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Physical Injuries, Pain, and Psychological Trauma: Pathways to Disability

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Abstract Because physical injuries occur so frequently and are associated with significant mortality and morbidity, these injuries have been acknowledged as a worldwide public health concern. While the greatest cost associated with physical injury is the loss of life, non-fatal injuries are associated with significant personal and societal costs. Traditionally, examinations of the personal costs of physical injuries have emphasized functional losses and limitations, in addition to resulting losses in work productivity and income earning power. Efforts to capture the societal costs associated with physical injury have emphasized medical expenditures related to their treatment as well as costs related to lost work performance and disability compensation. Less emphasized but possibly more relevant to post-injury functional outcomes is the experience of psychological distress that frequently accompanies injury-related changes in function and overall quality of life. Any calculation of the true cost of physical injuries must include a reckoning of their impact on psychological health and the interactive influence of physical and psychological injuries on immediate and long-term recovery of function. In the current article, we briefly summarize data pertaining to the prevalence and cost of physical injuries; we briefly describe the more common consequences of physical injury, including injury-related limitations in physical function, pain and pain-related limitations in physical function, occupational impairment, psychological distress, and impairment in interpersonal relating; we review select theoretical models that are considered to explain the transition from physical injury to disabilities and we identify the pre-, peri-, and post-injury influence of physical and psychological health on injury management, recovery of function, risk of re-injury, and disability.

Keywords Physical injuries · Pain · Psychological trauma · Disability

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Prevalence and Costs Associated with Physical Injuries

Physical injuries occur frequently and are associated with significant mortality and morbidity. Injury statistics compiled by the World Health Organization (WHO) indicate that five million deaths occur annually as a result of injuries, with injury-related deaths accounting for 9% of all deaths throughout the world (Peden et al. 2002). Injury statistics compiled by the Centers for Disease Control and Prevention (CDC) for the year 2002 suggest that nearly 161,000 deaths occurred in the United States as a consequence of injuries (Minino et al. 2002). Injury statistics compiled by the Public Health Agency of Canada for the year 2005 indicate that more than 14,500 Canadians died as a result of injuries (Public Health Agency of Canada 2005). In both Canada and the United States, injuries are the leading cause of death and disability for persons ages 1 to 44 years (CDC 2005; Public Health Agency of Canada 2005).

Although fatal injuries are shockingly frequent, it must be acknowledged that the vast majority of persons who sustain physical injuries survive them. Non-fatal injuries occur at rates that are exponentially higher than the rates of

fatal injuries. The United States National Health Care Survey documented the occurrence 76 million non-fatal, medically attended injuries for the year 2002 alone (Betz and Li 2005). Based on data from the 2009 Canadian Community Health Survey, Statistics Canada (2010) reported that more than four million Canadians over the age of 12 years sustained injuries severe enough to limit activity, with medical attention provided for 55% of those injuries.

Physical injuries are expensive in terms of the direct (e.g., medical treatments) and indirect (e.g., income replacements benefits) costs associated with them. Based on data compiled for the year 2000, the CDC (2006) has estimated that physical injuries account for 10% of the total medical expenditures for the United States, with annual injury-related expenditures totaling 224 billion dollars when costs associated with rehabilitation and lost wages and productivity are included. Using data from the 2000 National Vital Statistics System, Corso and colleagues examined the direct and indirect costs associated with medically treated injuries sustained by 50 million Americans (Corso et al. 2006). These medically treated injuries resulted in a lifetime cost of 406 billion dollars, with nearly 80 billion dollars of the overall cost associated with medical expenses and more than 320 billion dollars associated with lost productivity. While the absolute costs related to the medical management of physical injuries that are specific to the United States are many times greater than the costs of treating physical injuries in other countries, the relative economic burden of physical injury is similar across Western countries. For Canada, direct and indirect costs related to injuries are estimated to approach 20 billion dollars annually (SMARTRISK 2009). An examination of the economic burden of injuries sustained by Canadians for the year 2004 revealed the total cost of injuries to approach 20 billion dollars for that year alone, with direct costs accounting for 54% (10.7 billion dollars) and indirect costs accounting for 46% (9.1 billion dollars) of the total cost (SMARTRISK 2009). Costs expenditures associated with lost work productivity and work loss compensation are likely to reflect losses due to physical injuries and limitations in physical functioning as well as losses that are due to the injured person's experience of pain and psychological distress, along with the functional impairments that are a consequence of pain and psychological distress. The personal and societal cost of physical injuries might be reduced by addressing the injury-related changes in psychological functioning that are themselves associated with increased disability.

