comparison of Diagnosis-Related Groups (DRGs) and Pediatric-Modified DRGs\* (PM-DRGs\*) in Explaining Variations in Discharge-Level Length of Stay (LOS) and Charges: State and National Data**

LOS and Charges	States					
	Connecticut	Maryland	New York	California	Illinois	National Data <sup>1</sup>
Number of Discharges	37,891	59,901	179,997	335,706	163,125	136,780
<b>LOS</b>			<i>Adjusted R-square</i>			
DRG	.3125	.2861	.2432	.1886	.2426	.2162
PM-DRG*	.3894	.4643	.3545	.2008	.2585	.3682
Percent Difference <sup>2</sup>	25	62	46	6	7	70
<b>Standardized Charge</b>						
DRG	.2700	.2411	.2600	.1379	.1830	.1793
PM-DRG*	.4035	.4226	.3672	.1579	.2079	.3553
Percent Difference	49	75	41	15	14	98
<b>Log of LOS</b>						
DRG	.4385	.4606	.3691	.3516	.3447	.4235
PM-DRG*	.4807	.5173	.4283	.3681	.3615	.4955
Percent Difference	10	12	16	5	5	17
<b>Log of Standardized Charge</b>						
DRG	.4084	.4738	.3080	.3212	.3254	.4041
PM-DRG*	.4550	.5394	.3778	.3385	.3426	.4836
Percent Difference	11	14	23	5	5	20

\*Not including ventilation time.

<sup>1</sup>The weighted data set was used. Discharges from 43 hospitals were included.

<sup>2</sup>Percent difference calculated as  $([R\text{-square using PM-DRGs}^*] - [R\text{-square using DRGs}]) / ([R\text{-square using DRGs}])$ .

SOURCE: Payne, S.M.C., Boston University School of Medicine, and Schwartz, R.M., National Perinatal Information Center, 1993.

.3505 for STCH (an 11-percent increase) (Table 4). As before, when the log values were used, PM-DRGs did not offer as great an improvement in *R*-squares as when untransformed values were used.

### Low-Volume Categories

The percent of discharges in low-volume categories changed very little when PM-DRGs were used (Table 5). In the State data bases, using PM-DRGs\* instead of DRGs would result in an increase of 4 percentage points or less in the proportion of discharges in low-volume categories. In some data bases, depending on

the definition of low volume, PM-DRGs\* actually reduced the percent of low-volume categories.

Neonates were grouped into 45 PM-DRGVs (national data) and 30 to 32 PM-DRGs\* (State and NPIC data) (Table 6). In contrast, DRGs dispersed neonates over a much larger number of categories (a mean of 67 categories in the study data bases, with a range of 24 to 147).

### Explanatory Power, Hospital-Level Analysis

*R*-squares increased from .5028 using DRGs to .5936 using PM-DRGs\* in the State data bases. Comparable figures for the NPIC data base were .5552 and .7395. Thus, use of PM-DRGs\* increased the *R*-squares by 18 percent and 33 percent in the State and NPIC data bases, respectively.

The performance of PM-DRGs\* in the NPIC data vis a vis the State data is probably influenced by the analytical method used. As previously discussed, the unit of observation in this analysis is the hospital, not weighted by the sampling fraction; teaching hospitals and hospitals with NICUs were over-sampled for the NPIC data base. To the extent that such hospitals had more non-normal neonatal discharges than other hospitals, and that PM-DRGs\* classify such discharges more accurately than DRGs, the relative performance of PM-DRGs\* will be greater in the national data base than in the States.

## DISCUSSION

### Summary

We used discharge data for pediatric patients from 5 States and a national sam-

Table 4

**Comparison of DRGs, PM-DRGs\*, and PM-DRGVs in Explaining Variations in Discharge-Level Length of Stay (LOS) and Charges: National Data<sup>1</sup>**

Length of Stay and Charges	Adjusted <i>R</i> -Square	Percent Difference
<b>LOS in Days</b>		
DRG	.2310	
PM-DRG*	.3602	<sup>2</sup> 56
PM-DRGV	.3738	<sup>3</sup> 4
<b>Standardized Charge</b>		
DRG	.1822	
PM-DRG*	.3170	74
PM-DRGV	.3505	11
<b>RCC-Adjusted Charge</b>		
DRG	.1938	
PM-DRG*	.3266	68
PM-DRGV	.3564	9
<b>Natural Log Value of LOS</b>		
DRG	.4391	
PM-DRG*	.5028	15
PM-DRGV	.5055	( <sup>4</sup> )

<sup>1</sup>The weighted data set was used. Hospitals that provided ventilation services but did not submit ventilation time data were excluded. There were 97,604 discharges from 28 hospitals.

