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Abstract
Background: Improving outcomes after serious injury is important to patients, patients' families, and healthcare providers. Identifying early risk factors for long-term disability after injury will help critical care providers recognize patients at risk.

Objectives: To identify early predictors of long-term disability after injury and to ascertain if age, level of disability before injury, posttraumatic psychological distress, and social network factors during hospitalization and recovery significantly contribute to long-term disability after injury.

Methods: A prospective, correlational design was used. Injury-specific information on 63 patients with serious, non–central nervous system injury was obtained from medical records; all other data were obtained from interviews (3 per patient) during a 2½-year period. A model was developed to test the theoretical propositions of the disabling process. Predictors of long-term disability were evaluated using path analysis in the context of structural equation modeling.

Results: Injuries were predominately due to motor vehicle crashes (37%) or violent assaults (21%). Mean Injury Severity Score was 13.46, and mean length of stay was 12 days. With structural equation modeling, 36% of the variance in long-term disability was explained by predictors present at the time of injury (age, disability before injury), during hospitalization (psychological distress), or soon after discharge (psychological distress, short-term disability after injury).

Conclusions: Disability after injury is due partly to an interplay between physical and psychological factors that can be identified soon after injury. By identifying these early predictors, patients at risk for suboptimal outcomes can be detected.

Disciplines
Medicine and Health Sciences | Nursing

Early Predictors of Long-Term Disability After Injury

By Therese S. Richmond, PhD, CRNP, Donald Kauder, MD, Janice Hinkle, PhD, CNRN, and Justine Shults, PhD. From School of Nursing (TSR) and School of Medicine (DK, JS), University of Pennsylvania, Philadelphia, Pa, and School of Nursing, Villanova University, Villanova, Pa (JH).

• BACKGROUND *Improving outcomes after serious injury is important to patients, patients' families, and healthcare providers. Identifying early risk factors for long-term disability after injury will help critical care providers recognize patients at risk.*

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• CONCLUSIONS *Disability after injury is due partly to an interplay between physical and psychological factors that can be identified soon after injury. By identifying these early predictors, patients at risk for suboptimal outcomes can be detected. (American Journal of Critical Care. 2003;12:197-205)*

Evidence gathered during the 1990s on patients' outcomes after trauma indicates that survivors do not recuperate as quickly or completely as previously assumed. Recently, the measure called disability-adjusted life years has been used to indicate the burden of injury. The value is calculated by combining information on (1) the number of years of productive life lost because of premature death and (2) the occurrence of disability or loss of health in survivors of injury. Using disability-adjusted life years, the World Health Organization calculated that in 1998, 16% of the world's burden of disease was due to injury and projected that injuries would pose an even higher burden by the year 2020.[1]

Because of this evidence of incomplete recovery from injury,[1] determining early predictors of suboptimal recovery is vital. Disability is a complex concept that signifies limitations in the actual fulfillment of socially defined roles and tasks expected of an adult in a sociocultural environment.[2] The timely and accurate ability to predict long-term disability shortly after injury would make it possible to recognize patients at high risk and efficiently implement interventions to limit the duration and severity of long-term disability.

The injuries that lead to disability are not randomly distributed, and the ensuing disabilities also may not be.[3]

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■ The long-lasting effects associated with traumatic injury are related not only to the severity of the physical injury but also to the psychological results. Early identification of both physical and psychological risk factors for long-term disability after injury may provide a focus for comprehensive, acute nursing care.

Because of this assertion, closing the gaps in our understanding of the factors that contribute to disability after injury is important. As proposed by Bickenbach[4] and corroborated by empirical findings, severity of physical injury alone does not completely account for variations in outcomes in a variety of injury types.[5-7]

In the investigation described here, we were guided by Nagi's theory of the disabling process,[2] which posits that by themselves the anatomic and physiological derangements of an injury do not completely explain the variation in disability after injury. This investigation extended previous research in which we found that notable short-term disability after injury is associated with risk factors that extend beyond the physical injury itself to the psychological effects of the injury.[8-10] The purpose of the study reported here was to determine early predictors of long-term disability after injury. We tested an explanatory model to ascertain if age, disability (before the injury and in the short-term after injury), psychological (posttraumatic psychological distress), and social (social network) factors identified during hospitalization and early in recovery significantly contribute to long-term disability after injury (Figure 1).