Contextual and Individual Factors Associated with the Occurrence of Physical Injuries

To better understand the occurrence of physical injuries and, thereby, reduce or prevent such events, efforts have been made to identify those contextual and individual factors that are most strongly associated with their occurrence. Most frequently, physical injuries are classified as either intentional injuries or unintentional injuries based on the intent ascribed to the causal event or behavior. Included among intentional injuries are those that result from physical assault, with the assault perpetrated by the self or some other and occurring in the context of interpersonal or political violence. Included among unintentional injuries are those that result from motor vehicle collisions (MVCs), falls, accidental discharge of firearms, drowning, exposure to smoke, fire, or flames, poisoning, and other accidental occurrences (e.g., accidental injury related to sports or leisure time activities). Unintentional injuries occur more frequently than intentional injuries, accounting for 67% of all injury-related deaths (Baker et al. 1992). Unintentional injuries are the fifth leading cause of death in the United States, with MVCs identified as the leading cause of death for persons aged 1 to 44 years (CDC, 2006). Intentional injuries that result in death of the self (suicide) or death of the other (homicide) are the 11th and 13th leading causes of death, respectively. In Canada, unintentional injuries represent the fourth leading cause of death, with deaths due to self-harm serving as the leading intentional cause of death among Canadians (Public Health Agency of Canada 2005; SMARTRISK; 2009).

Analysis of worldwide trends suggests that injuries are likely to increase over the next decade, with MVCs projected to be the second leading cause of deaths worldwide by the year 2020 (Murray and Lopez 1996). Organizations and agencies with worldwide reach are acting individually and in conjunction to draw attention to social factors that are associated with increased risk of physical injury. Income is strongly associated with the occurrence of physical injuries and the healthcare that is received consequently. Persons residing in low and middle income countries suffer physical injuries at a disproportionately high rate, due in large part to the lack of work and travel/transport safety standards (WHO 2001a, b). Individual factors are also relevant to the experience of physical injuries, with age and gender interacting with injury context to predict higher rates of physical injuries. At different ages, people are vulnerable to different types of injury events. Those related to sexual violence are more prevalent among persons under the age of 18, with one-third of lifetime rapes suffered by persons under 12 years and one-half suffered by persons under 18 years (Betz and Li 2007). Among the elderly, falls are the leading cause of injury deaths, non-fatal injuries, and hospital admissions (CDC 2006). Across all age groups, men have higher fatality rates and higher rates of non-fatal injuries than women. However, women are more likely to develop posttraumatic stress disorder

(PTSD) from physical injuries (Holbrook et al. 2001) and more likely to experience poorer quality of life post-injury than men (Holbrook and Hoyt 2004).

The Predictable Aftermath of Physical Injuries

Although physical injuries may be differentially categorized based on the intent ascribed to the injury-causing circumstance (intentional versus unintentional) and based on the mechanism of injury (MVC involvement or discharge of a firearm), the procedures involved in the immediate management of physical injuries is relatively consistent across all types of such events. Although the specific patterns of recovery from physical injuries are as numerous and as individual as are the survivors of them, recovery patterns generally fall within five categories:

1. Physical injuries are evaluated, medically managed, recovery occurs over the expected time course, and physical limitations and limitations in function remit as soon as physical recovery from injuries has occurred.
2. Physical injuries are evaluated, medically managed, recovery occurs over the expected time course, and physical limitations and limitations in function remit some reasonable time after physical recovery from injuries has occurred, with the reasonableness of the time required for restoration of function largely determined by medical care providers.
3. Physical injuries are evaluated, medically managed, recovery occurs over the expected time course, injury-related physical limitations and limitations in function are permanent, post-recovery efforts involve a redefinition of physical and functional capacities.
4. Physical injuries are evaluated, medically managed, recovery is complicated by the experience of re-injury and/or pain, injury- and pain-related physical limitations and limitations in function persist, persisting pain and functional limitations are viewed by both the medical care provider and the injured person as "the new baseline of function," and efforts are made to minimize pain and maximize function.
5. Physical injuries are evaluated, medically managed, recovery is complicated by the experience of re-injury and/or pain, injury- and pain-related physical limitations and limitations in function persist, persisting pain and functional limitations are viewed by the injured person as evidence that complete recovery from physical injuries has not occurred, injury- and pain-related physical limitations and limitations in function are viewed by the injured person as life-interfering; a variety of efforts are undertaken to minimize pain and maximize function; efforts to minimize pain and maximize function do not result in significant pain relief or restoration of function, persisting pain and functional impairments contribute to significant psychological distress, and long-term disability is likely.

Because the fifth pattern of recovery is so challenging, requires repeat engagement with multiple health care and compensation systems, and is likely to be associated with long-term disability, a more in-depth description of this recovery pattern is provided below.

Immediate Medical Management of Injuries

The emergency department (ED) is usually the point of entry for injured persons. In the ED, evaluation is undertaken to establish the potential threat conveyed by each physical injury and to prioritize intervention based on that threat assessment. In instances of serious physical injury, members of a multidisciplinary trauma team are tasked with performing resuscitation and stabilization procedures that are part of the primary survey as well as tasks specific to the secondary survey, including conducting a thorough evaluation of the injured person's history, performing a complete physical examination, and ordering and performing investigations necessary to manage injuries and support life (Parry and Girotti 2008). More invasive diagnostic and treatment procedures usually require hospitalization, simultaneously allowing for management of injuries and associated pain and disability.

While life-threatening physical injuries are necessarily the primary focus for healthcare providers working through EDs, the ED can be the first setting in which injury-related emotional distress reactions are evidenced. The injured person's experience of emotional distress is immediately understandable when consideration is given to the contexts in which most non-fatal injuries occur (e.g., an MVC that resulted in fatal and non-fatal injuries); the threat to physical integrity that serious physical injuries may represent; and the often unfamiliar settings, persons, instruments, and procedures that are part of intensive ED efforts to evaluate and manage physical injuries. Clinical researchers working in the context of emergency medicine point to the importance of evaluating, normalizing, and where necessary, intervening to lessen peri-injury distress reactions (Duckworth et al. 2008; Richmond and Jacoby 2008). Richmond and Jacoby (2008) debunk the notion that eliciting information regarding the traumatizing, injury-causing event will exacerbate the injured person's distress and recommend that a psychological interview be conducted, with the interviewing focusing on information considered relevant to the injury event and to medical management. Research findings suggest that healthcare

providers' efforts to evaluate, normalize, and intervene around peri-injury emotional distress reactions may serve to offset the development of posttraumatic stress disorder (Hamanaka et al. 2006), and by offsetting the development of PTSD, reduce healthcare utilization (Duckworth and Iezzi 2005).

Medical Management of Persisting Physical Limitations

Even under the most ideal circumstances, complete healing from serious injuries is likely to occur at some point following hospital discharge. At the point of hospital discharge, patient care is usually transferred from the hospital setting to the primary care setting. The management of post-injury physical and psychological sequelae requires the assistance of a variety of primary care providers, including medical specialists, physiotherapists, occupational therapists, and representatives of other disciplines. In the initial weeks and months following hospital discharge, medical care providers are tasked with (a) maximizing patient recovery from physical injury, acute pain, and impairment; (2) minimizing the occurrence of clinically significant distress reactions in response to physical injury, acute pain and impairment; (3) minimizing the impact of distress reactions on pain and recovery of physical function; and (4) minimizing the likelihood that acute experiences of pain and impairment will transition into chronic experiences of pain and impairment through the interacting influences of physical and psychological symptoms.