<sup>2</sup>The percentage difference in explanatory power, indicated by the *R*-square, of PM-DRG\*s compared with DRGs.

<sup>3</sup>The percentage difference in explanatory power, indicated by the *R*-square, of PM-DRGVs compared with PM-DRGs\*.

<sup>4</sup>Less than 1 percent.

NOTES: DRG is diagnosis-related group. PM-DRG is pediatric modified diagnosis-related group. PM-DRG\* does not include ventilation time. PM-DRGV does include ventilation time. RCC is ratio of costs to charges.

SOURCE: Payne, S.M.C., Boston University School of Medicine, and Schwartz, R.M., National Perinatal Information Center, 1993.

**Table 5**  
**Percent of Low-Volume Categories (With Small Number of Discharges) and Percent of Discharges in Low-Volume Categories: Connecticut, Maryland, New York, and National Data**

Location	Number of Discharges/ Number of Categories	Percent of Low-Volume Categories			Percent of Discharges in Low-Volume Categories		
		<30	<50	<100	<30	<50	<100
<b>Connecticut</b>							
<i>n</i>	37,891	—	—	—	—	—	—
DRG	322	59	68	78	5	8	14
PM-DRG*	387	60	69	81	6	10	18
<b>Maryland</b>							
<i>n</i>	59,901	—	—	—	—	—	—
DRG	351	56	68	78	4	6	10
PM-DRG*	419	55	66	79	4	7	13
<b>New York</b>							
<i>n</i>	179,997	—	—	—	—	—	—
DRG	359	33	44	57	1	2	4
PM-DRG*	437	32	41	57	1	2	5
<b>National<sup>1</sup></b>							
<i>n</i>	136,780	—	—	—	—	—	—
DRG	371	31	43	57	1	2	4
PM-DRG*	429	27	39	53	1	2	5
PM-DRGV	442	28	39	54	1	2	5

<sup>1</sup>The weighted data set was used.

NOTES: DRG is diagnosis-related group. PM-DRG is pediatric-modified DRG. PM-DRG\* does not include ventilation time. PM-DRGV does include ventilation time.

SOURCE: Payne, S.M.C., Boston University School of Medicine, and Schwartz, R.M., National Perinatal Information Center, 1993.

Table 6

**Number of Total Categories, Pediatric Categories, and Neonatal Categories into Which Discharges Were Classified: Connecticut, Maryland, New York, and National Data**

Case-Mix System	All Categories	Pediatric Categories <sup>1</sup>			Neonatal Categories <sup>2</sup>		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean
DRGs	475	322	370	350	24	147	67
PM-DRGs*	587	387	437	429	30	32	31
PM-DRGVs	600	—	—	442	—	—	45

<sup>1</sup>Categories that are specific to children (e.g., "age < 29 days" or "age 0-17 years") or for which no age is specified.

<sup>2</sup>Categories for patients aged 0-28 days.

NOTES: DRG is diagnosis-related group. PM-DRG is pediatric-modified DRG. PM-DRG\* does not include ventilation time. PM-DRGV does include ventilation time.

SOURCE: Payne, S.M.C., Boston University School of Medicine, and Schwartz, R.M., National Perinatal Information Center, 1993.

ple of 43 hospitals to compare the performance of PM-DRGs and DRGs. We found that, in data bases with birth weight information, PM-DRGs without ventilation time (PM-DRGs\*) explained 25 percent to 70 percent more of the discharge-level variation in LOS than DRGs and 41 percent to 98 percent more of the variation in standardized charges. Ventilation time increased the observed *R*-squares for average LOS and charges by 4 percent and 11 percent, respectively, in a subanalysis of 28 hospitals. At the hospital level, we found that the case-mix index calculated using PM-DRGs\* explained 18 percent to 33 percent more of the variation in average wage-adjusted charge than the index using DRGs, a less dramatic improvement than we observed at the discharge level. Contrary to expectations, neonatal discharges were classified into fewer PM-DRGs\* than DRGs, and the larger number of PM-DRG\* categories did not increase the proportion of discharges in low-volume categories.