Methods

Sample

A total of 63 consenting, English-speaking adults were followed for 2½ years after injury. Each patient

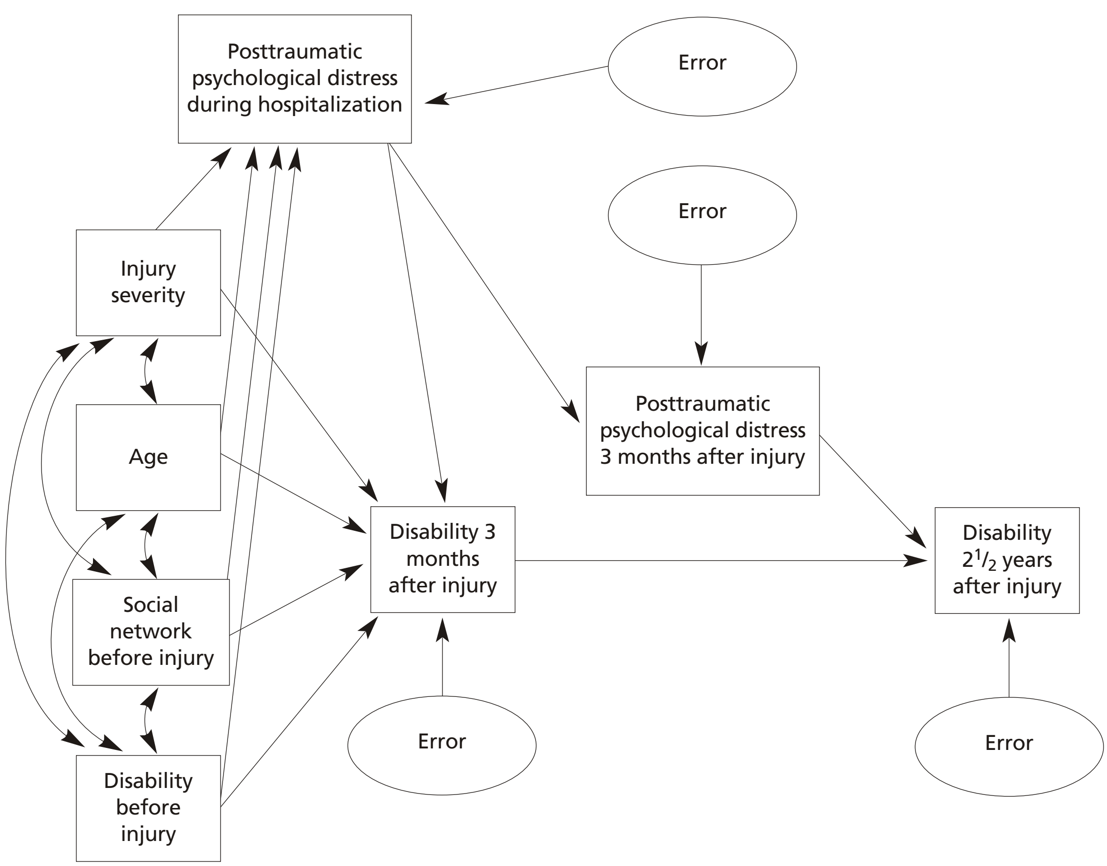

Figure 1 Proposed model of early predictors of long-term disability after injury. Single arrows connect the dependent and independent variables. The error variables associated with each independent variable are denoted with circles (rather than boxes) to indicate that they are not measured directly. Curved, double-headed arrows connecting the variables on the left indicate that these variables may be correlated.

was interviewed 3 times: during hospitalization, 3 months after discharge from the hospital, and 2½ years after injury. The sample was obtained from a group of 123 adults who were entered into a study of short-term disability after injury during their initial admission to 3 accredited trauma centers in the northeastern United States.[8] Patients were eligible for the study if they had injuries severe enough to require at least one of the following: a surgical procedure, intensive care, or hospitalization of at least 3 days. Patients were excluded if they had self-inflicted injuries, concomitant central nervous system injuries, a preexisting active psychiatric disorder, or if they would be imprisoned at discharge.

■ Data concerning physical and psychological factors that might affect long-term disability were obtained through interviews of patients.

