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Evaluating Performance of Statewide Regionalized Systems of Trauma Care

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A new methodology is presented for evaluating the extent to which patients within regionalized systems of trauma care are treated at the appropriate hospitals. Criteria are proposed for retrospectively classifying trauma patients as to whether they should have been treated at a trauma center. The criteria were developed by a panel of nationally recognized trauma experts and are based on the age of the patient and the type and AIS severity of injuries sustained. The criteria were then applied to uniformly collected data available for all trauma discharges in 1988 from acute care hospitals in a state with a well developed system of regionalized trauma care. According to the criteria, 19% of all trauma discharges in 1988 should have been treated at trauma centers. Of those who should have been treated at a trauma center according to criteria, 66% actually received treatment at a center. Of those who were classified not to have required care at a trauma center, 62% actually were treated at non-trauma center hospitals. The congruence between where patients should have been treated and the actual level of hospital care received varied by the type and severity of the traumatic injuries sustained. The results of the analysis provide insights into the characteristics of trauma patients at higher risk of not getting the appropriate level of trauma care and should assist in improving guidelines for triage and transfer within a regionalized system of care.

Regionalization of trauma care has been under way for over a decade. The development of regionalized systems has involved improvements in transport and response capability, creation of destination guidelines, and perhaps most important, the designation of regional trauma centers for treatment of the severely injured. By 1987, 21 states had a formal process for the designation of trauma centers (1, 23). Despite the growing trend towards regionalization, there has been little scientific evaluation of the extent to which regionalized systems achieve the goal of "getting the right patient to the right facility."

Early efforts at monitoring utilization of facilities within a trauma system were inadequate due to limited availability of comprehensive, population-based data, and the lack of adequate measures of injury severity (12, 24). With the increasing availability of computerized statewide hospital discharge data, there are new opportunities for the timely and efficient analysis of system performance (15, 18). The development of a computerized conversion table that maps ICD-9CM coded discharge diagnoses into ICD/AIS and ICD/ISS scores enhances the utility of these databases, providing population-based data specific to the severity of injuries (16).

A major impediment to monitoring performance of regionalized systems, however, remains the lack of consensus as to which trauma patients should be treated at designated trauma center facilities (14, 21). Although the ISS is a well accepted measure of anatomic severity and is widely used in trauma care evaluation, there is disagreement as to which values of ISS represent major trauma that should be treated at a trauma center. In addition, the ISS has more recently been criticized for its underweighting the severity of isolated head injuries and multiple injuries to the same body region (8).

This paper describes the development and application of uniform evaluation criteria for identifying patients who should be treated at trauma centers. The criteria were developed in conjunction with a multidisciplinary panel of traumatologists. These criteria are compared to criteria based on ISS scores alone in examining the status of regionalization in Maryland, a state with a well established regional trauma system. Measures of appropriate utilization are examined by age, ISS, and body region of the principal injury.

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METHODS

Development of Criteria. Using an expert panel approach, evaluation criteria were developed for retrospectively classifying trauma cases as to the lowest level of hospital care the patient should receive in an optimal regionalized system of care. Three levels of care were defined: 1) community hospitals including hospitals that meet the criteria established by the American College of Surgeons' Committee on Trauma (ACS/COT) for a Level III trauma center and other hospitals not meeting level III criteria; 2) regionally designated trauma centers (ACS/COT levels I and II); and 3) regionally designated specialty referral centers for burns (7).

The criteria were based on the age of the patient (0–4; 5–14; 15–54; 55+ years), the maximum AIS severity of injuries sustained in each of seven body regions (head/neck, spine, face, thorax, abdomen, extremities, and external/burns) and in some cases on the specific injury diagnosis. The criteria were developed to indicate where patients should be treated under an idealized set of circumstances when full knowledge of the type and severities of injuries is available. That is, the criteria were based on the injuries as ultimately described by discharge and autopsy results. It is important to emphasize that the criteria were not designed to be used as triage guidelines. In triage, decisions have to be made under circumstances involving considerable uncertainty regarding the extent and severity of injury. Appropriateness criteria based on final diagnoses, on the other hand, enable the evaluation as to whether triage decisions made in the field ultimately result in trauma cases arriving at the appropriate level of hospital care.