Evaluation and Management of Injury-Related Pain

There are a number of physical and psychological conditions that are part of a less than optimal recovery from physical injuries. Pain is an injury-related symptom that may persist beyond "recovery from injury" and may transition from an acute circumstance to a chronic condition. Although most health care professionals would acknowledge that pain is a multi-determined phenomenon that is understood best from a biopsychosocial perspective, it is still one of the more frustrating clinical presentations that injured persons experience and that health care providers are called upon to manage. Injury-related pain is significant in terms of its immediate and long-term impacts on recovery of physical function as well as function across a variety of lifestyle domains (e.g., intrapersonal, interpersonal, occupational, recreational, and social). Pain, when conceived of as a physical stressor, exerts its effects on recovery from physical injury through disruption of immune responses and tissue repair and sleep interference (Landis et al. 2004).

The importance of early evaluation and management of pain also rests in the strength of early pain reports in predicting pain persistence and future pain-related disability. Gureje et al. (2001) examined the persistence of pain syndromes among primary care patients. Using data from WHO's international study of psychological problems in general health care, these authors tested the contribution of baseline reports of pain, other somatic symptoms, and anxiety and depression to the persistent experience of these symptoms as well as to recovery of function. Forty-nine percent of primary care patients with persistent pain at baseline had not recovered at 12-month follow-up, with non-recovery of function best predicted by the number of pain sites reported at baseline. In managing the injured person's experience of pain in the days and weeks immediately following injury, the medical care provider places emphasis on those strategies that have been demonstrated to be effective for reducing pain and restoring function. In the context of managing acute pain, it is important that medical care providers emphasize the beneficial effects of early return to normal (pre-injury) activities and the detrimental effects of rest and the use of medical devices such as collars on recovery from physical injuries (McClune et al. 2002).

No matter how effective the strategies employed to manage acute pain, some injured persons will experience the persistence of pain and its associated impact on physical and lifestyle functions. In the face of chronic pain, medical care providers are required to shift from treatment that is consistent with a pain relief model to treatment that is consistent with a pain coping model. A pain coping model emphasizes pain acceptance and living as normal a life as possible in the presence of pain. In a recent study of the adjustment to chronic pain experienced by 117 chronic pain patients, Esteve et al. (2007) found acceptance of pain to determine functional status and functional impairment. Medical care providers promote pain acceptance among injury survivors with the following objectives: (1) avoidance of medical procedures that are either inappropriate or that have been proven less effective for the management of pain that persists long after the expected recovery from physical injury has been achieved; and (2) increased patient acceptance of the adjustments to physical and lifestyle functions that are required to ensure the most optimal post-injury quality of life. The provider can increase the effectiveness of chronic pain management efforts by collaboratively generating lifestyle goals, emphasizing the breadth of goals, gradually increasing goals, emphasizing exercise as a means of increasing physical flexibility and strength as well as reducing stress and improving mood, and emphasizing the importance of return to work to quality of life and well-being.

Evaluation of Quality of Life: Functional Impairment Across Life Domains

Millions of medically attended physical injuries occur each year. Physical injuries, whether minor, moderate, or severe, often result in a predictable mix of functional limitations, lifestyle disruptions, and psychological distress reactions. The relevance of these functional impairments, lifestyle disruptions, and distress reactions lies in the fact that they impact the injured person's ability to engage in the medically prescribed activities that contribute most to physical recovery and restoration of function. Healthcare providers and injured persons would probably agree to the singular importance of return-to-work in evaluating quality of life outcomes post-injury. Injury- and pain-related disruptions in occupational functioning may be considered the start of a cascade of injury-related lifestyle disruptions that move from lost work days to increased financial burden to increased interpersonal and intrapersonal distress (Iezzi 2008). The loss in the ability to work has profound implications for the injured person. That person is no longer able to financially control his or her destiny. Economic instability may precipitate depression, anxiety, and even increase pain perception (Mendelson 1995). Being able to work also provides opportunities for structured and purposeful use of time, task mastery and skill use, social status, interpersonal contact, and social support. In considering factors that are important to post-injury recovery, it is important to recognize that occupational disruptions and the associated personal and social opportunity losses influence the levels of physical impairment and disability experienced by injured persons (Jackson et al. 1996; 1997; Jackson et al. 1998).

