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PMCs—An Alternative to DRGs for Trauma Care Reimbursement

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Payments made for inpatient trauma care were compared using two different patient classification systems—Patient Management Categories (PMCs) and Diagnosis Related Groups (DRGs). Two databases were used in this study: 1) estimated costs for all inpatient claims from one large payor for adult injured patients (n = 5,256) treated at 79 acute care facilities (trauma centers and non-trauma centers) in one geographic region; and 2) hospital charges from statewide, all-payor Maryland data, including 25,987 adult injured patients. The accuracy of PMCs and DRGs in predicting actual costs was examined by level of injury severity and by types of hospital, trauma center vs. non-trauma center. Level of injury (minor, single significant, multiple significant, and major) were defined and operationalized using PMCs. Overall, both DRG and PMC payment systems were nearly equal to the actual costs associated with all injured patients. This relationship can be designed into the weighting scale used for payment. The distribution of DRG payments by injury severity level, however, is not reflective of the differential resources required to manage each patient type. In particular, multiple injuries and major injuries that require the specialized services of a trauma center were inaccurately categorized by DRGs and systematically underpaid by 21.0% to 39.0% by DRG payment. By contrast, the Patient Management Category System classifies patients into more clinically specific and accurate categories and offers a more equitable method of distributing payments by injury severity. These same relationships were also found at the hospital level, demonstrating the potential for use of PMCs as an equitable and viable alternative.

In recent years, much attention has been focused on inner city trauma centers because of the high costs of treating large numbers of indigent trauma patients. Although the financial consequences of providing care to uninsured patients appear to be significant, the equity of hospital payment systems for insured injury patients requires similar attention. Since many injured patients have some form of health or accident insurance, the payment methods used by large payors (e.g., Medicare, Medicaid, Blue Cross, auto insurers) can have a significant impact on the financial stability of acute care hospitals, especially those that treat a large number of trauma patients.

In 1983, with health care costs rising uncontrollably, the Health Care Financing Administration (HCFA) changed its method of reimbursement to hospitals for the inpatient care of Medicare beneficiaries from a retrospective cost-based system to a prospective per case payment rate based on Diagnosis Related Groups (DRGs). Since the implementation of this DRG-based Prospective Payment System (PPS) by the federal government, several private payors and state governments have also implemented similar prospective or case mix adjusted payment systems using DRGs for the general inpatient population. At least one state (Pennsylvania) has even mandated the use of DRGs for payment of all claims associated with motor vehicle accidents.

Studies have shown that, for certain types of injuries such as those admitted for intensive care, DRG payment does not cover the cost of care (1, 2). Other authors, using different samples of patients, have concluded that the use of DRGs for trauma care reimbursement may be acceptable (3). The results of these studies are not convincing, however, because they are limited to single hospitals or selected injuries and patient populations within single institutions. In fact, HCFA contends that any DRG payment inadequacies that exist are acceptable as long as they are spread across all hospitals in a random fashion and as long as they do not affect a particular class of hospital differentially.

In two large multi-hospital databases, this study examines whether there are types of hospitals that are systematically disadvantaged or underpaid because of

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the inaccurate classification of injuries by DRGs. These results are compared with the financial impact of a payment system based on Patient Management Categories (PMCs), an alternative patient classification that has been shown to identify injuries more accurately than DRGs (4).

BACKGROUND

Although both of the patient classifications examined here, PMCs and DRGs, are diagnosis-based patient classifications, there are some fundamental differences between the two systems. The DRG classification does not specifically or separately identify injuries. Instead, injured patients are assigned DRGs that include other diseases and disorders, making it difficult to clearly identify a subset of DRGs that might be useful in monitoring the incidence or the costs of hospitalized injuries (4). In addition, the DRG computerized algorithm or grouper assigns only one DRG to a patient record, even if the patient has multiple injuries. Complications and comorbidities are therefore not specifically identified by DRGs. In an attempt to address this limitation, four new DRGs for multiple trauma have been proposed by HCFA and are scheduled for release in October 1990. As part of this study, the investigators developed software to replicate the proposed DRG modifications. As shown by subsequent analyses, the proposed multiple trauma DRGs do not appear to make a significant difference in the classification or payment results presented.

In contrast to DRGs, PMCs were first defined by physicians and then applied to data. The PMCs combine all of the important dimensions of case mix—clinical specificity, severity, and comorbidity—into one system. Additionally, the intensity of hospital resources required to manage each clinically specific patient type is measured. The overall PMC Classification, consisting of 852 diagnosis-based categories, is particularly suited for trauma care analyses since it assigns up to 20 PMCs to a patient record, identifying multiple injuries, comorbidities, and complications. Within the PMC Classification, there are 126 injury PMCs that were refined for injury and trauma analyses under NCHSR Grant Number HS 05532-02 (1986–1989).

The 126 injury PMCs have been aggregated into the following injury areas for analysis purposes:

Head injuries
Maxillofacial injuries
Spine injuries
Abdominal injuries
Thoracic injuries
Upper extremity injuries
Lower extremity injuries
Femur/pelvic fractures
Burn injuries
Ophthalmic injuries
Physical/chemical injuries

Each of the 126 injury PMCs is also assigned to one of the following three levels of severity that will be used in this study: 1) minor injuries, 2) significant injuries, and 3) major or tertiary injuries. Note that both the significant and major injury categories may be further subdivided to identify patients with single versus multiple injuries. The level of injury and additional criteria for defining major trauma patients were defined by trauma surgeons as part of the NCHSR project and are displayed in Appendix A for the 126 injury PMCs.

