I appreciate the opportunity to participate in this symposium and the invitation to serve on a panel presentation with Jerry Jurkovich, Charlie Mock, and Howard Champion. My comments will focus on several issues that we have begun to address today and several topics that need to be incorporated into our deliberations. First, the difficult methodologic issues already raised in our symposium on preventable trauma death studies and trauma registries are not unique to studies of trauma care effectiveness. An overriding concern throughout health care is how to better establish an evidence base for health services provided and how to establish this evidence within existing budgets. Enormous gaps persist in our capacity to study health care processes and outcomes. Mark Pauly, a health economist at the Wharton School, has summarized the general problem: "Current techniques for measuring appropriateness and effectiveness of care are deficient in the sense of not accurately measuring initial severity, not capturing the full spectrum ... of outcomes, and not being based on good statistical methodologies." That we lack definitive measures of trauma system effectiveness is not surprising. What would be surprising is if such measures were readily available.

My second comment is that the use of hospital trauma mortality data to measure trauma system effectiveness exemplifies the general methodologic shortcomings described by Dr. Pauly. The limitations of widely used methods of measuring initial injury severity, the understandable but all too narrow focus on trauma deaths as an outcome, and the questionable application of the TRISS model to compare groups of trauma patients illustrate important gaps in our present capacity to study the impact of trauma systems. Even the scope of what composes a trauma system needs to be carefully reevaluated. If the scope is too narrowly defined, then trauma system effectiveness is reduced to the question of whether trauma center treatment makes a difference in patient survival. As a counterweight to this tendency, I will introduce into the discussion the episode of care concept. Use of this concept helps extend trauma system evaluation in both the prehospital and posthospital directions and expands the scope of effectiveness to include outcomes other than survival.

Third and finally, I want to emphasize that capitalizing on rapid advances in information technology can yield benefits for evaluating trauma systems and other systems of care and nonsystem interventions. Gaps in the evidence base for clinical and health policy decision-making are not unique to trauma care. An important reason for these gaps is the extensive processing of medical information needed to answer basic questions about effectiveness. New tools for collecting, analyzing, and disseminating medical information are available and entering into clinical practice at an accelerating pace. However, maximizing the yield of these new technologies for evidence-based decision-making will require closer attention to how they are applied in day-to-day practice. Leadership at the national level is needed to ensure that clinical data captured during episodes of trauma care are recorded in a way that facilitates their reuse in outcome studies and trauma systems evaluations.
The 11 studies in the evidence table presented by Drs. Jurkovich and Mock focus on the survival of trauma patients treated at trauma center hospitals. The relevance of these studies to trauma systems evaluation rests on the assumption that the acute hospital phase of trauma care, measured in terms of patient survival or death at hospital discharge, provides the necessary and sufficient data for evaluation of trauma system performance. Use of these studies for trauma systems evaluation also rests on the assumption that methods of measuring injury severity are sufficiently well developed to adjust for case mix of patient populations and attribute differences in patient outcomes across hospitals to differences in treatment rather than underlying injury severity. This assumption deserves a closer look, particularly in light of the well-known pitfalls and peculiarities of severity adjustment methods. Dr. Champion has discussed the problem of measuring injury severity, and Drs. Jurkovich and Mock have done so as well. Eight of 11 studies in the evidence table presented by Drs. Jurkovich and Mock used the TRISS methodology in some way to compare hospital outcomes. Embedded in this methodology are use of the Abbreviated Injury Scale (AIS) to score the severity of individual injuries and use of the Injury Severity Score as an aggregate severity measure. The limitations of the AIS and Injury Severity Score have important implications for determining probability of survival by using the TRISS methodology. For example, in an audit of 31 unexpected trauma deaths (i.e., deaths for which the TRISS-generated probability of survival exceeded 0.5), 26 deaths were found on peer review to have been misclassified even though the predictive model was correctly applied. The reviewers attributed most of the misclassification to limitations of the Injury Severity Score and AIS, which underestimated the severity of the injury. These limitations contributed to the decision by Dr. Champion and his coworkers to develop a new predictive model, published it in 1990, and to develop additional models. But TRISS continues to figure prominently in trauma outcome studies, including most of the studies included in the evidence table under discussion.

