Hypothesis: Although demographic and clinical information are known to affect hospital length of stay (LOS), we hypothesized that LOS after traumatic injury would be significantly influenced by nonclinical factors.

Design: Retrospective database analysis.

Patients: Trauma patients treated at hospitals participating in data submission to the National Trauma Data Bank.

Methods: The National Trauma Data Bank was queried for all patients older than 18 years with an LOS longer than 48 hours and complete demographic information including age, sex, and race/ethnicity; nonclinical factors including payment type (commercial, Medicaid, Medicare, uninsured, and other) and discharge destination (home, rehabilitation facility, nursing home, and other); and clinical information (body region injured, Injury Severity Score, and Revised Trauma Score). Statistical analysis was performed using generalized linear modeling adjusted for multiple comparisons.

Main Outcome Measures: Length of stay greater than the mean.

Results: We obtained 313,144 medical records. Mean LOS was 9.6 days. Discharge destination had the greatest effect on LOS. Mean LOS for patients with Medicaid (11.3 days) was significantly longer than for patients with commercial insurance and uninsured patients (each 9.3 days) and patients with Medicare (8.8 days). Length of stay was longer for patients discharged to a nursing home (14.2 days) or rehabilitation facility (11.5 days) compared with those discharged to any other facility (9.6 days). In multivariate analysis, factors significantly associated with extended LOS included age, sex, race/ethnicity, insurance status, discharge destination, and Revised Trauma Score.

Conclusions: Nonclinical factors significantly influence LOS. If LOS is used as a quality measure for injured patients, adjustment for these factors is necessary.

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tors, as well as the interaction term of race/ethnicity and payer status. Discharge destination was identified as significant using a .05 level, and only these were included in a stepwise method to determine a final model. Results of the analysis of variance are given in Table 1; results of the generalized linear model analysis are given in Table 2.

Intensive care unit LOS and need for admission to the intensive care unit were initially included in the models but were ultimately excluded because intensive care unit LOS is essentially a subset of total hospital LOS. In the final regression model, we examined not only the significance of the risk coefficients but also the strength of association. For each effect from the models, the odds ratio and 95% confidence interval were calculated. $P<.05$ was considered statistically significant. Analyses were carried out using SAS statistical software (version 9; SAS Institute, Cary, NC).

The analysis included 313,144 medical records. Mean±SD age of patients was 48.2±21.1 years; 62.3% were men. Seventy-four percent of the patients were white, 17% were black, 6% were Hispanic, 1% were Asian/Pacific Islander, and 0.5% were Native American or Native Alaskan. Forty percent of the patients had commercial insurance, 11% had Medicaid, 25% had Medicare, 16% were uninsured, and 9% had other insurance. Mean±SD Injury Severity Score was 12.3±9.3. Overall survival was 97%. Discharge destination was home for 63% of patients, a rehabilitation facility for 16%, a nursing home or other long-term care facility for 13%, another hospital for 4%, and other for 4%. Mean±SD LOS was 9.6±12.8 days. Patients with Medicaid insurance had the longest stay (mean±SD), 11.3±15.8 days, while those with Medicare had the shortest stay, 8.8±11.3 days (Table 3). However, there was a significant interaction effect between race/ethnicity and payer status on LOS (Table 2).

In the multivariate generalized linear models, 8 factors were associated with discharge destination (Table 2): sex, race/ethnicity, age, payment type, body region injured, discharge destination, Injury Severity Score, and Revised Trauma Score, and the interaction term race/ethnicity × payer status. Discharge destination had the greatest association with extended

### Table 1. Mean Length of Stay by Race/Ethnicity and Payer Status *

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Commercial</th>
<th>Medicaid</th>
<th>Medicare</th>
<th>Uninsured</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>9.33</td>
<td>11.29</td>
<td>8.77</td>
<td>9.47</td>
<td>10.74</td>
</tr>
<tr>
<td>Black</td>
<td>9.70</td>
<td>11.37</td>
<td>10.30</td>
<td>9.99</td>
<td>10.11</td>
</tr>
<tr>
<td>Hispanic</td>
<td>10.40</td>
<td>13.12</td>
<td>9.11</td>
<td>9.32</td>
<td>11.22</td>
</tr>
<tr>
<td>Asian</td>
<td>9.04</td>
<td>11.42</td>
<td>10.01</td>
<td>9.37</td>
<td>9.68</td>
</tr>
</tbody>
</table>

*Data are given as days.