Associated with each PMC is a Patient Management Path, which delineates services required for the effective care of a typical patient in that category. The Patient Management Path for PMC 3508, Head Injury: Hematoma/Edema with Moderate/Prolonged LOC without Operation is shown in Figure 1. A relative intensity score (PMC-RIS), which is a means of measuring injury severity, is derived for each patient based on the relative costs of the services required for effective care of that patient type and listed on the path.* For the patient with multiple injuries, comorbidities, or complications, the relative intensity score reflects the types and degree of services required for the effective care of all conditions of the patient. This is accomplished by meshing the costs of the overlapping services (counting them only once) and combining them with the cost of the unique services associated with each condition. This is in sharp contrast to the DRG weight, which is an empirically derived relative value that is based on average charges for patients assigned to that DRG.

Although the data elements used by both PMCs and DRGs are the same, there is a critical difference in the way *ICD-9-CM* diagnosis and procedure codes are used by each of the two computerized patient classification systems. The DRG assignment to a patient record is primarily driven by the one diagnosis code identified as principal on the patient's discharge abstract even though secondary diagnoses are used in some cases. By contrast, the PMC grouper disregards the sequence of diagnoses and procedures in making appropriate PMC assignment(s). An example of the consequence of these differences in the two classification algorithms is shown by the patient abstract in Figure 2.

In this example, the PMC Software scanned all coded *ICD-9-CM* diagnoses and procedures to identify the two injuries sustained by the patient, as well as the pneumonia and septicemia conditions. The DRGs, however, based on the principal diagnosis, identified only the head injury and disregarded the fractured radius and the other comorbid and complicating conditions. Note the difference in the relative values assigned by the two systems: PMC-RIS of 6.516 versus a DRG relative weight of

* The PMC Classification can also be used with other weighting systems, such as an empirically derived scale that reflects actual resources used rather than the expected resources identified on the Patient Management Path and used in the derivation of the PMC-RIS.

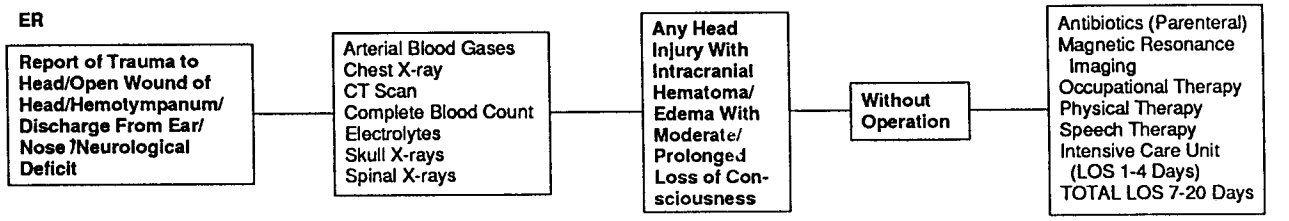

FIG. 1. Patient Management Path for PMC 3508 Head Injury: Hematoma/Edema with Moderate/Prolonged LOC without Operation.

Sample Patient Discharge Abstract

ICD-9-CM Diagnoses

852.45	Extradural Hemorrhage Following Injury, with Prolonged LOC
813.07	Other Unspecified Closed Fracture of Proximal End of Radius
510.90	Empyema without Mention of Fistula
038.10	Staphylococcal Septicemia
482.40	Pneumonia Due to Staphylococcus

ICD-9-CM Procedures

01.18	Other Diagnostic Procedures on Brain and Cerebral Meninges
79.32	Open Reduction of Fracture of Radius and Ulna with Internal Fixation
34.51	Decortication of Lung

Patient Management Categories (PMCs)

3508	Head Injury: Hematoma/Edema with Mod/Pro LOC without Operation
2911	Upper Extremity: Closed Fracture Forearm/Wrist with ORIF
2404	Respiratory Disorder: Pneumonia with Effusion/Empyema
5004	Complication: Septicemia

PMC-RIS: 6.516

Diagnosis Related Group (DRG)

27 Traumatic Stupor and Coma, Coma > 1 hr.

DRG Relative Weight: 1.3209

FIG. 2. PMC and DRG classification.

1.3209 (each scale has a base of 1.0 for all hospitalized patients, not just injury patients). The PMCs not only identified the patient's condition more precisely than DRGs, but the relative intensity weight is more reflective of the extensive resources required to manage this patient.

DATA AND METHODS

Two major databases are used in this study. The first and primary analysis was completed on fiscal 1989, non-Medicare UB-82 paid claims data from one large payor. This database will be referred to as non-Medicare 1989. Patients in this database were discharged from 79 acute care facilities (trauma centers and non-trauma centers) in one geographic region. The second database used was calendar year 1988 all-payor data from the state of Maryland. This secondary data source, referred to as Maryland all-payor, was introduced to replicate the findings of the study on a larger but less precisely constructed database of hospital charges.

Both of these databases include patient data such as age, sex, *ICD-9-CM* diagnoses (up to 5), and procedures (up to 3), as well as some financial data such as hospital charges in total, and by ancillary service. Estimated costs were derived at a patient level for the non-Medicare 1989 database by multiplying patient charges by hospital-specific cost-to-charge ratios (from Medicare cost reports). The cost of capital and direct medical education costs were also removed from charges, based on hospital-specific ratios derived from data available in hospital cost reports. None of these adjustments were made on the Maryland all-payor data. The state of Maryland, however, is a rate setting state and thus hospital charges are presumably more comparable across hospitals than in other states and regions.