The panel consisted of nationally recognized experts in the delivery of trauma care (*Appendix*). The panel included representation from the ACS/COT and the Committee on Injury Scaling of the Association for the Advancement of Automotive Medicine (AAAM/CIS) and was configured to cover a range of clinical expertise in trauma.

A modified Delphi approach was used to arrive at final criteria. First, each panel member was asked to independently assign appropriateness ratings to single system and multisystem injuries as described by the maximum AIS severity within each body system. Panel members were also asked to indicate the extent to which patient age would affect their ratings.

These independent ratings were summarized and then discussed by all panel members at a subsequent meeting. As anticipated, there was a relatively high level of agreement among panel members as to the appropriate level of care for patients with minor (AIS 1–2) and severe (AIS 4–6) injuries; disagreements concentrated among the moderately severe (AIS 3) injuries. After considerable discussion, criteria for AIS 3 injuries evolved that varied with the age of the patient, the body region involved, and in some cases on the specific diagnosis. So, for instance, all AIS 3 injuries to the head, spine, and thorax were classified as cases that should be treated at a trauma center. Isolated facial injuries of AIS 3 severity, on the other hand, were judged not to require treatment at a trauma center. AIS 3 abdominal injuries were classified as trauma center cases only if they were potentially hypovolemia producing; AIS 3 extremity injuries were judged as requiring a trauma center only if there was major vascular involvement or there was a crush injury or pelvic fracture. Individuals aged 55 years and older or less than 5 years who sustained an AIS 3 injury were initially classified as trauma center cases regardless of the specific nature of the injury.

The criteria that evolved from the meeting were subsequently sent to panel members for final review. To assist the panel in reviewing the criteria, results of a preliminary application of the criteria to all hospital trauma discharges in Maryland were included in the correspondence. Upon reviewing these analyses, the panel recommended altering the criteria so that adults aged 55 years and over with isolated hip fractures were reclassified as requiring treatment at a community hospital and not at a trauma center as originally defined.

The final criteria are available from the authors upon request; they are summarized below:

1) If one or two body systems are involved and all injuries are of AIS severity less than or equal to 2, then all patients (regardless of age) should be treated at a non-trauma center.

2) If three or more body systems are involved, each with an injury of AIS 2 or greater, the patient should be treated at a trauma center.

3) If there is at least one injury of AIS 4 or AIS 5 then the patient (regardless of age) should be treated at a trauma center.

4) Patients between the ages of 5 and 54 years whose most severe injury is of AIS 3 severity should be treated at a community hospital unless the injury is one of the following: 1) AIS 3 head, spine, or thoracic injury; 2) a potentially hypovolemia-producing AIS 3 injury to the abdomen; 3) an AIS 3 pelvic fracture, an AIS 3 crush injury to the extremities, or an extremity injury with major vascular involvement.

5) Patients aged 55 years and older, with an AIS 3 injury other than a closed hip fracture should be treated at a trauma center. Patients aged 55 and older with an isolated hip fracture should be treated at a non-trauma center.

6) Patients below the age of 5 who sustain at least one injury of AIS 3 severity (regardless of the nature of injury) should be treated at a trauma center.

7) Burns of AIS 5–6 should be treated at a burn center. If a burn of AIS ≥ 4 is involved together with AIS 5–6 injuries to other body systems, then the patient should be initially sent to the trauma center and transferred to a burn center.

Application of Criteria to Maryland System. The appropriateness criteria were retrospectively applied to all trauma patients discharged in 1988 from acute care hospitals in the State of Maryland. Maryland was chosen because it maintains computerized discharge abstract data on all admissions to its 51 acute care, non-federal hospitals and supports a regionalized trauma system of care that has evolved over the past 16 years to become one of only two statewide coordinated systems of trauma care in the country (23).