Instruments

Disability was measured with the Sickness Impact Profile (SIP), a 136-item behaviorally based instrument used to detect relatively small alterations in function across numerous types and severities of illness.[11,12] Items are weighted on the basis of their relative contribution to dysfunction in each of 12 categories. Total SIP scores and scores for the physical and psychosocial dimensions range from 0 to 100, with higher scores indicating greater disability. Internal consistency in the study reported here was 0.94. Construct and concurrent validity are well established.[13]

The 15-item Impact of Event Scale was used to assess posttraumatic psychological distress associated with the traumatic event.[14] Total scores on this scale range from 0 to 75; the intrusion subscale score ranges from 0 to 35, and the avoidance score ranges from 0 to 40. Higher scores denote greater levels of psychological distress. Two key elements of posttraumatic stress disorder (event intrusion and event-related avoidance) are measured. These 2 dimensions were established by factor analysis, confirming the validity of these subscales.[14] The 2 subscales correlate ($r = 0.42$), but not to the degree that the identical dimensions of distress are surveyed. The Cronbach α for the study reported here was 0.90. The Impact of Event Scale is sensitive to changes across time and has been extensively used to delineate distress after a traumatic event.[14,15]

The 6-item Social Support Questionnaire Network Subscale[16,17] was used to assess each patient's social network before the injury and 2½ years after the injury on the basis of the number of persons the patient thought he or she could turn to in particular circumstances. The score on this subscale is calculated by dividing the total number of persons listed for the complete scale by the total number of items (each item represents a different circumstance). Higher numbers indicate a larger social network; the possible range is 0 to 9. In the study reported here, the Cronbach α was 0.88.

Injury type was categorized by using the Abbreviated Injury Scale, an anatomically based injury classification scheme used to rank and compare injuries according to the body system involved (head/neck, face, thorax, abdomen, extremities, and external/skin and soft tissue).[18] Injuries are scored according to severity on a scale of 1 (minor) to 6 (incompatible with life). Information used to code the injury is obtained from surgical findings or diagnostic workups.

The Injury Severity Score was used to quantify the severity of injury and allows comparison of severity among dissimilar types of injury.[19] The Injury Severity Score is calculated by using the sum of the squares of the highest Abbreviated Injury Scale in each of the 3 most severely injured body regions and ranges from 0 to 75.[19] Taken together, the Abbreviated Injury Scale contributes distinct information about the body system involved and the severity of injury within that body system, and the Injury Severity Score indicates the severity of all injuries in totality.

Procedure

The study was approved by the appropriate human subjects board. A letter of invitation and a consent form were sent to all patients (n = 123) who participated in an earlier study on short-term disability after injury. Addresses were confirmed for returned envelopes, and the letters and consent forms were mailed again. Telephone contact was attempted for subjects whose letters remained undeliverable or who had not responded. Those reached by telephone who agreed to participate provided verbal consent and later supplied written consent. If the primary telephone number was not in service, secondary numbers of the subject's family and friends were used. This process yielded 63 subjects who could be located and who agreed to participate.

Each patient participated in a 1-hour interviewer-administered structured interview in which the SIP, the Impact of Event Scale, and the 6-item Social Support Questionnaire Network Subscale were completed. These data on long-term outcomes supplemented the existing data set from the previous study on short-term disability after injury.[8] Participants were paid $25 at the end of the long-term interview.

Data Analysis

Descriptive statistics (means, medians, SDs) were first calculated for the study variables. Mean and median values of continuous variables were compared between subjects who were and were not lost to follow-up by using a *t* test and the Wilcoxon rank sum test, respectively. Mean disability scores were compared among body systems by using analysis of variance. Independence of categorical variables was assessed by using a χ^2 test. Predictors of long-term disability were evaluated by using path analysis, in the context of structural equation modeling with the Amos 4.0 graphical interface.[20] Competing models were compared by assessing their goodness-of-fit statistics.

The standardized regression weights of the final model are drawn on the corresponding arrows. Standardized regression weights are regression coefficients for models for which the variables are adjusted to an SD of 1.0 before the analysis. These coefficients are useful because they allow assessment of the relative importance of variables in the final model; more important variables correspond to larger standardized regression weights. In contrast, unstandardized coefficients cannot be directly compared because they vary according to the SDs of the variables in the model, which depend on their units of measurement (eg, years vs months for age).