The DRGs and PMCs were assigned to each inpatient record in each database using the respective patient classification software. The PPS' DRG relative weights (empirically derived) were assigned to each patient record based on its DRG assignment. Similarly, the PMC relative intensity score (PMC-RIS), reflecting expected resources, was appended to each record based on the PMC(s) assigned to the patient.

To construct prospective payment systems for PMCs and DRGs, the total costs, total PMC-RIS units, and the total DRG weights were computed for each inpatient

database. By dividing the total PMC-RIS units into the total costs, a single multiplier was derived representing the payment amount for a PMC-RIS equal to 1.0. Accordingly, at the patient level, the PMC unit payment was multiplied by each patient's PMC-RIS to compute the PMC prospective payment for that patient. Using the inpatient database, a similar dollar value for the DRG weight when it equals 1.0 (unit price) was computed and subsequently applied to the patient-level DRG relative weight to compute the DRG prospective payment for each patient in each database.

Because PMCs identify injuries more accurately than DRGs (4), PMCs were used to identify injuries in each database and classify them by severity level. A total of 5,256 adult injured patients (age ≥15) in the non-Medicare 1989 database and 25,987 adult injured patients (age ≥15) in the Maryland all-payor database were identified for analysis. Extreme cost outliers and patients with a discharge disposition of transfer were excluded from these analyses because they are typically handled separately in prospective payment systems.

RESULTS

Using the Injury PMCs and their associated injury severity levels shown in Appendix A, the 5,256 injury patients in the non-Medicare 1989 database were separated into four levels of injuries: 1) minor injuries, 2) single significant injuries, 3) multiple significant injuries, and 4) patients with at least one major or tertiary injury. The distribution of these patients by injury severity level, with their average PMC-RIS and DRG relative weight, is shown in Table I. Of the 5,256 injury patients, 1,333 had only one minor injury, with an average PMC-RIS of 0.745, compared with the 458 injured patients with major (or tertiary) injuries who had an average PMC-RIS of 3.481. This represents a difference in the average score values of 367%. By contrast, the DRG relative weights have a more compressed range, with an average weight for minor injury patients of 0.691 and 1.679 for the major injury patients, a difference of 143%.

Overall, the average DRG weight for all patients in this database (0.909) indicates that these injured patients are slightly less resource intense and costly than the average patient in HCFA's Medicare database (1.0). These same injured patients are expected to be 37% more resource intense and costly than the average patient (1.0) based on the complexity of these patients as measured by PMCs.

For each patient in the database, an estimated cost was derived by the method described above. These patient level costs were regressed on the patient's PMC-RIS and the patient's DRG weight. This procedure was completed for all patients, and for patients treated in Level I trauma centers versus all other acute care facilities. The results shown in Table II indicate that the PMC-RIS values explain a greater proportion of the variance in patient costs than DRG weights. Surprisingly, both PMCs and DRGs explain a greater proportion of the variance in patient costs in trauma centers versus non-trauma centers.

As described previously, using the patient related costs (excluding capital and teaching) associated with all patients (injured as well as non-injured patients) along with the PMC and DRG relative values, respectively, a PMC unit price and a DRG unit price were derived. It is this PMC and DRG unit price that is multiplied by each patient's PMC-RIS and DRG weight to obtain the overall financial impact of a payment system using each classification as a base.

Table III shows the distribution of estimated costs and the prospective PMC and DRG payments by level of injury. The total estimated cost for the 5,256 injured patients in the non-Medicare 1989 database was $12,600,882. Overall, the simulated prospective PMC payment was only 0.2% greater than the actual total costs for all patients, whereas the total prospective DRG payment was less than the actual cost by 2.7%.

Results indicate that DRG-based payment is substantially lower than the costs of care for both multiple significant injuries (21.4%) and major injuries (38.9%). On average, an acute care facility if paid under DRGs would lose $2,714 on each major or tertiary injury patient. Conversely, under the DRG system, hospitals would gain an average of $260 for each minor injury admitted.

By contrast, even though the PMC payments are almost equivalent to costs overall, hospitals would lose approximately $214 per minor injury under the PMC system. This is primarily due to the fact that, in the PMC system, minor injuries have very low weights, reflecting the expectation of few resource requirements. In some cases, the PMC-RIS actually reflects ambulatory management to encourage the lower cost treatment mo-

TABLE I
Distribution of injured patients and average intensity weights by level of injury

PMC Injury Severity Level	Discharges		Average PMC-RIS	Average DRG Weight
	Number	Percent		
Minor	1,333	25.4%	0.745	0.691
Single Significant	3,122	59.4	1.257	0.879
Multiple Significant	343	6.5	1.997	1.021
Major	458	8.7	3.481	1.679
Overall	5,256	100.0%	1.369	0.909

TABLE II
Variance in costs explained by PMCs and DRGs: non-Medicare data

Type of Facility	Patient Management Categories (PMCs)		Diagnosis Related Groups (DRGs)	
	R-Square	F-Value	R-Square	F-Value
Non-trauma Centers	0.2918	1758.99	0.1618	822.05
Trauma Centers	0.4853	927.79	0.3082	433.52
Overall	0.3850	3288.57	0.2073	1368.30

TABLE III
Prospective PMC and DRG payments by injury level: non-Medicare data

Injury Level	Actual Costs	Patient Management Categories (PMC)			Diagnosis Related Groups (DRG)		
		Total Payment	Percent per Case Over/(Under) Costs (%)	Payment per Case Over/(Under) Costs	Total Payment	Percent per Case Over/(Under) Costs (%)	Payment per Case Over/(Under) Costs
Minor	$2,027,913	$1,741,731	(14.0)	($214)	$2,374,347	17.1	$260
Single Significant	6,244,605	6,888,532	10.3	206	7,044,528	12.8	264
Multiple Significant	1,134,429	1,202,249	6.0	198	891,468	(21.4)	(677)
Major	3,193,935	2,797,630	(12.0)	(866)	1,950,925	(38.9)	(2,714)
Overall	$12,600,882	$12,630,142	0.2	$6	$12,261,269	(2.7)	($54)

dality when it appears to be equally effective. For tertiary patients, given the current weighting framework, hospitals would still lose approximately $866 per case, but that amount is much less (206% less) than the comparable DRG loss.