Maryland's trauma system supports ten areawide trauma centers and nine specialty referral centers for the treatment of neurotrauma, pediatric trauma, burns, eye trauma, and hand trauma. For the purpose of the present analysis the specialty referral centers for neurotrauma and pediatric trauma were classified together with the areawide trauma centers to identify the group of "trauma center hospitals."

The routine reporting of uniform hospital discharge data is mandated by law in Maryland (19). Included in the discharge abstract are patient demographics, up to five ICD-9CM coded discharge diagnoses, use of hospital resources, and discharge disposition. The quality of the Maryland discharge abstract data, including the diagnostic information, is high as it is used in paying all hospitals in the state. Excluded from the database are deaths that occur at the scene, in transport, or in the hospital emergency department. These deaths are estimated to account for less than 5% of all trauma in Maryland that is serious enough to result in death or hospitalization. However, they represent approximately 80% of all trauma deaths (i.e., 20% of all trauma deaths occur in hospital).

Included in the definition of an acute trauma hospitalization for the purpose of this study was any discharge with a principal diagnosis of an injury as defined by the ICD-9CM N-codes N800-N959, excluding N958 (traumatic complications), N905-N909 (late effects of injuries), N930-N939 (foreign bodies), and N940-N949 (burns). Burns were excluded since the conversion of their ICD codes to AIS scores was found to be unreliable.

Injury severity was determined using a computerized mapping of ICD-9CM coded discharge diagnoses into Abbreviated Injury Scale (AIS) and Injury Severity Scores (ISS) (16). The resulting severity scores are referred to as ICD/AIS and ICD/ISS. Validation studies have shown that errors in chart abstracting and ICD coding, as well as the conservative assumption used in assigning ICD/AIS, lead to lower than average AIS values (16). Therefore ICD/AIS and ICD/ISS scores will on average be slightly lower than scores obtained by reviewing the entire medical record.

Measuring Performance. The extent to which trauma patients receive care at the appropriate level of hospital according to the evaluation criteria was measured by calculating traditional rates of sensitivity and specificity. Sensitivity refers to the likelihood that a patient who should be treated at a trauma center will in practice be treated at a trauma center. Patients who are appropriately referred to trauma centers are known in epidemiologic terms as "true positives." Specificity, on the other hand, refers to the likelihood that a patient judged not to require trauma center care will actually be treated at a non-trauma center facility. Thus specificity measures the ability of the system to identify the "true negatives."

Performance, as measured by the sensitivity and specificity of the system, was determined using the criteria established by the panel. The results were contrasted with an analysis based on two alternative ISS criteria (ISS ≥13 and ISS ≥16). These specific ISS criteria were used because they have been used in previous studies to identify major trauma patients. In addition, the ISS ≥13 criterion has been used in Maryland to authorize a Medicaid waiver of a 20-day limit on length of stay for patients treated at trauma centers.

RESULTS

In 1988 30,126 trauma patients were discharged from the 51 acute care hospitals in Maryland. For 753 (2.5%) of these cases, information on the discharge abstract was not sufficient for classification as to the appropriate level of care. These cases were excluded from subsequent analyses, leaving a total of 29,373 cases for review. Of these cases, 12,724 were treated at trauma center hospitals with the remaining 16,649 having been treated at hospitals that do not maintain a trauma center.