### Table 2. Factors Associated With Extended Length of Stay

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Odds Ratio (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1 [Reference]</td>
</tr>
<tr>
<td>Male</td>
<td>0.83 (0.80-0.86)</td>
</tr>
<tr>
<td>Payer status</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>1 [Reference]</td>
</tr>
<tr>
<td>Medicaid</td>
<td>1.30 (1.22-1.39)</td>
</tr>
<tr>
<td>Medicare</td>
<td>0.77 (0.73-0.82)</td>
</tr>
<tr>
<td>Uninsured</td>
<td>1.18 (1.12-1.25)</td>
</tr>
<tr>
<td>Other</td>
<td>1.09 (1.00-1.18)</td>
</tr>
<tr>
<td>Body region injured</td>
<td></td>
</tr>
<tr>
<td>Extremity</td>
<td>1 [Reference]</td>
</tr>
<tr>
<td>Head</td>
<td>0.78 (0.73-0.82)</td>
</tr>
<tr>
<td>Face or neck</td>
<td>0.80 (0.75-0.84)</td>
</tr>
<tr>
<td>Thorax</td>
<td>0.83 (0.79-0.87)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>1.09 (1.04-1.15)</td>
</tr>
<tr>
<td>Spine</td>
<td>1.05 (0.998-1.09)</td>
</tr>
<tr>
<td>Discharge destination</td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>1 [Reference]</td>
</tr>
<tr>
<td>Rehabilitation facility</td>
<td>3.74 (3.59-3.89)</td>
</tr>
<tr>
<td>Nursing home</td>
<td>3.83 (3.61-4.07)</td>
</tr>
<tr>
<td>Hospital</td>
<td>2.23 (2.06-2.42)</td>
</tr>
<tr>
<td>Other</td>
<td>1.15 (1.09-1.44)</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>1.07 (1.07-1.08)</td>
</tr>
<tr>
<td>Revised Trauma Score</td>
<td>0.85 (0.84-0.86)</td>
</tr>
</tbody>
</table>
LOS. Compared with patients discharged to home, the odds ratio for an extended LOS for patients discharged to another hospital, rehabilitation facility, or nursing home was 2.23, 3.74, and 3.83, respectively. Payer status had the next greatest effect; Medicare patients were significantly associated with an LOS less than the mean compared with patients with commercial insurance (odds ratio, 0.77; 95% confidence interval, 0.73-0.82). Medicaid patients and those designated as self-payers were associated with an extended LOS (Table 2).

Patients with head, face or neck, and thorax injuries had stays shorter than the mean, and those with abdominal and spine injuries had stays longer than the mean. However, the magnitude of these associations, as well as the associations of sex, age, Injury Severity Score, and Revised Trauma Score, was relatively small compared with discharge destination and payer type status.

### Table 3. Mean Length of Stay by Payer Status

<table>
<thead>
<tr>
<th>Payment Category</th>
<th>Length of Stay, Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>9.3 ± 11.8</td>
</tr>
<tr>
<td>Medicaid</td>
<td>11.3 ± 15.8</td>
</tr>
<tr>
<td>Medicare</td>
<td>8.8 ± 11.3</td>
</tr>
<tr>
<td>Uninsured</td>
<td>9.3 ± 13.2</td>
</tr>
<tr>
<td>Other</td>
<td>9.7 ± 14.3</td>
</tr>
</tbody>
</table>

Length of stay is a commonly used outcome measure. University HealthSystem Consortium (UHC), National Surgical Quality Improvement Program (NSQIP), and the NTDB all provide reports to participating hospitals providing LOS performance data indexed to some benchmark. This comparison between hospitals is used as one measure of the quality of care provided. It is suggested that if LOS decreases, care has become more efficient and more effective, because patients with extended LOS often consume substantial hospital resources. The relationship of LOS, effectiveness, and efficiency may not always be direct. Our data from the NTDB involving hospitalized injured patients suggest that nonclinical factors significantly affect LOS. Based on these data, it is tempting to suggest that LOS should not be used as a quality indicator. Rather, we suggest these data bring into question whether LOS should be considered a process measure or an outcome measure.

Length of stay should not be used as a comparison between trauma centers or as a benchmark outcome measure unless it is appropriately adjusted. A simple comparison using injury severity will be inadequate. Although injury severity was significantly associated with extended LOS, other factors had much stronger associations. Clearly, age, physiologic status, and body region injured are also important. Adjustment for clinical factors, or risk adjustment, is also inadequate. Clinical factors alone may capture only 27% of the variation in extended LOS. Most risk-adjustment models do not include adjustment for the important nonclinical factors that affect LOS.