The *R*-squares we observed are somewhat higher than those in an earlier NACHRI comparison of DRGs and PM-DRGs (then called Children's DRGs [CDRGs]), although the relative differences between the two systems observed by NACHRI

are comparable to our results. NACHRI calculated *R*-squares for both systems using data from 84,000 pediatric discharges in 12 children's hospitals (National Association of Children's Hospitals and Related Institutions, 1986). *R*-squares for LOS were .19 and .24 using DRGs and CDRGs, respectively, a 26-percent difference; for charges they were .16 and .22, a 38-percent difference (based on untrimmed data, i.e., including outliers).

The fact that PM-DRGs\* performed substantially better than DRGs in the study data bases with birth weight data compared with those without such data (California and Illinois) suggests that much of the improvement in explanatory power of PM-DRGs\* we observed is due to the reclassification of neonatal discharges. Two other studies of neonatal discharges support this conclusion. In the 1986 NACHRI study of neonatal patients, CDRGs resulted in a 75-percent increase in *R*-square for LOS (from .16 to .28) and a 150-percent increase for charges. A study done by one of the authors (Schwartz, 1991), which examined non-normal newborn discharges from tertiary perinatal facilities and non-tertiary facilities (those without a neonatal intensive care unit), showed that PM-DRGs\* increased explanatory power substantially.

For example, using LOS as the measure, the model *R*-square increased from .25 to .50 (100 percent) in tertiary facilities and from .10 to .45 (350 percent) in the non-tertiary facilities.

### Limitations of the Study

Several caveats are in order. First, the States were not selected randomly, which may limit the generalizability of the findings. Due to the availability of birth weight data, Connecticut and Maryland were used both to develop PM-DRGs and in this evaluation. Second, we did not have data on actual hospital costs and lacked RCC-adjusted charges for the State data bases, so we could not estimate the impact of PM-DRGs on costs. There is evidence, however, that RCC-adjusted costs are highly correlated with charges (Cottrell, Bobula, and Connerton, 1986) although recent charge data may not be as highly correlated with costs (Price, 1989). The correlation between unadjusted and RCC-adjusted charges in the 12 children's hospitals in the NACHRI classification system project was .985 (National Association of Children's Hospitals and Related Institutions, 1986). Third, Maryland and New York had all-payer hospital reimbursement systems in place during the study years. The direction and magnitude of any bias thus introduced is not clear, however, and these two States are not consistently similar to each other nor distinct from the others in terms of findings related to charges. Fourth, the facility-specific data obtained from the AHA is not corroborated or audited, and the information on the IRB ratio may be inaccurate. We have assumed that any errors in the IRB ratio are random. Finally, as mentioned previously, discharges with miss-

ing birth weight were excluded. In Connecticut and Maryland the quality of birth weight data was a substantial problem. If birth weight data had been more complete and consistent in those States, the performance of the PM-DRG\* system would probably have been better than observed, because PM-DRGs were developed to classify more accurately high-cost discharges.

It is important to note here that, by studying only pediatric patients and excluding normal newborns, the impact of PM-DRGs was exaggerated, especially for hospitals that treat adult as well as pediatric patients. Pediatric patients including normal newborns constitute only 19 percent of the general acute-care case-load (National Center for Health Statistics, 1992). Normal newborns are a large proportion of pediatric discharges (35 percent of the discharges of all patients 14 years of age or under in 1987). They are relatively homogeneous by definition and are treated similarly in the two case-mix systems. The difference in performance between the two systems will be less for hospitals treating a large proportion of adults and/or normal newborns than observed in our study data bases.

### Implementation Issues

The differences between the PM-DRG and DRG systems have several ramifications. Because of the classification of all neonatal discharges into a single neonatal PM-MDC, the creation of additional neonatal-specific PM-DRGs, and the use of five instead of three birth weight categories, PM-DRGs can more accurately describe resource use among high-risk, high-cost newborns. This would be expected to increase the accuracy of the re-

imbursement for those non-normal newborn stays with higher than average charges that do not qualify as cost or LOS outliers, and for neonatal discharges classified as outliers for which the outlier payment is insufficient to cover actual costs.

Depending on the purpose, different components of the new system could be adopted. Payers could adopt only the neonatal PM-DRGs\*, as the CHAMPUS program did. This would maximize sensitivity to resource use but avoid increasing the number of categories in the system and any potential incentive to increase the use of or reporting of ventilation time. Hospitals, researchers, and evaluators could use all the PM-DRG\* or PM-DRGV categories for managing services or analyzing case mix.