Results

The demographics of the sample are given in Table 1. Of the subjects, 16% lived alone. The percentage of subjects who predicted problems returning to their prior activities (52.4%) was similar to the percentage of those who did not (47.6%). The mean duration of hospital stay was 12 days (SD 13.1, range 3-95). Most of the subjects (83%) were discharged directly to their homes.

An attrition of 49% occurred during the 2½ years of the study. Therefore, for demographic and injury variables, subjects available for the long-term follow-up (n=63) were compared with those who were not available (n=60). Subjects who completed the study were similar to those who were lost to follow-up except in 3 ways. Those lost to follow-up had more serious injuries than did those who remained in the study. Subjects who experienced violent injury were more likely than those who did not to be lost to follow-up. A marginally significant difference was found in work status; subjects who remained in the study were more likely to have been working full- or part-time before the injury.

As a categorical variable, body system injured could not be tested in the explanatory model. Therefore, body system with maximal injury was examined for its effects on long-term disability after injury. We found no significant difference in long-term injury after disability among body systems injured.

Table 1 Demographics of the sample*

Variable	Subjects in the study (n=63)	Subjects lost to follow-up (n=60)	*P*
Age, mean (SD), years	39.73 (16.99)	35.58 (17.57)	.18
Years of education, mean (SD)	12.98 (2.2)	12.22 (2.32)	.06
Injury Severity Score, mean (SD)	13.46 (8.42)	17.72 (10.86)	.02
Sex			.31
Male	42 (67)	45 (75)	
Female	21 (33)	15 (25)	
Ethnic background			.11
White	40 (64)	27 (45)	
African American	21 (33)	31 (52)	
Other	2 (3)	2 (3)	
Marital status			.28
Currently married	24 (38)	16 (27)	
Never married	24 (38)	31 (52)	
Widowed/divorced	15 (24)	13 (21)	
Worked full- or part-time before injury			.051
Yes	49 (78)	37 (62)	
No	14 (22)	23 (38)	
Mechanism of injury			.001
Motor vehicle/motorcycle crash	23 (37)	24 (40)	
Violent assault	13 (21)	29 (48)	
Fall	10 (16)	3 (5)	
Pedestrian hit by motor vehicle	8 (13)	3 (5)	
Other	9 (14)	1 (2)	

*Values are No. of subjects (%) unless otherwise noted.

Descriptive summary statistics for the variables included in the explanatory model are shown in Table 2. Disability, as indicated by the total SIP score, 2½ years after injury was significantly higher than disability before the injury, as were the physical and psychological dimensions of the SIP. Although the severity of posttraumatic psychological distress 2½ years after injury was significantly less than the severity 3 months after injury, it did not differ significantly from the severity of psychological distress experienced in the hospital immediately after the injury.

The final (best fitting) model is presented in Figure 2. A total of 36% of the variance in long-term disability after injury was explained by predictors present either during hospitalization or soon after discharge. Both the before-injury (age and disability before the injury) and in-hospital predictors (posttraumatic psychological distress) of disability after injury were significant. Age at the time of injury indirectly affected disability after injury through its influence on in-hospital psychological distress; older subjects experienced lower levels of posttraumatic psychological distress than did younger subjects. On the other hand, disability before the injury was associated with higher levels of both disability after injury and psychological distress. Elevated levels of both posttraumatic psychological distress and disability 3 months after discharge contributed to the long-term disability after injury. Furthermore, elevated levels of posttraumatic psychological distress during the initial hospitalization were predictive of subsequent elevated levels of psychological distress and disability at 3 months. In addition to determining the variance in long-term disability accounted for by the model, the squared multiple correlations (proportion of its variance that is accounted for by its predictors) of the other variables were 17.6% for short-term disability after injury, 36.8% for short-term posttraumatic psychological distress, and 15.7% for in-hospital posttraumatic psychological distress.