Classification by the Appropriate Level of Care. Nineteen per cent of all trauma discharges in 1988 should have been treated at a trauma center according to the panel criteria. Using the ISS ≥13 and ISS ≥16 criteria, the per cents who required treatment at a trauma center were 12% and 7%, respectively (Table I). To better understand the differences between criteria based on the panel judgments versus ISS scores, trauma patients classified as trauma center cases according to the panel criteria but not according to either the ISS ≥13 or ISS ≥16 criterion were classified into one of three categories. Group I consisted of patients with isolated ICD/AIS 3 injuries who, because of the nature of the injury or their age, should have been treated at a trauma center according to the panel. Recall that the panel criteria classified all isolated AIS 3 head, spine, and thoracic injuries and a proportion of isolated AIS 3 injuries to the abdomen and extremities as trauma center cases. Age was also a factor in classifying patients with isolated AIS 3 injuries. These Group 1 patients scored 9–11 on the ICD/ISS scale and therefore would not have required trauma center care according to either the ISS ≥13 or ISS ≥16 criterion. In 1988 there were 2,283 such patients treated in Maryland hospitals. They represented 8% of all trauma patients and 27% of patients with ICD/ISS scores of 9–12. Closer examination of these patients indicates that 26% had ICD/AIS 3 head injuries, 21% had ICD/AIS 3 thoracic injuries, 40% had ICD/AIS 3 injuries to the vertebrae or spinal cord, 7% had AIS 3 extremity injuries, and 2% had AIS 3 abdominal injuries. The remaining 4% should have been treated at a center according to the panel criteria because they were less than 5 or older than 55 years old.

The second group of patients who should have been treated at a trauma center according to the panel criteria but not according to either ISS criterion were those who sustained injuries to three body systems, each of maximum severity ICD/AIS 2. These patients scored an ICD/ISS of 12. In 1988 they numbered only 87—less than 1% of all trauma patients.

The third group of interest consisted of patients with ICD/ISS scores of 13–15. These are patients who sustained significant injuries to two body regions—one of AIS 3 severity, the other of AIS 2 severity. According to the ISS ≥13 criterion, all of these patients should have been treated at a trauma center. The panel criteria classified all but a small proportion as trauma center cases. The exceptions were individuals who sustained an AIS 3 face injury in combination with an AIS 2 injury to any other body region. These individuals did not require trauma center care according to the panel criteria. In 1988 there were 1,277 patients (4% of all trauma patients) with ICD/ISS scores of 13–15. All but 2% were classified as trauma center cases according to the panel criteria. None of these patients should have been treated at a trauma center according to the ISS ≥16 criterion. Thus the panel criteria were more specific than criteria based solely on ISS in identifying patients with moderately severe injuries who require trauma center care.

System Performance. The per cents of patients appropriately referred to the trauma center versus community hospital (i.e., the sensitivity and specificity of the system) are summarized in Table I for the panel and ISS criteria. The per cent appropriately referred to a trauma center (i.e., the "sensitivity" of the system) was 66% using the panel criteria, 75% using the ISS ≥13 criterion, and 78% using the ISS ≥16 criterion. Patients who received a lower level of care than judged appropriate according to the panel criteria (i.e., treated at a community hospital when the recommended level was a trauma center) represented 6% of total trauma discharges for 1988.

The per cents appropriately referred to a community hospital (i.e., the specificity of the system) were 62%, 60%, and 59%, respectively, using the three sets of criteria. The specificity measure implies a level of "over-

TABLE I
Per cent who should have been treated at a trauma center and per cent referred to the appropriate level, panel vs. ISS criteria (Maryland hospital discharges, 1988)

Criterion for Classifying Trauma Cases	Per Cent Who Should Have Been Treated at a Trauma Center	Per Cent Appropriately Treated at a Trauma Center (Sensitivity)	Per Cent Appropriately Treated at a Non-Trauma Center (Specificity)
Panel	19%	66%	62%
ISS ≥ 13	12%	75%	60%
ISS ≥ 16	7%	78%	59%