Similar differences in PMC versus DRG prospective payments exist when various types of hospitals are examined. Trauma centers, for example, are differentially impacted by DRG payments because of their higher percentage of injured patients that have major or multiple significant injuries. In the non-Medicare 1989 database, DRG payments to trauma centers are 29% less than the cost of care while non-trauma center hospitals would be paid 8.7% more than costs. Trauma centers would lose an average of $4,848 per tertiary patient admitted, while non-trauma centers would lose considerably less ($1,030).

Table IV combines multiple and major injury patients and describes the ability of each patient classification to predict hospital costs by body system. It should be noted that the body systems were identified using PMCs, since DRGs do not provide a method to accurately identify patients by body system. As shown, head injuries were the most frequent severe injury in the database and accounted for 24.4% of the severe injury patients and had average acute care costs of $5,801. The average prospective PMC payment for these same patients was $4,520, reflecting a difference of 22.1% below the average hospital cost. The DRG average prospective payment for the head injury patients was $4,459, representing a 23.1% underestimate of the average hospital cost. DRGs significantly underestimate hospital costs in all other body systems as well. PMCs underestimate costs in four of the nine body systems, however, at a much lower rate than DRGs. Keep in mind that these tertiary injuries represent the most extreme of the cost versus payment differences.

All-Payor Maryland Database. All of the analyses described here using the non-Medicare database were also completed using the calendar year 1988 statewide all-payor Maryland database. This was done to replicate the findings on a larger and more diverse sample of patients. In general, as shown in Table V, the impact of applying PMC and DRG unit pricing yields similar results on this all-payor Maryland database. Overall, both PMC and DRG payments approach the actual costs of care, but the distribution of payments by severity level reflects the same inadequacies as seen in the non-Medicare database. That is, multiple significant and tertiary injuries are systematically and substantially underpaid by the DRG system. Those hospitals that treat larger numbers of severely injured patients (such as trauma centers) are much more likely than non-trauma centers to have negative financial consequences as a result of inaccurate DRG classification. This result has been obscured and somewhat ameliorated in the PPS by the

TABLE IV
Severe injuries (major and multiple combined) by PMC body system: non-Medicare data

Body System Injury	Percent	Average Cost	PMCs		DRGs	
			Average Payment	$/Case Over/(under) Costs	Average Payment	$/Case Over/(under) Costs
Head	24.4	$5,801	$4,520	($1,281)	$4,459	($1,342)
Upper/Lower Ext.	23.3	3,292	3,672	380	2,349	(943)
Thoracic	11.4	4,539	3,754	(785)	2,872	(1,667)
Femur/Pelvic	11.0	7,299	6,533	(766)	3,641	(3,658)
Spine	9.0	7,521	7,844	323	4,580	(2,941)
Ophthalmic	5.8	2,268	2,433	165	1,547	(721)
Other	5.4	3,474	3,472	(2)	2,506	(968)
Abdominal	5.3	9,474	8,911	(563)	5,215	(4,259)
Burn	3.9	5,817	7,272	1,455	8,441	2,624
Severe Injuries	100.0	$5,229	$4,944	($285)	$3,598	($1,631)

TABLE V
Prospective PMC and DRG payments by injury level: 1988 Maryland data

Injury Level	Patient Management Categories (PMC)		Diagnosis Related Groups (DRG)	
	Percent per Case Over/ (Under) Charges	Payment per Case Over/ (Under) Charges	Percent per Case Over/ (Under) Charges	Payment per Case Over/ (Under) Charges
Minor	(7.6)	($150)	18.0	$356
Single Significant	18.7	500	21.1	564
Multiple Significant	2.8	124	(16.0)	(707)
Major	(17.9)	(1,610)	(36.5)	(3,277)
Overall	1.3	$45	(2.4)	($83)

additional payment adjustment made to teaching hospitals. With that teaching adjustment diminishing, the inadequacies of DRG payment for patient-related costs will be more apparent.

Proposed DRG Modifications. As mentioned previously, HCFA has proposed modifications to the DRGs (to be effective October 1990) in an attempt to correct some of the DRG misclassification. Changes are being made to identify significant, multiple trauma patients and adjust payment levels to be more reflective of the intense resource management required for these patients. The four proposed DRGs are:

DRG#	Description
484	Craniotomy for Multiple Significant Trauma
485	Hip, Femur, and Limb Reattachment Procedures for Multiple Significant Trauma
486	Other O.R. Procedures for Multiple Significant Trauma
487	Other Multiple Significant Trauma

By utilizing the May 9, 1990. *Federal Register* and consulting with the Division of Hospital Payment Policy of HCFA, we computerized the proposed DRG modifications and applied them to the databases examined in the study.

As shown in Table VI, the classification effect of these changes will be minimal. Approximately 968 patients out of 25,987 injuries in the all-payor Maryland database (3.7%) were classified in one of the four new multiple trauma DRGs. The distribution of these cases is shown by PMC level of severity in Table VI. It is clear that there are still a number of multiple injuries that will be misclassified by DRGs even after this change. In fact, the proposed DRG modifications will identify only 307 of 2,331 multiple significant injuries (13.1%) and 609 of 3,270 tertiary or major injuries (18.6%) identified by PMCs. Consistent with other published findings, approximately half (51.8%) of the patients that are not assigned to a multiple trauma DRG will be assigned to a DRG that is not even injury related (4).