Discussion

Trauma care in the United States has improved markedly during the past 20 years; the implementation of trauma systems has led to decreases in mortality.[21] The focus during the early phase of traumatic injury has been on establishing physiological stability, accurately diagnosing and managing injuries, and preventing and/or aggressively managing complications. The focus has now expanded to maximizing return to optimal function.[22-26] This new focus has stimulated acute care clinicians to look beyond the critical care unit and hospital setting. The importance of this expanded focus is supported by the findings of the study reported here, which confirm our previous findings[8-10] and indicate that even in the absence of injuries to the central nervous system, patients with serious injury continue to experience disability in the long-term.

A limitation of the study is that only 51% of the subjects could be located for the 2½-year follow-up, resulting in the possibility of a type II error. Thus, in testing the final model, paths that were deemed nonsignificant may actually have been significant. When interpreting the findings, it is important to consider that subjects lost to follow-up were more likely than those who remained in the study to have experienced violent injury, more likely to have more serious injuries,

Table 2 Means and SDs for variables in the explanatory model (n=63)*

Variable	Before injury or during hospitalization	3 months after injury	2½ years after injury
Disability before injury			
Total Sickness Impact Profile	4.3 (8.7)	23.3 (14.8)	13.8 (15.6)†
Physical dimension	1.9 (5.6)	13.2 (11.6)	7.6 (9.7)†
Psychological dimension	5.1 (9.8)	11.9 (14.0)	13.5 (20.9)†
Social network before injury	2.7 (2.0)	Not collected	3.5 (2.2)
In-hospital posttraumatic psychological distress			
Total Impact of Event Scale	22.4 (16.5)	27.4 (18.7)	22.5 (21.2)‡
Avoidance subscale	10.3 (8.7)	13.8 (10.0)	10.2 (10.7)
Intrusion subscale	12.2 (10.1)	13.6 (10.2)	12.3 (11.9)

*Values are mean scores (SD).
†Level of disability 2½ years after injury remained higher than the level before injury ($P<.001$).
‡Psychological distress 2½ years after injury was less than at 3 months ($P=.003$) but no different from level during hospitalization.