triage" that might be assumed to equal one minus the specificity. This, however, is not an accurate measure of overtriage since hospitals with trauma centers are expected to also function as community hospitals for trauma within their local service area (i.e., when they are the closest hospital). To estimate the extent of overtriage, "community hospital" or minor trauma cases that occur in the service area of the trauma center hospital have to be subtracted from one minus the specificity. Unfortunately, there is no routine data source that can systematically identify this proportion. An estimate of the per cent of all community trauma that would go to trauma center hospitals is proposed as an alternative. One approach is to take the proportion of all inpatient discharges in the state (including trauma and non-trauma) that occur at trauma center hospitals (30%) as an estimate of the proportion of community hospital trauma cases that would be expected to come to trauma center hospitals. Using this estimate would suggest that 8% of trauma cases that should have been treated at a non-trauma center were overtriaged, i.e., one (1.0) minus the specificity (0.62) minus the expected proportion of community trauma cases to be treated at a trauma center (0.30) equals eight percent (0.08). This suggests that 6.5% of all hospitalized trauma cases in Maryland are "overtriaged" (i.e., 8% of the 81% of all trauma the criteria indicate should have been treated at non-trauma center hospitals).

Variations in System Performance. Performance based on the panel criteria was further examined by ICD/ISS scores, age of the patient, and body region of the injury identified in the discharge abstract as the principal diagnosis. Results are summarized in Table II. Sensitivity of the system increased significantly with higher ICD/ISS scores. Over 88% of patients with ICD/ISS scores of 20 and higher were treated at trauma centers. On the other hand, of the 2,370 patients with ISS scores of 9–12 who should have been treated at a trauma center according to the panel criteria only 53% actually received care at that level.

The overall per cent of patients appropriately referred to trauma centers was inversely related to age, ranging from approximately 75% for children and young adults (ages 0–44) to only 41% for the elderly aged 65 years and older. Sensitivity is lower for the elderly for both severe and moderately severe injuries (Table III). While more than 90% of patients aged 0–44 with ICD/ISS scores of 20 and above were treated at trauma centers, less than 70% of elderly patients 65 years and older with injuries of similar severity were treated at trauma centers. Among the elderly with ISS scores of 13–19, only 44% of those who should have been treated at trauma centers actually received treatment at a trauma center. The comparable figure for children and young adults was 77%.

The per cent of patients appropriately referred to trauma centers also varied substantially by the body region of the principal diagnosis. Sensitivity was lowest for patients whose principal diagnosis was an injury to the spine or thorax. The particularly low per cent of appropriate trauma center cases among patients with a principal injury to the spine (50%) deserves further comment. Of a total of 2,245 patients with a spine injury as their principal diagnosis, 64% (N = 1,430) should have been treated at a trauma center according to the panel criteria. Of these 1,430 patients, 715 were actually treated at community hospitals. The majority (79%) of those who did not reach the appropriate level of care according to the criteria were isolated fractures of the spine without mention of spinal cord injury. These injuries were all assigned an ICD/AIS of 3 by the computerized conversion table even though an unknown proportion of these fractures were stable and would only have been rated as AIS 2 injuries and hence should not have been treated at a trauma center. The ICD classification does not distinguish between AIS 2 and 3 closed spine fractures.

DISCUSSION

Although several studies have now documented the benefits of a regionalized approach to trauma care (3, 22), recent reductions in federal support for EMS systems and increasing pressures placed on hospitals to contain costs and compete for patients have raised new concerns about the adequacy and performance of regionalized systems (11, 13, 23). These concerns underscore the need for objective measures of system performance that can be applied on a timely and routine basis. Existing measures emphasize structural characteristics of the system while little is known concerning the utilization of system components, including patterns of transport and transfer. This paper proposes a methodology that

TABLE II
Performance of regionalization by age, ISS and body region of principal injury (Maryland hospital discharges, 1988)