Evaluation of Injury-Related Psychological Distress

Physical injuries may result in a variety of distress reactions, with the type and intensity of these distress reactions determined by parameters of the injury-causing event; the number and severity of physical injuries and associated impairments; the level of pain that accompanies injuries; and the level of compromise to various lifestyle domains and overall quality of life (Duckworth 2008). The relation between injury and psychological distress seems to be most reliable when distress occurs in the form of PTSD symptoms or depressive symptoms, the two types of psychiatric symptoms found to occur most frequently following traumatic injury (O'Donnell et al. 2004a; b). Recognizing that a myriad of distress reactions that may occur consequent to injury, we review PTSD and major depressive disorder (MDD) because of the frequency of occurrence of these disorders following injury. Additionally, we review substance use disorders because of the influence of substance use on risk of both intentional and unintentional injury and because of the potential for abuse of medications used to manage injuries and injury-related pain.

Posttraumatic Stress Disorder

Physical injuries often occur in the context of traumatic events, and these injury-causing traumatic events can serve to initiate a variety of extreme stress responses. When an injury-causing event results in actual death, serious injury, or the threat of death or serious injury to the self or others, the event is considered sufficient to elicit PTSD. A diagnosis of PTSD requires the endorsement of one or more re-experiencing, avoidance/affective numbing, and hyperarousal/hypervigilance symptoms (American Psychiatric Association 2000), with symptom onset and duration determining the use of Acute PTSD (symptom duration no greater than 3 months), Chronic PTSD (symptom duration greater than three months), and Delayed PTSD (symptom onset occurring 6 months or more following the traumatic event) diagnostic labels.

Several intentional and unintentional injury contexts have occasioned the study of injury-related PTSD. Considerable research attention has been paid to PTSD occurring consequent to MVC involvement. MVCs are identified as the first, second, or third leading cause of non-fatal injuries, depending on the age range sampled (CDC, 2000). Therefore, studies of PTSD occurring consequent to MVC involvement are likely to capture PTSD occurring in the presence of physical injury. In a sample of 1,000 participants recruited from Southern cities in the United States, Norris (1992) determined that 23% of the sample had been involved in a serious MVC at some point in their lifetime, with nearly 12% of those MVC survivors reporting the experience of PTSD. Kessler et al. (1995) examined National Comorbidity Study data provided by 5,877 telephone respondents who underwent assessment for PTSD. Nearly 20% of this subset of survey respondents reported involvement in a serious MVC, with 6.5% of MVC survivors diagnosed with MVC-related PTSD. Natural disasters have served as another context for studying the intersection between physical injury and PTSD. Although natural disasters impact far fewer people than do MVCs, they frequently involve physical injury. Accordingly, rates of disaster-related PTSD are high. Lifetime rates of PSTD associated with disasters have been estimated at 15% for females and 19% for males (Kessler et al. 1995). Higher rates of PTSD in the disaster context tend to be associated with degree of physical injury, severity of

property damage, and frequency of fatalities (Neria et al. 2008).

Intentional injuries are typically the result of physical assault. In the general context of interpersonal violence, 61.1% of individuals who were physically assaulted and 36.7% of individuals who were raped described the assault as involving actual injury or the threat of injury (Kilpatrick and Acierno 2003). Fifty-five percent of individuals who have been raped will develop PTSD (Kessler et al. 1995) and physical assault results in PTSD in 20% to 38% of cases (Birmes et al 2001; Brewin et al. 1999; Johansen et al. 2007; Kilpatrick and Acierno 2003).

Major Depressive Disorder

Depression is a common consequence of injury that can serve to magnify residual physical experiences of injury and contribute to post-injury functional limitations and lifestyle impairment. The diagnosis of major depressive disorder requires that at least five of the following nine symptoms be experienced on an almost daily basis for a period of at least 2 weeks: feeling depressed or sad; decreased interest or pleasure in almost all activities; significant weight loss or changes in appetite; insomnia or hypersomnia; psychomotor agitation or retardation; decreased energy or endurance; feelings of worthlessness, helplessness, or hopelessness; concentration and memory impairment; and recurrent thoughts of death and/or suicide thoughts and plan (American Psychiatric Association 2000). These symptoms must interfere with occupational, social, and other areas of functioning to yield a diagnosis of MDD. The vegetative/somatic symptoms of depression and the functional impairments that define the disorder may make it difficult to recognize the MDD in the context of incapacitating physical injuries.