The financial consequences of the proposed DRG modifications will be inconsequential as well. Table VII illustrates the impact of the DRG modifications on the DRG weights and the DRG prospective payment per case. The DRG weights show relatively little change. This minimal impact is the result of the following facts: 1) DRGs misclassify injury patients; and 2) the multiple trauma DRG that has the largest number of patients has been assigned a relatively low DRG weight. Overall, the DRG modifications increase the average DRG prospective payment for injury patients to $3,400, an increase of 0.9% or $30 per case from the current DRG amount of $3,370. For multiple injury patients (excluding major injuries), the DRG prospective payment increases an average of $223 per case. However, for patients with major injuries, of which only 18.6% were identified by the DRG modifications, the increase in prospective payment is only $89 per case. Thus, although the DRG modifications will improve overall payment to hospitals by 0.9%, the systematic underpayment of tertiary and multiple injuries remains the same.

DISCUSSION

There are a number of components of a prospective per-case payment system, each of which affects the resultant payment level and its relationship to the actual cost of managing particular patients. First, the classification of patients that is the basis of the system influences and drives the system. Second, the weighting methodology and resultant weights will affect the differentiation or lack of differentiation of payment levels among hospitals. And, finally, the way in which the payment system handles non-patient related costs, such as capital and teaching costs, may be just as important as patient costs are to a hospital's bottom line.

It is clear that patient category weights can be set to force overall payment to be at a certain level. HCFA

TABLE VI
Impact of proposed DRG modifications

Level	Proposed Multiple Trauma DRGs					All Other DRGs			All DRGs
	DRG 484	DRG 485	DRG 486	DRG 487	Subtotal	Non-Injury	Injury	Subtotal	
Minor	0	0	1	0	1	3,856	2,364	6,220	6,221
Single Significant	0	0	4	47	51	4,017	7,097	14,114	14,165
Multiple Significant	1	26	6	274	307	850	1,174	2,024	2,331
Tertiary	33	74	24	478	609	1,233	1,428	2,661	3,270
Overall	34	100	35	799	968	12,956	12,063	25,019	25,987

TABLE VII
Comparison of the proposed multiple trauma DRGs to current DRGs: Maryland all-payor database

Injury Level	Current DRGs		Proposed DRGs	
	Average DRG Weight	Payment/ Case	Average DRG Weight	Payment/ Case
Minor	0.719	$2,339	0.719	$2,338
Single Significant	0.994	3,232	0.994	3,230
Multiple Significant	1.139	3,705	1.209	3,928
Major	1.749	5,689	1.778	5,778
Overall	1.036	$3,370	1.046	$3,400

refers to this process as recalibrating the DRG weights to keep the overall system budget neutral. Without a meaningful classification, however, the results of this process are highly unpredictable for individual hospitals. As we have seen in this study, when patients are misclassified, they are inappropriately weighted and the system fails to make appropriate distinctions among whole classes of patients and whole classes of hospitals. In this study, the DRG payment system has been shown to have a differential impact on hospitals that treat large numbers of major injury patients and patients with multiple, significant injuries in contrast to those that treat primarily minor injuries. In fact, because of this payment system bias, if overtriage were eliminated, we would have even more trauma centers that are financially unstable. In this sense, under the current DRG payment system, overtriage is necessary.

These results are not caused by the DRG empirical weighting methodology; rather, they are caused by the basic misclassification of injuries in the DRG patient classification. Thus, neither recalibrating the DRG weights nor tinkering with the DRG categories will fix the problem. This was shown by the lack of effect of the proposed multiple trauma DRGs.

This paper has also proposed a potential solution—the Patient Management Categories. At minimum, PMCs identify injuries more accurately and specifically than DRGs. Recall that PMCs also include categories for all hospitalized diseases and disorders with the same level of clinical specificity. Although the weights that are associated with PMCs reflect the cost of expected services (in contrast to the DRG weights, which are based on average charge differences), they appear to do a much better job than DRGs in differentiating high cost, severe injuries from low cost, minor injuries as well as predicting cost differences between single and multiple injuries. Since the computerized algorithms of PMCs and DRGs operate using the same data elements as input, PMCs are readily implementable on a regional or national basis.

It is important to provide hospitals and physicians with equitable payments, but PMCs will also provide the analytic tool to examine and monitor the incidence and costs of injuries in a hospital as well as across all hospitals (trauma centers and non-trauma centers) in a geographic region. Such a tool could improve trauma systems evaluation as well. One limitation of such analyses is the lack of comparable cost data across hospitals. This study is an initial attempt to use the data available in Medicare hospital cost reports to estimate patient level costs, but studies should be funded to improve the comparability and accuracy of the cost estimates used in such analyses. Only in this way will the relationships found in this study be able to be replicated, confirmed, or further specified.