Two modifications of DRGs are available that incorporate selected PM-DRG categories. AP-DRGs incorporate all the PM-DRG neonatal categories and some of the non-neonatal categories. Birth weight is defined using either *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)* codes or birth weight in grams. Use of mechanical ventilation is included as a classification variable, but there is no differentiation by length of ventilation. All-Patient-Refined DRGs (APR-DRGs) include a more detailed severity measure than is used for DRGs or AP-DRGs. All the PM-DRG categories are incorporated, and the PM-DRG categories for mechanical ventilation are used (including the length of ventilation). Both the AP-DRG and APR-DRG systems group neonates into a single MDC based on age.

Birth weight is an extremely powerful predictor of neonatal charges and LOS. However, birth weight in grams is not in-

cluded in most routinely collected hospital discharge data sets at this time.<sup>6</sup> Our findings and those of Brunskill (1990) suggest that hospitals have not consistently or completely entered birth weight information on discharge abstracts. This suggests that case-mix based reimbursement is best introduced with advance notice, to allow the hospitals to improve their data collection and recording efforts, so that high-risk neonatal cases can be classified appropriately in calculating relative payment weights and determining reimbursement, and birth weight for transferred patients can be captured.

The relatively small marginal improvement resulting from adding ventilation time to the classification system, in conjunction with the additional data collection required and payer resistance to the use of procedures as a reimbursement variable, argue against adding ventilation time to the classification system for reimbursement, although it may be useful for research and internal management.

Case-mix systems such as DRGs and PM-DRGs first gained prominence in the health policy arena because of their use in PPSs. Refinements in case-mix classification will continue to be important in prospective reimbursement. In the future, case-mix systems that describe utilization and costs with greater precision will also play an important role in managed care settings and markets in which prices are established competitively. The improved performance of the PM-DRG system in explaining resource use suggests that it is preferable to DRGs for use by

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<sup>6</sup>Recent refinement of the ICD-9-CM codes for prematurity and low birth weight, which have many more weight categories, have been introduced, but the accuracy and completeness with which they are used has not been evaluated.

both payers and hospitals in describing, monitoring, and reimbursing pediatric hospitalization.

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## TECHNICAL NOTE

### Summary of Key Differences Between DRGs and PM-DRGs<sup>7</sup>

#### *New Classification Variables*

PM-DRGs incorporate several classification variables not used in DRGs: age at death, age at transfer, hospital of birth, back referral or down transfer (i.e., transfers from tertiary to non-tertiary hospitals), and duration of mechanical ventilation. Birth weight, which is strongly related to neonatal costs and LOS (McCarthy et al., 1979; Phibbs, Williams, and Phibbs, 1981; Boyle et al., 1983; Schwartz,

1989; National Center for Health Statistics, 1992), is handled differently in the two systems. DRGs use ICD-9-CM diagnostic codes to create three birth weight categories, and PM-DRGs use birth weight recorded in grams to make five weight categories.

#### *Age, the Pre-Eminent Classification Variable*

In the DRG system, discharges are first classified into an MDC based on the principal diagnosis and then into a DRG based on the principal diagnosis, operating room procedure, complications and comorbidities, age, and disposition. A neonatal discharge is assigned to 1 of the 7 DRGs comprising MDC 15 (Normal Newborns and Other Neonates with Conditions Originating in the Perinatal Period) if the principal diagnosis is specific to neonates. However, it will be assigned to any one of a number of other MDCs if the principal diagnosis is condition- or procedure-specific. In contrast, in the PM-DRG system, age is the first classification variable applied. All discharges of neonates (patients 28 days or of age or younger at admission) are classified into the single neonatal PM-MDC. Other discharges are then assigned to one of the remaining non-neonatal PM-MDCs. For example, an infant with a principal diagnosis related to a cardiac problem will be assigned to MDC 5, Disease and Disorders of the Circulatory System, and an infant with a principal diagnosis specific to newborns, such as perinatal jaundice, will be assigned to MDC 15. In the PM-DRG system the discharges previously described would both be assigned to PM-MDC 15, Newborns and Neonates, based on their age.

<sup>7</sup>This section draws heavily on Lichtig et al., 1989.

## ***Cystic Fibrosis Discharges Grouped Together***

Discharges of children with cystic fibrosis are assigned to any one of a number of DRGs based on their principal diagnosis, which may or may not relate to cystic fibrosis. In the PM-DRG system, discharges with any diagnosis (principal or subordinate) of cystic fibrosis are grouped together into PM-DRG 298.1: Cystic fibrosis as any diagnosis, age < 18.

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