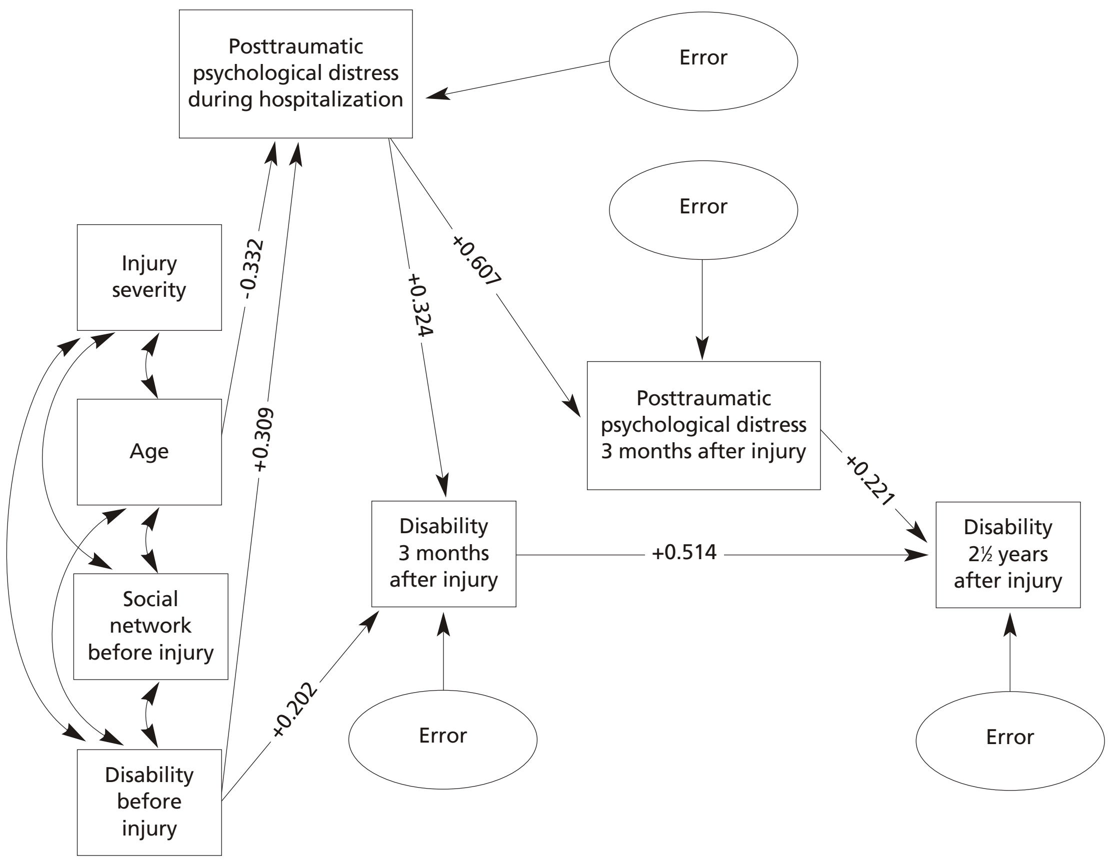

Figure 2 Final model of predictors of long-term disability after injury. Single arrows connect the dependent and independent variables. The error variables associated with each independent variable are denoted with circles (rather than boxes) to indicate that they are not measured directly. Curved, double-headed arrows connecting the variables on the left indicate that these variables may be correlated. The numbers on the straight arrows are standardized regression weights.

and less likely to have worked before injury. When located, subjects from the short-term study agreed to participate in the long-term study. We do not know why we could not contact all participants of the previous study. One reason may be the relative instability in living arrangements in the urban population of persons who are injured, particularly those who experience violent injury. From a study-design perspective, the interval between the 3-month study and the start of the long-term follow-up was extended and most likely contributed to the attrition.

On the basis of research by Haukeland,[27] who found no significant improvement in recovery from 2 years to 4½ years after injury, 2½ years after discharge is an appropriate end point for measuring recovery. Our findings verify that return to levels of function experienced before the injury is not complete for all patients even at 2½ years after injury. Disability at 2½ years was less than that experienced 3 months after injury but continued to be significantly greater than that present before injury. This finding extends the work of Mata et al,[28] who reported that quality of life 2 years after injury continued to be significantly worse than the quality before injury in a series of 351 survivors of multiple trauma who were admitted to intensive care. Our findings indicate that this incomplete recovery occurs even in patients who are moderately injured.

Because trauma often affects adults at the peak of their productive work years, the public health and financial ramifications of their disabilities after injury are substantial. Continuing disability is expensive because of short- and long-term loss of productivity.[22,24,29,30] The expense, however, is not just financial or work related but is due to multiple avenues of disruptions in individuals' lives. Injury has profound effects that extend beyond work.[25] Substantial physical repercussions such as decline in physical ability,[26,27,31,32] loss of sexual function,[33] and fatigue with physical activities[23,27] have been reported. The aftereffects extend beyond the physical to loss of health and happiness,[23] and diminished quality of life and ability to pursue leisure pastimes occur.[23,28,34] We therefore chose to use this broad model to examine disability after injury.

Numerous studies, including our previous research, indicate only a weak and tenuous link between severity of physical injury and the many dimensions of disability.[6-9,35] Our data suggest that severity of physical injury did not influence long-term disability after injury in our subjects. Type of injury, specifically serious extremity injury, can be an independent predictor of disability.[24,29,30,36] In our study of long-term disability after injury, type of injury was not a predictor. Neither the type nor the severity of injury fully explained the variations in outcomes. This finding raises the question, what factors do influence disability after injury?

- Return to preinjury function did not consistently occur at 2½ years after injury, even for patients with moderate injuries. Patients who were the most severely injured were not necessarily those with the greatest degree of long-term disability, indicating that factors other than physical injury affect recovery. A complex interplay of age, disability before injury and 3 months after injury, and higher levels of psychological distress were significant risk factors for long-term disability.

Our findings validate the premises of Nagi's theory of the disabling process,[2] specifically that disability is the result of a complex interplay of factors. Further, our results suggest that these factors can be identified soon after injury. Two immutable factors, age and disability before injury, contributed to increased levels of long-term disability after injury. Although many persons who are injured are healthy before the injury, this situation is not universal. For example, in our cohort, one subject was blind and another had a degenerative neuromuscular disease. Our findings indicated that those who had disability before the injury were more likely than those who did not, to experience disability 3 months after the injury, a situation that in turn exerted a powerful influence on long-term disability after injury. This finding provides ample evidence of the importance of obtaining an accurate history of patients' functional status before the injury and of maximally enhancing patients' self-care ability, mobility, and ambulation in partnership with rehabilitation colleagues during and after the initial hospitalization for the injury.