As a process measure, LOS would be used differently. In hospitalized injured patients, LOS in an acute care hospital is clearly affected by the need for rehabilitation or long-term care. The current data demonstrate that discharge destination had the strongest association with extended LOS, with odds ratios ranging from 1.15 to 3.83 for discharge destinations other than home. While acute care is provided without concern for insurance status in most cases, rehabilitation or placement in a long-term acute care facility (LTACF) is done only after an assessment of payment has been made. Placement of patients without adequate and appropriate insurance requires substantial personnel time and effort and may often depend on a very few beds in LTACFs in any given

Quality medical care has become the primary focus in US health care since the 2000 report from the Institute of Medicine. Organizational performance improvement is the cornerstone on which advances and increases in quality are based. Building on the foundations established by Shewhart and Deming, Donabedian enumerated the 3 essential components necessary to measure the quality of health care—structure, process, and outcome.

**Structure** is simply the infrastructure of the health care system, which includes the individuals, the equipment, and the physical plant. **Process** involves the various steps involved in the delivery of health care. Examples include the use of perioperative α-blockers, the timeliness of perioperative antibiotic administration, and the presence of an attending physician at a trauma resuscitation. **Outcomes** are, simply put, results. Some are relatively easy to measure, including mortality, perioperative myocardial infarction, and surgical site infection. Others, including pain, function, and quality of life, are more difficult to measure.

Many current quality improvement efforts focus on measuring structure and process because these are usually easier to measure than outcomes. The relationship of structure and process to outcomes can be direct or indirect. However, an assumption that cuts through most performance improvement or quality programs is that attention to structure and process will result in better outcomes. This relationship is best illustrated with process measures. Compliance with evidence-based guidelines is a process measure. For example, adherence to a guideline for management of patients with splenic injuries improved outcome, measured as splenic salvage rate. Process measures are also used in the Institute for Healthcare Improvement 100 000 Lives initiative in an effort to reduce catheter-related bloodstream infection, ventilator-associated pneumonia, surgical site infection, hospital cardiopulmonary arrest, death after myocardial infarction, and adverse drug events. Early results suggest that compliance with the identified process measures improves the targeted outcomes. Other studies have not confirmed that standardized process implementation will have significant effect on outcomes. While process measures may correlate directly with desirable outcomes, it is not clear that all process or outcome measures will monitor or measure what is intended to be measured.
community. In some communities, none of these beds may be available.

These realities of rehabilitation and skilled subacute care needs suggest that using LOS as a process measure may be helpful to a trauma system of care. Length of stay could be part of assessing rehabilitation and long-term care similarly to assessing acute care. Transfer agreements for rehabilitation and LTACF care could be incorporated into a trauma center's overall care plan. Length of stay could become a monitor for how well a community and a trauma system is identifying and managing available LTACF beds in the community. As with other aspects of a well-run trauma system, this approach should be inclusive and enable postacute care for all patients including the uninsured or underinsured. Continued extended LOS might indicate an unmet LTACF bed need, which would need to be addressed at the system level.

Although much of the influence of discharge destination on extended LOS may be because of insurance status, payment type has an independent influence in the multivariate model second only to discharge status. Some of this is moderated by race/ethnicity, inasmuch as interaction terms between groups were significant. The influence of race/ethnicity and payment type on other outcome measures of resource use has been noted by others. Liu et al found that Medicaid patients, blacks, Hispanics, and Asians were less likely to receive complex surgical care at high-volume hospitals.

Other reasons for an extended LOS may relate to its surrogate for socioeconomic status, including nutritional status, social support networks, and incidence of posttraumatic stress disorder. Using LOS as a process measure rather than a benchmark outcome measure enables an individual trauma center to investigate and address all of these potential reasons.

This study has limitations. The NTDB is a nonsystematic sample of hospitalized injured patients using data submitted voluntarily by participating hospitals, and population-based estimates or conclusions are impossible. However, the large number of hospitals from different regions of the United States that do contribute allow many possible regional influences to be overcome. Different hospitals may have different inclusion criteria for patient inclusion in a trauma registry. Because we included all injuries in patients surviving more than 48 hours, this difference in inclusion criteria should have a minimal effect. Comorbid conditions, clearly shown to affect LOS in hospitalized injured patients, were not considered in the model because of the large amount of missing data and quality of this field in the version used. However, the large cross-sectional sample suggests that the results reflect general associations with extended LOS.