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APPENDIX A
INJURY PATIENT MANAGEMENT CATEGORIES BY LEVEL
RELEASE 3.2

PMC Number	PMC Description	Level
0501	Burn: Partial Thickness <10 percent with Vital Site	Significant
0502	Burn: Partial Thickness 10–30 percent without Vital Site	Significant
0503	Burn: Partial Thickness 10–30 percent with Vital Site	Tertiary
0504	Burn: Partial Thickness >30 percent	Tertiary
0505	Burn: Full Thickness ≤10 percent with Vital Site	Tertiary
0506	Burn: Full Thickness ≤10 percent without Vital Site	Significant
0507	Burn: Full Thickness >10 percent	Tertiary
0508	Burn: Smoke Inhalation with Inhalation Injury	Tertiary
0509	Burn: Smoke Inhalation without Inhalation Injury	Minor
0512	Burn: Unspecified/Minor Burn	Minor
0513	Burn: Electrocution Injury with Minor Burn	Significant
2201	Maxillofacial Frx: Mandible/Maxilla Fracture	Significant
2202	Maxillofacial Frx: Nasal Fracture	Minor
2203	Maxillofacial Frx: Orbital Fracture with Operation	Significant
2204	Maxillofacial Frx: Obital Fracture without Operation	Minor
2205	Maxillofacial Frx: Zygomatic Fracture	Significant
2206	Maxillofacial Frx: Multiple Facial Fractures	Tertiary
2211	Maxillofacial Frx: Superficial Facial Injury	Minor
2801	Ophthalmic Injury: Eye Burn	Tertiary
2802	Ophthalmic Injury: Lacrimal System Laceration	Minor
2803	Ophthalmic Injury: Laceration/Rupture of Cornea/Sclera	Tertiary
2804	Ophthalmic Injury: Blunt Globe Trauma with Operation	Tertiary
2805	Ophthalmic Injury: Blunt Globe Trauma without Operation	Minor
2901	Upper Extremity: Dislocated Elbow/Shoulder with ORIF	Significant
2902	Upper Extremity: Dislocated Elbow/Shoulder without ORIF	Significant
2903	Upper Extremity: Closed Frx Proximal/Head Humerus with ORIF	Significant
2904	Upper Extremity: Closed Frx Proximal/Head Humerus without ORIF	Significant
2905	Upper Extremity: Closed Frx Shaft Humerus with ORIF	Significant
2906	Upper Extremity: Closed Frx Shaft Humerus without ORIF	Significant
2907	Upper Extremity: Closed Frx Distal Humerus/Elbow with ORIF/Pinning	Significant
2908	Upper Extremity: Closed Frx Distal Humerus with Traction	Significant
2909	Upper Extremity: Closed Frx Distal Humerus with Closed Reduction	Significant
2910	Upper Extremity: Closed Frx Ulna with Dislocated Radial Head	Significant
2911	Upper Extremity: Closed Frx Forearm/Wrist with ORIF	Significant
2912	Upper Extremity: Closed Frx Forearm/Wrist without ORIF	Significant
2913	Upper Extremity: Open Fracture Hand, Crush Injury Fingers	Significant
2914	Upper Extremity: Open Fracture Radius/Ulna/Humerus	Significant
2915	Upper Extremity: Crush Injury Hand/Arm	Tertiary
2916	Upper Extremity: Nerve Laceration, Upper Extremity	Significant
2917	Upper Extremity: Fingertip Evulsion with Pedicle Graft	Significant
2918	Upper Extremity: Fingertip Evulsion without Pedicle Graft	Minor
2919	Upper Extremity: Digit Loss with Reattachment	Tertiary
2920	Upper Extremity: Digit Loss without Reattachment	Significant
2921	Upper Extremity: Other Traumatic Amputation	Tertiary
2922	Upper Extremity: Periarticular Soft Tissue Injury with Operation	Significant
2923	Upper Extremity: Periarticular Soft Tissue Injury without Operation	Minor
2925	Upper Extremity: Closed Frx/Dislocation Hand with ORIF	Minor

***APPENDIX A* (Continued)**
INJURY PATIENT MANAGEMENT CATEGORIES BY LEVEL
RELEASE 3.2

PMC Number	PMC Description	Level
2926	Upper Extremity: Closed Frx/Dislocation Hand without ORIF	Minor
2927	Upper Extremity: Vascular Injury	Significant
3001	Lower Extremity: Torn Meniscus/Knee Cartilage	Significant
3002	Lower Extremity: Periarticular Soft Tissue Injury with Operation	Significant
3003	Lower Extremity: Compartment Syndrome	Significant
3004	Lower Extremity: Dislocated Knee	Significant
3005	Lower Extremity: Dislocated Patella	Significant
3006	Lower Extremity: Closed Frx Patella with Operation	Significant
3007	Lower Extremity: Closed Frx Patella without Operation	Significant
3008	Lower Extremity: Closed Frx Tibial Plateau with ORIF	Significant
3010	Lower Extremity: Closed Frx Tibial Plateau without ORIF	Significant
3011	Lower Extremity: Closed Frx Tibia/Fibula Shaft with ORIF	Significant
3012	Lower Extremity: Closed Frx Tibia/Fibula Shaft without ORIF	Significant
3013	Lower Extremity: Ankle Dislocation/Closed Fracture	Significant
3014	Lower Extremity: Calcaneus Fracture with ORIF	Significant
3016	Lower Extremity: Calcaneus Fracture without ORIF	Significant
3017	Lower Extremity: Closed Frx/Dislocation Foot with ORIF	Minor
3018	Lower Extremity: Closed Frx/Dislocation Foot without ORIF	Minor
3019	Lower Extremity: Open Frx Ankle/Tibia/Fibula	Significant
3020	Lower Extremity: Crush Injury Foot/Leg	Tertiary
3021	Lower Extremity: Traumatic Amputation Foot/Leg	Tertiary
3022	Lower Extremity: Periarticular Soft Tissue Injury without Operation	Minor
3023	Lower Extremity: Open Frx Foot, Crush Injury/Amputation Toes	Significant
3025	Lower Extremity: Vascular Injury	Significant
3103	Physical/Chemical Injury: Near Drowning	Tertiary
3104	Physical/Chemical Injury: Frostbite	Significant
3105	Physical/Chemical Injury: Hypothermia	Tertiary
3106	Physical/Chemical Injury: Caustic Injury of GI Tract with Operation	Tertiary
3107	Physical/Chemical Injury: Caustic Injury of GI Tract without Operation	Minor
3201	Abdominal Injury: Minor Organ without Operation	Significant
3202	Abdominal Injury: Minor Organ with Exp	Tertiary
3203	Abdominal Injury: Minor Organ with Operation	Tertiary
3204	Abdominal Injury: Major Organ Injury	Tertiary
3205	Abdominal Injury: Vascular Injury	Tertiary
3206	Abdominal Injury: Abdominal/Perineal Laceration/Contusion	Minor
3301	Thoracic Injury: Laceration/Contusion of Chest Wall	Minor
3303	Thoracic Injury: Rib Frx/Pulmonary Contusion	Significant
3304	Thoracic Injury: Myocardial Contusion	Tertiary
3305	Thoracic Injury: Pneumothorax/Hemothorax with Operation	Tertiary
3306	Thoracic Injury: Pneumothorax/Hemothorax without Operation	Significant
3307	Thoracic Injury: Vascular Injury	Tertiary
3308	Thoracic Injury: Penetrating Cardiac Injury	Tertiary
3309	Thoracic Injury: Trachea/Broncheal/Esophagus Injury with Operation	Tertiary
3310	Thoracic Injury: Trachea/Broncheal/Esophagus Injury without Operation	Significant
3312	Thoracic Injury: Penetrating Neck Injury with Operation	Tertiary
3313	Thoracic Injury: Penetrating Neck Injury without Operation	Minor
3314	Thoracic Injury: Flail Chest	Tertiary
3315	Thoracic Injury: Foreign Body Trachea/Bronchus/Esophagus	Minor