		Total Number of Trauma Discharges	Per Cent Who Should Have Reached Trauma Center According to Panel Criteria	Per Cent Appropriately Referred to Trauma Center According to Panel Criteria (Sensitivity)	Per Cent Appropriately Referred to Non-Trauma Center According to Panel Criteria (Specificity)
Age (yrs)	0–4	784	12%	76%	56%
	5–14	1,961	11%	71%	62%
	15–44	14,926	23%	75%	54%
	45–54	2,289	20%	65%	66%
	55–64	2,186	20%	56%	68%
	65+	7,227	15%	41%	74%
ISS	1–8	17,482	0%	N/A	60%
	9–12	8,407	28%	53%	66%
	13–15	1,277	98%	71%	10%
	16–19	1,251	100%	70%	N/A
	20–24	424	100%	84%	N/A
	25+	505	100%	92%	N/A
Body region of principal injury	Head/neck	4,034	41%	76%	41%
	Spine	2,245	64%	50%	59%
	Face	1,542	8%	75%	49%
	Abdomen	1,091	40%	82%	43%
	Thorax	1,556	70%	62%	62%
	Extremities	15,314	6%	70%	71%
	External	3,591	5%	66%	51%

N/A: Not applicable.

TABLE III
Per cent appropriately referred to a trauma center (sensitivity) according to panel criteria by age and ICD/ISS (Maryland hospital discharges, 1988)

ICD/ISS	Age (yrs)		
	0–44	45–64	65+
1–8	N/A	N/A	N/A
9–12	64%	43%	35%
13–15	76%	67%	44%
16–19	77%	72%	44%
20–24	88%	80%	65%
25+	95%	88%	71%

trauma systems can use to begin to monitor utilization and performance.

The Methodology and Its Limitations. The limitations of the methodology are well recognized. First, the criteria developed for identifying patients who require treatment at trauma centers would benefit from further testing and validation. The expert panel used in this study was purposely chosen to represent surgeons based at Level I trauma centers. The criteria should be further scrutinized by appropriate experts and the classification rules refined as broader consensus evolves. The criteria do, however, provide a set of classification rules that are more specific than those based on ISS scores alone. Specifically, the panel identified subsets of patients with moderately severe injuries that should have been treated at trauma centers. Based on the ISS score alone these patients have not traditionally been thought of as major trauma patients requiring trauma center care. When the criteria were applied to Maryland discharge data, 2,370 patients with ISS scores of 9–12 and 1,256 patients with ISS scores of 13–15 were classified as those who should have been treated at a trauma center; together they accounted for 12% of all hospital trauma admissions in the state.

As an initial step towards validating the panel criteria for patients with moderately severe injuries, hospital mortality rates among the patients with ISS 9–12 were compared for those who should and should not have been treated at a trauma center according to the criteria. For all patients, except those 75 years and older, in-hospital mortality was twice as high for those who the criteria specified should have been treated at a trauma center as for those who should have been treated at a community hospital. Among patients aged 75 years and older, however, mortality was 1.7 times as high for those classified as non-trauma center or community hospital cases. The majority of these cases (97%) were isolated hip fractures. These comparisons provide some preliminary evidence to suggest that ICD/ISS 9–12 patients classified by the panel as requiring trauma center care were indeed more severely injured compared to patients with ICD/ISS 9–12 not classified as requiring trauma center care. A study currently under way in Maryland is evaluating the extent of potentially preventable trauma deaths for those who reached the appropriate level of care versus those who reached a lower level of care than judged appropriate by the panel criteria. The results of this study should assist in further validation of the criteria.

The application of the criteria to statewide hospital discharge data represents both a strength and a limitation of the methodology. These data are particularly well

suited for examining system performance as they incorporate uniform information on all hospitalized trauma regardless of where the patients are treated. This represents an advantage over most state or regional trauma registries that are limited in their coverage to patients treated at designated trauma centers only. While the data obtained for this select group of severe injuries are generally more detailed than would be available from state hospital discharge abstract data, the exclusion of trauma patients treated at non-trauma center hospitals limits the potential use of these registries for examining patterns of utilization and evaluating system performance.