Definitions of excessive, increased, or extended LOS are varied, and there is no acceptable gold standard. Length of stay greater than the mean or median has been used by others and is appropriate in this large database containing patients with many different injury diagnoses. Attribution of inappropriate hospital days requires either prospective determination of clinical need or comparison of carefully selected similar patients with similar diagnoses, in addition to similar clinical and nonclinical factors that affect LOS.

Discharge destination and insurance status are major factors in increased LOS in the injured patient. This confirms associations found by others, primarily in small, single-institution studies. Once this relationship is established, it is difficult to look at unadjusted LOS as an outcome measure evaluating quality of hospital-based medical care. Approximately one fourth to one third of the LOS may be associated with nonmedical factors. However, many organizations using LOS as a quality benchmark do not adjust for these important nonclinical factors. As an outcome measure, LOS must be adjusted for both clinical and nonclinical factors. While unadjusted LOS may not be a valid outcome measure, it may have value as a process measure for many trauma programs.

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Author Contributions: Study concept and design: Brasel, Lim, Nirula, and Weigelt. Acquisition of data: Brasel. Analysis and interpretation of data: Brasel, Lim, and Nirula. Drafting of the manuscript: Brasel, Lim, and Nirula. Critical revision of the manuscript for important intellectual content: Brasel, Lim, Nirula, and Weigelt. Statistical analysis: Lim and Nirula. Administrative, technical, and material support: Brasel and Weigelt. Study supervision: Brasel and Weigelt.

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DISCUSSION

R. Stephen Smith, MD, Wichita, Kan: Since the report “To Err Is Human” was published by the Institute of Medicine in 2000, there has been an appropriate emphasis on quality of care and performance measurement. Business and industry have recog-
nized the importance of this topic through the Leapfrog Ini-
tiative. Commercial entities such as HealthGrades have at-
tempts to assess the quality of care provided by both institutions and physicians and have made their conclusions available to the public. We have all heard recently, and frequently, the man-
tra of “pay for performance,” which will greatly affect our prac-
tices regardless of our geographic locations and our practice setting. Dr Brasel and her colleagues have brought forward an important issue: How is quality measured? Can a single statisti-
tic serve as a valid indicator of quality and efficiency? The American College of Surgeons Committee on Trauma suggests the use of LOS as an example outcome measure in a performance improvement program. The authors have thoughtfully and conv-
incingly demonstrated that a seemingly simple and straight-
forward statistic is influenced by myriad complex factors, many of which are nonclinical and beyond the control or influence of surgeons or hospitals. Some of these factors include discharge destination, the presence or absence of family support, payer status, and the availability of rehabilitation or long-term care facilities. While extended LOS certainly demonstrates holes in our health care system, is this an appropriate measure of qual-
ity of care in a trauma center? Based on this work, the answer appears to be no. Dr Brasel and her colleagues could have enti-
tled this paper “Lies, Damn Lies, and Statistics.” I have sev-
eral questions. Many facilities that submit data to the NTDB do not include financial information such as payer type. Are you certain that your data are broadly representative of pa-
tients with injury? For example, the percentage of uninsured patients, 16% in your study, seems small for a trauma popula-
tion. Were there state or regional differences in either LOS or the nonclinical factors that seemed to influence LOS? Your categ-
ories of discharge destination were somewhat broad. For ex-
ample, discharge to home included the subcategories of home, home with health care assistance, psychiatric facility, and jail. While my teenage children may consider home the equivalent of incarceration, I am not sure this is true of trauma patients. Did you assess LOS for the various subcategories of discharge destination? Did mechanism of injury, for example, blunt vs penetrating trauma or an assault vs a motor vehicle crash, have a significant effect on LOS? It is my impression that victims of violent acts are much more difficult to place and thus, have a prolonged LOS even though their injuries are essentially equiva-

tent to those of others. Finally, based on your analysis, is LOS a meaningless measure of quality measurement? Should or-

ganizations that purport to measure quality of care abandon LOS as an indicator of effective and efficient care?