***APPENDIX A* (Continued)**
INJURY PATIENT MANAGEMENT CATEGORIES BY LEVEL
RELEASE 3.2

PMC Number	PMC Description	Level
3401	Spine Injury: Vertebral Dislocation	Significant
3402	Spine Injury: Cord Injury without Fracture/Dislocation	Tertiary
3403	Spine Injury: Fracture with Cord Injury with Operation	Tertiary
3404	Spine Injury: Fracture with Cord Injury without Operation	Tertiary
3405	Spine Injury: Fracture without Cord Injury with Operation	Tertiary
3406	Spine Injury: Fracture without Cord Injury without Operation	Minor
3501	Head Injury: Superficial Head Injury	Minor
3502	Head Injury: Linear Frx/Concussion with No/Brief LOC	Significant
3503	Head Injury: Linear Frx/Concussion with Moderate/Prolonged LOC	Tertiary
3504	Head Injury: Depressed Skull Frx with Operation	Tertiary
3505	Head Injury: Hematoma/Edema with No/Brief LOC with Operation	Tertiary
3506	Head Injury: Hematoma/Edema with No/Brief LOC without Operation	Tertiary
3507	Head Injury: Hematoma/Edema with Mod/Pro LOC with Operation	Tertiary
3508	Head Injury: Hematoma/Edema with Mod/Pro LOC without Operation	Tertiary
4720	Supplementary Category: Uncomplicated Contusions/Superficial Wound	Minor
4721	Supplementary Category: Uncomplicated Sprain/Strain	Minor
4801	Femur/Pelvic Frx: Closed Pelvic Ring Frx with ORIF	Tertiary
4802	Femur/Pelvic Frx: Closed Pelvic Ring Frx without ORIF	Significant
4803	Femur/Pelvic Frx: Open Pelvic Ring Frx	Tertiary
4804	Femur/Pelvic Frx: Acetabular Frx with ORIF	Tertiary
4805	Femur/Pelvic Frx: Acetabular Frx without ORIF	Significant
4806	Femur/Pelvic Frx: Dislocated Hip	Significant
4807	Femur/Pelvic Frx: Transcervical/Intertrochanteric Frx	Significant
4808	Femur/Pelvic Frx: Impacted Subcapital Frx with Operation	Significant
4809	Femur/Pelvic Frx: Impacted Subcapital Frx without Operation	Significant
4810	Femur/Pelvic Frx: Supracondylar/Intracondylar Frx with ORIF	Significant
4811	Femur/Pelvic Frx: Supracondylar/Intracondylar Frx without ORIF	Significant
4813	Femur/Pelvic Frx: Shaft/Distal Femur Frx with ORIF	Significant
4814	Femur/Pelvic Frx: Shaft/Distal Femur Frx without ORIF > Age 5	Significant
4815	Femur/Pelvic Frx: Shaft/Distal Femur Frx without ORIF ≤ Age 5	Significant
4823	Femur/Pelvic Frx: Vascular Injury	Significant

***APPENDIX A* (Continued)**
INJURY PATIENT MANAGEMENT CATEGORIES BY LEVEL
RELEASE 3.2

ADDITIONAL PMC TERTIARY PATIENT CRITERIA

Combination #1
Presence of any of the following injuries with another significant injury:
2927 Upper Extremity: Vascular Injury
3003 Lower Extremity: Compartment Syndrome
3025 Lower Extremity: Vascular Injury
4823 Femur/Pelvic Frx: Vascular Injury