As with PTSD, MDD has been examined in relation to intentional and unintentional injuries. A number of the better studies are longitudinal investigations in which patients attending trauma centers have been followed for periods of 6, 9, and 12 months post-discharge. Michaels et al. (2000) followed 247 trauma patients from hospital admission to 1-year post-discharge. Nineteen percent of these trauma patients evidenced depression at hospital admission, with that number increasing to 40% at 6-month follow-up, and decreasing to 28% at 1-year follow-up. Based on their evaluation of a mixed sample of fire and MVC survivors, Maes et al. (2000) reported that 13.4% of these persons experienced MDD at 7 to 9 months post-trauma. Holbrook et al. (1998) assessed the progress of 1,048 persons attending a trauma center from discharge to 6 months post-discharge. These researchers determined that 60% of the trauma center attendees were depressed at discharge, with depression persisting at 6 months post-discharge for 31% of the sample.

Further complicating recovery from physical injuries is the fact that MDD frequently co-occurs with PTSD, with comorbidity estimates ranging from 26% to 59% across community, MVC-only, and mixed trauma samples (Frommberger et al. 1998; Shalev et al. 1998; Maes et al. 2000; Blanchard et al. 2004; O'Donnell et al. 2004a). MDD and PTSD, separately and in combination, are associated with significant levels of functional impairment and disability (Duckworth & Iezzi 2008; Geisser et al. 1996; Mayou et al. 2002; Palyo and Beck 2005). The presence of co-morbid MDD and PTSD might be more predictive of long-term post-injury outcomes than other variables.

Substance-Related Disorders

Substance-related disorders are associated with unintentional and intentional fatalities and injuries, as well as injury-related impairment and disability. Twenty percent to 55% of patients hospitalized for trauma surgery have difficulties with substance abuse or dependence, and alcohol intoxication has been linked to recurrent traumatic injury (Gentilello et al. 1995; Soderstrom et al. 1997). A diagnosis of substance dependence is applied when the pattern of substance use leads to significant distress and impairment as indicated by any three of the following: the experience of tolerance; the experience of withdrawal; an increase in the amount of substance that is consumed; the desire to cut down or stop substance use; an increase in the time dedicated to seeking, using, and recovering from substance use; reduced involvement in role-functioning as a result of substance use; and continued substance use despite the knowledge that substance use is causing recurrent physical or psychological damage (American Psychiatric Association 2000). The essential feature of substance abuse is the maladaptive pattern of substance use that results in multiple and recurrent adverse consequences. The diagnosis of substance abuse requires that an individual engage in recurrent substance use (1) that interferes with role-functioning at work, school, or home; (2) that occurs in hazardous situations (e.g., while operating a motor vehicle); (3) that leads to legal ramifications (e.g., being charged and/or arrested for driving under the influence or for substance-related disorderly conduct); and (4) that leads to persistent social or interpersonal problems (e.g., an increase in marital discord or increase in physical altercations) (American Psychiatric Association 2000).

The relation of substance use to injury risk does not hold only at the level of substance dependence or abuse. Being a current drinker is associated with an increased risk of

mortality for each major cause of injury (Chen et al. 2005). Alcohol is a factor in 41% of fatality-involved MVCs (National Highway Traffic Safety Administration [NHTSA] 2003). Fifty-nine percent of persons involved in collision fatalities, 37% of persons who suffered falls, and 74% of drowning victims were current drinkers (Chen et al. 2005). Borges et al. (2008) used data derived from the WHO Collaborative Study on Alcohol and Injuries to establish the contribution of alcohol use to traumatic injuries occurring in violent and non-violent contexts. Results indicated that alcohol was a factor in 46% of violent injuries and 11.5% of non-violent injuries. The authors indicated that the risk of violence-related injury increased with drinking; higher levels of drinking were associated with a 15-fold in risk for violence-related injuries and a fourfold increase in risk for non-violent-related injuries (Borges et al. 2008). Alcohol use is highly correlated with death due to self-harm; 70% of persons who completed suicide by hanging were identified as current drinkers (Chen et al. 2005).