The studies that relied on the TRISS methodology raise additional concerns about how this predictive model was applied to compare patient outcomes across groups of hospitals. The central concern relates to patient mix and appropriate analytic methodology for comparing groups. Many subtle factors may interact and affect how models perform when they are applied to a second group of patients, for example, severely injured patients admitted to San Diego trauma centers. The large sample size of the Major Trauma Outcome Study database may not compensate for these case mix factors. Applying the TRISS model to San Diego data assumes that the variables in the model are the only ones and the correct ones to apply to San Diego patients. Also, this use of the model assumes that the variables are being used in the correct way. It may be that in San Diego one of the variables needs to be transformed or interaction terms added for an appropriate application of the model.

A preferred approach to applying a predictive model to San Diego's data, and one that follows a more conventional analytic strategy, is to combine independent datasets into a single set, fit a logistic model by using all possible risk factors plus a group variable (a so-called indicator or dummy variable that indicates whether the data are from San Diego or the comparison group) and address interaction first. If there is no significant interaction, the coefficient for the group variable provides the odds that trauma care outcomes in San Diego differ from the comparison group in the dataset. If there is significant interaction, a single overall comparison is not possible. Instead comparisons must be confined to different strata within the dataset. For example, if comorbidity is determined to be an effect modifier, then comparisons must be confined to different categories of comorbidity.

The bottom line is that when a predictive model is applied to a second dataset, a significant Z-score
needs to be interpreted cautiously. If the Z-score is significant and you assume the model includes the right variables and in the right form, then you can attribute the difference in observed to expected mortality to a missing variable, i.e., more effective trauma care. However, a significant Z-score also can be found when a model is not applicable to the data. Under these circumstances, the Z-score simply indicates that the model is a poor predictive instrument for the data at hand. This situation is a major issue with most, if not all, the studies that have incorporated TRISS methodology.

In addition to concerns about the methods used to compare hospital outcomes, we also need to consider whether trauma system evaluation should be based on analyses of entire episodes of care rather than just the hospital component. An episode of care is a concept that health services researchers have used for years; it is defined as one or more medical services received by an individual during a period of relatively continuous contact with one or more providers of service, in relation to a particular medical problem or situation. This analytic framework can help focus attention on the entire sequence of trauma care events, from initial contact with prehospital emergency medical services through rehabilitation and return to previous level of function or optimal level of function. Trauma care outcome studies that are restricted to the hospital phase of care do not address prehospital access issues, the adequacy of emergency medical services triage and transport, and posthospital health status. For example, a retrospective cohort study of trauma patients treated at hospitals in the state of Washington indicates that deaths within 30 days of hospital discharge add 14% to the death rate among hospitalized patients.

Application of the episode of care framework to outcome studies has been limited in the past by difficulties assembling data from disparate sources of patient-specific information. This obstacle most likely will be overcome with the transition from paper-based to electronic patient records and enhanced capacity to link data from discrete encounters or phases of care into a single, episode of care record. Computerization is essential if the episode of care approach is to achieve practical value in trauma and other outcome studies. Fortunately, we are in the midst of a large-scale, technologic movement toward patient records in which data generated and used during episodes of care are more readily available for aggregation and reuse after the episode. Leveraging this movement will require concerted and coordinated attention to data standardization at the national level and measures to protect data privacy and security.

We have an unprecedented opportunity to better organize health data for evidence-based decisions in trauma and other fields. We need to create electronic patient records that can be linked electronically and ensure adequate data to risk adjust outcomes. We need to report key health indicators regularly, and we need to make population-based and patient-level data accessible to appropriate users to better understand treatment outcomes and the impact of alternative systems of providing care.

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Address for correspondence: National Center for Injury Prevention and Control (F41), Centers for Disease Control and Prevention, Atlanta, GA 30341; email: dap1@cdc.gov.