Combination #2
Any one of the following lower extremity injuries:
3008 Lower Extremity: Closed Frx Tibial Plateau with ORIF
3011 Lower Extremity: Closed Frx Tibia/Fibula Shaft with ORIF
3019 Lower Extremity: Open Frx Ankle/Tibia/Fibula
in combination with one of the following femur fractures:
4813 Femur/Pelvic Frx: Shaft/Distal Femur Frx with ORIF
4814 Femur/Pelvic Frx: Shaft/Distal Femur Frx without ORIF > Age 5
4815 Femur/Pelvic Frx: Shaft/Distal Femur Frx without ORIF Age ≤5

Combination #3
The following injury:
4802 Femur/Pelvic Frx: Closed Pelvic Ring Frx without ORIF
in combination with one of the following injuries:
3202 Abdominal Injury: Minor Organ with Exploration
3203 Abdominal Injury: Minor Organ with Operation
3401 Spine Injury: Vertebral Dislocation
3406 Spine Injury: Fracture without Cord Injury without Operation

Combination #4
Presence of any three significant level injury PMCs.

Combination #5
Presence of at least two significant level injury PMCs, with a PMC-RIIS ≥4.0*

* The PMC Relative Injury Intensity Score (PMC-RIIS) reflects the type and intensity of services defined by physicians that are required for the effective care of the typical patient in each PMC assigned to a patient. A PMC-RIIS is calculated for each trauma patient and is based on only the Injury PMCs assigned excluding complications and comorbidities.

DISCUSSION

DR. ARTHUR L. TRASK (Falls Church, Virginia): I thank Doctor Young for sending me her manuscript in advance of this meeting. I will admit, after hearing her presentation this morning and having read her manuscript, I am a bit at a loss to make comments because I had prefaced my comments on her manuscript and the presentation in many respects did not cover the issues that she does in her manuscript.

The inadequacies of payment for trauma care utilizing the DRG format have been demonstrated by a number of previously presented papers. The authors in this case have presented another method for classifying injured patients and then suggested a mechanism to compensate hospitals based on this classification system. The authors have emphasized the differences between DRGs and PMCs, pointing out that physicians were used to define the PMCs.

Through my association with John Udell, who is currently doing a study on the cost of trauma care for the State of Texas, I am familiar with this methodology. However, I could not find any detail, either in the presentation this morning or in Doctor Young's manuscript and accompanying references that would allow anyone to use this PMC/RIS methodology as independent observers to test its validity.

The purposes of this study were to determine if different types of hospitals were compensated inequitably by the DRG methodology and to compare payment based on the PMC relative intensity score and DRG rates in an effort to determine the better way to equally compensate different levels of hospitals who provide trauma care.

I originally had four questions, but since the paper and the manuscript differ, I will reduce that number. First, why did you use your own basic stratification of levels of severity of injury rather than the generally recognized scoring systems, which you had pointed out on your slides, such as the ISS or APACHE, et cetera? Perhaps you have introduced a bias in favor of the

PMC methodology by approaching the level of severity in this manner.

Second, in an effort to support your purpose, you used a multiple regression in your manuscript, using the cost variances explained by the PMC relative intensity score and DRG rates. PMCs and the DRGs are correlated with one another. If the PMCs enter the regression equation first, then the R^2 associated with the PMCs would include the independent variances associated with the PMCs as well as some of the co-variance that can be attributed to DRGs.

Also, bivariant correlation values between cost and DRGs, cost and PMCs, and between PMCs and DRGs could have more clearly compared how much of the cost variances were contributed by DRGs.

Perhaps a more meaningful way to compare the results of payments would be to multiply your statistics using the cost-per-patient and so on with the numbers of patients that you had.

In conclusion, I believe the patient management categories, using the relative injury severity methodology, present a viable methodology for compensating hospitals for caring for trauma patients in the future. This study does again show the inequalities of payments to trauma centers versus non-trauma centers when caring for different levels of severity.

I compliment the authors for a well-done and thought-provoking study. I thank the Association for allowing me to comment on this paper.

DR. WANDA W. YOUNG (Closing): First, in response to the technical point made by Doctor Trask, the regressions that were part of our analyses were done separately for DRGs versus PMCs. That is, one set of regressions was performed using DRG weights as the independent variable to explain the cost variation among 1) all patients, 2) all patients treated at trauma centers, and 3) all patients treated at non-trauma centers. A second set of regressions was specified using PMC intensity weights to explain the variation in patient costs. Thus, any multicollinearity that exists between DRG and PMC relative weights is not an issue. By the way, I have no evidence that the DRG and PMC weights are, in fact, highly correlated.

Second, the levels of severity that we used in all analyses were based on PMCs, primarily because those levels of severity can be readily derived using only discharge abstract data. By contrast, many of the other scores that you are familiar with, such as APACHE, ISS, and TRISS, require additional data such as is available in trauma registries. Since we were using very large databases from trauma centers and non-trauma centers, the PMC severity levels were the most readily available.

Finally, I would like to close this session by making one additional comment. We have shown that the DRG-based payment methodology has a differential impact on certain types of hospitals. The important thing to understand is that these results are not caused by the DRG empirical weighting or the pricing methodology of the Prospective Payment System. Rather, these results are caused by the fact that DRGs generally misclassify injuries. Unfortunately, the impact of that misclassification is especially costly for hospitals that treat the most severely injured patients. It is the accuracy or inaccuracy of the classification and the weights that contribute to the equity or inequity of the distribution of payments among hospitals. This is the reason that it is so important to have an accurate and clinically specific classification at the basis of a per-case payment methodology.

Again, I would like to thank the Association for the opportunity to present this paper, Doctor Trask for his comments, and my three co-investigators—Doctors Joseph Young, J Smith, and Michael Rhodes—for their major contribution to our trauma research.