Hospital discharge databases do not, however, include information on trauma deaths that occur at the scene, in transport, or in the emergency department. For evaluating overall performance of the system it is particularly important to know if deaths in the emergency department received the appropriate level of care. Linkages to computerized death certificate data and medical examiner data, if available, are thus necessary for a complete evaluation of the system.

It is also important to recognize that there is potential for double counting patients who are initially admitted to one hospital and transferred to another acute care facility. Although the per cent transferred is generally low (less than 2% of all trauma discharges in Maryland), they may represent an important subgroup of patients especially when using the data for the examining patterns of utilization. In some states the potential exists for linking discharge data to identify duplicate cases. This linkage is recommended whenever possible.

Computerized hospital discharge databases are also limited by their contents. Although the scope of the data collected varies, most states obtain a minimum of information as defined either by the Uniform Hospital Discharge Data Set (UHDDS) or the Uniform Billing Data Set (UB-82) (15). Neither database currently includes information needed to compute a Glasgow Coma Score, Trauma Score, or other severity measure based on physiologic parameters. Until such time as these data are routinely collected and computerized for all trauma patients, regardless of where they are treated, the criteria will have to rely on anatomic descriptors of the injury if they are to be useful in evaluating system performance. This is clearly a limitation, as it has been shown that a combination of physiologic and anatomic scores more accurately predicts patient survival than do anatomic scores alone (5, 6).

The utility of the methodology described also depends on the ability to assign accurate AIS severity based on computerized hospital discharge data. Although a computerized conversion from ICD-9CM coded discharge diagnoses into AIS and ISS scores has been carefully developed, the limitations of the conversion must be recognized when interpreting results (15, 16). ISS scores derived from ICD-9CM coded discharge diagnoses are imperfect measures of injury severity due to the lack of specificity of the ICD classification. For the most part, ICD/AIS scores were conservatively assigned. Therefore the per cent of cases judged as trauma center cases may be underestimated, potentially leading to an overestimate of the per cent of cases appropriately treated at non-trauma centers. The scoring of closed spine fractures represents an exception to this rule of conservatively assigning ICD/AIS scores. All closed fractures to the spine are assigned ICD/AIS scores of 3 since ICD does not distinguish between stable and unstable fractures or between fractures of the spinous or transverse process versus fractures of the vertebral body. Since spine fractures are relatively common, this limitation of the ICD has a significant influence on the degree of sensitivity. When all injuries to the spine are excluded from the analysis, sensitivity using 1988 Maryland discharge data increases from 66% to 71%.

Although limitations of statewide databases are recognized, they do provide unique opportunities for system evaluation. Currently, 28 states require that uniform hospital discharge data be collected on all acute care hospitalizations. Activities are currently under way which should further enhance the utility of these databases. First, it is expected that the tenth revision of the clinical modification of the ICD, to be published in the early 1990's, will provide more specificity with regard to injury diagnoses. The increased specificity will further improve the mapping of ICD rubrics into AIS severity scores. Second, several states have now mandated the inclusion of ICD E-codes which will provide much needed information on the mechanism of injury. Finally, the potential for linking statewide hospital discharge data to other databases such as death certificate data, trauma registries and prehospital transport records are being explored. Although careful attention must be given to issues of confidentiality when pursuing these data linkages, they would provide the information needed to address a broader array of issues relevant to policy in system evaluation.

Application of Methodology for Monitoring System Compliance. The methodology presented here provides a new and potentially valuable tool for planning regionalized systems and for monitoring their performance. In the planning stages, using discharge abstract data to document existing patterns of care may assist in identifying the optimal location of trauma centers. These data can provide estimates of the potential impact of regionalization in terms of redistribution of patients and revenues among trauma centers and non-trauma center facilities. Once the system is established, monitoring utilization patterns and compliance with evaluation criteria can provide a basis for evaluating overall performance and can serve as a quality assurance tool for identifying subgroups of the population who may not be receiving the appropriate level of care, i.e., patients for whom triage guidelines are less than optimal.