Age has an inverse relationship with work disability after injury[25,27] and with other aspects of disability.[28,29,32,37] However, Gruen et al[5] found no difference in disability after injury among age groups. In our study, age at injury was protective, a finding that deviates from the prevailing belief that older patients would have greater disability than would younger patients. As age increased, levels of posttraumatic psychological distress decreased, suggesting a psychological resilience available to persons as they become older. This negative correlation between age and psychological distress confirms the reports of Michaels et al.[38] Although the age range of participants in our study was 18 to 73 years, possibly we did not find a direct and negative effect of age on disability after injury because of the predominance of nonelderly patients in the sample. The sample was too small to identify specific age ranges at highest risk; however, our findings suggest the value of assessing for the presence of psychological distress in younger patients and of instituting supportive interventions.

An important finding of our study is that elevated levels of posttraumatic psychological distress both during hospitalization and 3 months after discharge were significant risks for long-term disability. Patients with higher levels of posttraumatic psychological distress experienced higher levels of disability. This finding supports the results of Green et al,[39] who reported that survivors of motor vehicle crashes who had posttraumatic stress disorder had higher levels of disability than did survivors without the disorder. These findings indicate that disability after injury results not solely from the physical injury but also from the psychological effects.[38] These emotional responses are prevalent and persist long-term.[23,36]

Our findings highlight the importance of recognizing and addressing the psychological responses to injury. Psychological consequences of traumatic events often go unrecognized in clinical settings.[39] Yet, our results suggest that a patient's psychological response to a traumatic event should be a major concern because of its contribution to ongoing disability. Research on early interventions to ameliorate this distress would be appropriate.

Surprisingly, the availability of a supportive social network at the time of injury did not reduce disability after injury or mediate the psychological responses. This finding diverges from the findings of previous studies[7,25,40] that availability of a confidant or a social network reduced both vocational and nonvocational disability. In contrast, others[37] reported no correlation between social support and return to function. We asked the participants in our study to report during their initial hospitalization their social network before the injury. Interviews were conducted in private and with confidentiality guaranteed. Possibly, however, during this vulnerable time, participants felt obligated to positively report their social network because of the possibility of future dependence on persons in the network.

Our research indicates that the presence of a severe injury in and of itself is not a major predictor of long-term disability, calling into question a commonly held belief among trauma care practitioners. The crucial clinical corollary to this finding is that clinicians must not assume that patients who sustain minor or moderate injuries are at lesser risk than those with severe injury for long-term physical or psychological sequelae. Of importance to critical and acute care clinicians is the finding that high-risk groups of patients can be recognized during their initial hospitalization. Critical care clinicians can assess the level of function that existed before an injury. Further, an in-hospital assessment of the psychological repercussions of injury can be included in a comprehensive assessment and holistic approach to care of patients with serious injury. Patients who had impaired function and higher than normal levels of psychological distress before injury might be considered at high risk and appropriate services instituted. Because early interventions to ameliorate psychological repercussions can improve recovery,[41] trauma systems should consider incorporating into their standards the requirement to assess for psychological distress and initiate interventions for this distress.

Conclusion

By beginning to determine why patients experience long-term disability after injury, we can more readily identify patients at risk for suboptimal outcomes after injury and design and test interventions to maximize recovery. The findings of this study reinforce the interplay between physical injuries and their psychological repercussions. Further, the findings indicate that the commonly held belief that age is directly correlated to disability is not necessarily true for all injured patients. Indeed, from a psychological perspective, age may provide a buffer that protects patients from undue psychological distress and therefore offsets the physical ramifications of age after injury. Finally, the results highlight the importance of designing and testing interventions that extend beyond the biomedical model to address the important linkages between the physical, psychological, and social aspects of injury.

■ Although psychological consequences of physical injury may contribute to long-term disability, all significant risk factors, physical as well as psychological, for long-term disability after injury have yet to be identified. Once these factors are known, however, interventions to ameliorate their effect on injury outcomes can be developed to maximize recovery in patients with traumatic injuries.

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