Dr Brasel: First, with respect to financial data, we did not use either costs or charges in this analysis, although that would be interesting, and all records that we included did have payer source. With respect to the uninsured, one of the problems with the NTDB is that it is not population-based, so these results, although I believe they would be relatively similar given the population-based sample, can only be general-
ized to the NTDB records. We did not assess regional differ-
ences. That would be interesting to do. I grouped discharge destination primarily based on my experience in that patients whom I discharge to jail or psychiatric facilities essentially must be able to take care of themselves, somewhat similar to patients whom I discharge to home. I do not think putting them in a separate group would be particularly helpful because they would be such a small minority, less than 5% in both groups. We included mechanism of injury, blunt vs penetrating trauma, in early analyses. It did not turn out to be independently significant, although, as you might imagine, patients who are injured through blunt mechanisms are sig-
ificantly different with respect to some of those nonclinical factors from patients who are injured via penetrating mecha-

nisms. However, this becomes overwhelmed by those other non-
clinical factors. I do not think we are going to be able to throw out LOS. It is so easy to measure and is such a part of the administrative culture. What I would like to see is LOS used intelligently and to work with administrators rather than having them spend inordinate amounts of personnel time and sta-

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a national forum to really increase access to rehabilitation, which is one of the frontiers of trauma systems that is totally undeveloped.

Dr Brasel: I am not sure I have a short or a simple answer to that question, but I do think it is important. And I think, going back to one of Dr Smith's questions, looking at this on a regional basis may help, or looking at a smaller subset where we might have days in rehabilitation, and use LOS as a system aspect rather than just in acute hospital care.

Scott R. Petersen, MD, Phoenix, Ariz: Hospital administrators are constantly looking at LOS and, subsequently, direct variable costs. Your study demonstrates that LOS is really process-related and not a quality outcome. I think it is an important concept. As a medical director of a hospital trauma service line, I am informed on a quarterly basis about our direct variable costs and where the service is in relation to our goal. Ninety percent of direct variable cost is directly related to LOS. Your article has highlighted that LOS and indirectly controllable costs are not necessarily a provider-only outcome but a process of care. I have 2 questions: Have you looked at the direct variable costs in your facility? What are you tracking now in your own facility insofar as LOS?

Dr Brasel: We looked at this about 4 years ago and found that about 25% to 30% of our extended LOS on a prospective basis was completely nonmedical. And that was not even because of some of these nonclinical factors. The patients were assessed as ready to go and the physicians were ready to write the discharge orders, but the consultant had not put a final opinion on the medical record, there was some nursing issue to be done, the discharge supplies were not ready, or there was no bed available in a rehabilitation facility or a nursing facility. I would like to say we have reduced that. We have case managers who work on that actively. We have not been very successful.

Mark Talamonti, MD, Chicago, Ill: Length of stay is also used as a measure of quality in surgical oncology, and is very complex in that setting. Other papers that have examined LOS in surgical oncology have tried to relate it to high-volume centers and to complexity of cases. In your database, did you look at high-volume trauma centers, different levels of trauma centers, and how that influenced LOS?

Dr Brasel: We did not look at level of trauma center. There are a lot of nondonated centers in the NTDB or centers that have chosen not to report a designation.

Gregory J. Jurkovich, MD, Seattle, Wash: Two quick questions: First, do you know what the UHC uses as risk adjustment? In your first slide, you showed that the UHC did have risk-adjusted LOS. What is the UHC using as risk adjustments in a trauma population for LOS? Second, have you considered interaction between the variables used in your regression analyses? Your multivariate logistic regression shows a number of these variables as being individually important, but I cannot imagine that many of these are not related to each other. Have you looked at interaction variables for those key nonmedical social sorts of issues that relate to LOS?

Dr Brasel: All of the factors that the UHC adjusts for are clinical, unlike the Hospital Efficiency Index, which includes some nonclinical adjustment. The UHC adjusts for age and comorbidity. They do not adjust for injury severity or anything specific to trauma populations. We did look at some interaction terms. The interaction of race/ethnicity and insurance is significant. We did not overwhelm the model with interaction terms, but that interaction term was significant.

Donald E. Low, MD, Seattle: Many of the comparisons in which we see LOS used as the most relevant factor have to do with the evolution from open to minimally invasive and even interventional types of procedures. Your study population was a diverse trauma population. It would be equally interesting to have the same objective comparisons in patients who have a single pathologic condition. However, do you believe that any assessment of LOS is relevant if readmission rates are not included?

Dr Brasel: I would say, probably not. If you are just discharging people from the hospital after a first admission and they return and are readmitted for another 4, 5, or 6 days, that probably does not influence resource consumption and may be an indicator of poorer quality of care rather than improved quality of care. You might suggest that readmission rate, as a clinical or nonclinical factor, is influential, but it goes to the point that you need to know what goes into the data and intelligently use the data when you talk with your administrators, and look at your own practice, your hospital's practice, and your system's practice.

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