As an illustration of their utility, the appropriateness criteria were applied to hospital discharge data from Maryland. The analysis indicates that the sensitivity of the system was significantly lower for the elderly patients, aged 65 years and older. Only 41% of patients 65 years and older were appropriately referred to trauma centers compared to 75% of children and adults below the age of 45 years. The difference in compliance rates held for those with both moderately severe and very severe injuries. Further analyses are required to identify factors contributing to the potential underutilization of trauma centers by the elderly. However, findings presented here raise important concerns regarding the effectiveness of triage for geriatric trauma patients. There may be a number of factors involved. First, it may be more difficult for prehospital providers to detect serious injury in elderly persons. Alternatively, there may be a failure in the triage guidelines to clearly recognize that injuries that are not life threatening to a healthy younger adult can be life threatening to an older person. Several studies have now documented that the elderly are at increased risk of dying from traumatic injury (4, 9, 10, 20). It is unclear, however, whether current triage criteria based on physiologic scores are adequate for identifying the elderly patients in need of trauma center care (4). There is increasing evidence to suggest that elderly patients who sustain low-impact, single-system injuries of moderate severity are at increased risk of complications and poor outcome even when their physiology appears normal at the time of triage (4). Triage criteria may need to be more sensitive to such factors as pre-existing disease and functional status to ensure that older trauma patients are appropriately triaged to the appropriate level of hospital care (17).

Standards for Regionalized Systems. The panel criteria provide a basis for measuring the extent to which trauma patients are being treated at the appropriate level of hospital care. It is not clear, however, what levels of sensitivity and specificity should be considered adequate. There are a variety of issues that will need to be addressed before it will be possible to set standards by which to judge the performance of regionalized systems. These include:

1) Should a standard be stated simply as a required level of sensitivity (i.e., proportion of patients who should have been treated at a trauma center actually reaching a trauma center), or should this be a weighted proportion that puts greater weight on the more severely injured who fail to reach a trauma center?

2) What are the acceptable tradeoffs between sensitivity and specificity in a regionalized system? Assuming there will always be a margin of patients for whom field decisions are made under considerable uncertainty regarding the extent and severity of injury, the system must be willing to accept a minimum number of false positives (i.e., patients referred to trauma centers when it is not needed) to ensure that patients who should have been treated at a trauma center in fact get there. The largely unanswered question is to what extent we can improve sensitivity through the use of more effective triage guidelines without significantly decreasing specificity.

Clearly false negatives, or patients inappropriately referred to non-trauma centers, present a far more serious problem than false positives. While patients inappropriately referred to trauma centers are of major economic concern for community hospitals, a patient who is inappropriately referred to a non-trauma center may suffer an adverse outcome unless the seriousness of his condition is promptly recognized and he/she is transferred to a higher level of care.

3) Should characteristics of the geographic area (e.g., rural, suburban, urban), populations served (e.g., age distribution, risk of injury), hospitals (e.g., location, trauma capabilities), and the capacity of transport systems (e.g., availability of helicopters) be taken into account in setting standards for regionalized systems? It may not be reasonable to establish one standard for systems (states or regions) having very different capabilities and/or meeting very different needs for trauma care.

Some of these questions will be answered, in part, if it can be shown that there is a strong negative relationship between level of performance according to the panel criteria and risk of death from trauma. Then, if sensitivity and specificity drop, the cost of poor performance could be measured in terms of increasing numbers of potentially preventable trauma deaths. Whether such a clear relationship emerges will have to await the findings from numerous studies or a few large scale studies. Before making such an investment in testing the significance of system level performance, the initial step should be to demonstrate that there are measurable differences at the patient level in survival between those who by criteria should have been treated at a trauma center and are not, versus comparable patients who do reach a trauma center. As indicated, this study is currently being undertaken using 1986 Maryland trauma deaths. Similar studies using data from other regions will be needed to assess the generalizability of the findings.

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