The Interactive Influences of Injury, Pain, and Psychological Distress

The general traumatic injury literature suggests that chronic pain (i.e., pain that persists for 3 months or longer) and PTSD are co-occurring experiences for a significant number of injury survivors (Hickling and Blanchard 1992; Geisser et al. 1996; Turk et al. 1996). The overlap between chronic pain and PTSD among injured persons is so significant that some authors have proposed chronic pain and PTSD to be mutually maintained (Schreiber and Galai-Gat 1993; Sharp and Harvey 2001). Studies suggests that the combination of chronic pain and PTSD may contribute significantly to post-injury psychosocial dysfunction (Duckworth and Iezzi 2005; Palyo and Beck 2005) and to the level of post-injury medical and psychological intervention received (Sherman et al. 2000; Duckworth and Iezzi 2005). Based on their evaluation of 183 MVC survivors, Palyo and Beck (2005) determined that more severe PTSD symptoms and more severe pain were associated with greater levels of psychosocial impairment, more severe pain was associated with greater impairment in physical functioning, and lower perceived life control was associated with more severe PTSD symptoms and more severe pain. Based on the evaluation of 152 litigating MVC survivors with injury-related chronic pain, Duckworth and Iezzi (2005) determined that MVC survivors reporting high numbers of posttraumatic stress symptoms evidenced significantly more physical impairment, greater psychological distress, and poorer coping strategies; were significantly more likely to be treated with antidepressants, pain medications, and other classes of medications; and were significantly more likely to be recommended for psychological management of pain and distress than MVC survivors reporting low numbers of posttraumatic stress symptoms.

Large-scale studies have been undertaken to examine the unique and interactive influences of injury severity, pain, and psychological dysfunction on recovery from physical injuries. Using data from the Trauma Recovery project, an epidemiological study of traumatic injury patients recruited through four San Diego hospitals, Holbrook et al. (1999) examined the functional, psychological, and quality of life outcomes experienced by 1,048 trauma patients. The majority of these patients sustained traumatic injuries consequent to MVCs, assaults, and falls. Patient outcomes were assessed at hospital discharge and at 6, 12, and 18 months post-discharge. At 18 months post-discharge, the vast majority of these trauma patients reported their health and well-being to be below the norm for healthy persons. It was determined that those trauma patients who experienced longer ICU stays, more depressive and PTSD symptoms post-injury, and declining social support also experienced increased levels of disability.

Michaels et al. (2000) conducted baseline and 6- and 12-month follow-up evaluations of 247 patients admitted to a trauma center with intentional and unintentional injuries. The investigators were particularly interested in patients' general health, mental health, work status, and overall satisfaction with recovery at 12-month follow-up. After controlling for baseline mental health, injury severity, and physical functioning at 12-month post-trauma follow-up, mental health at 12-month follow-up was predictive of general health, work status, and satisfaction with recovery. The authors interpreted these results as supporting the importance of mental health to post-trauma recovery of function across multiple functional and lifestyle domains. They opined that trauma centers that fail to assess and treat injury-related mental health outcomes are not fully attending to patients' needs.

Mayou and Bryant (2001) evaluated the course of recovery experienced by 1,148 consecutive ED attendees, most of whom (80%) had incurred MVC-related injuries. Although 61% of the ED attendees had sustained relatively minor injuries, 22% of these persons sustained injuries that were severe enough to require hospitalization. Of the 57 persons reporting major physical problems at 3-month follow-up, nearly 81% (n=46) reported the persistence of these major physical problems at one-year follow-up. A full 36% of persons reporting major physical problems at 3-month follow-up evidenced symptoms of at least one psychological condition at 1-year follow-up. Injury severity was related to functional outcomes at 1-year follow-up, with more severely injured persons being twice as likely to experience PSTD, travel anxiety, financial strain, and work

problems than less severely injured persons. Findings from a 3-year follow-up study of this sample of injured persons revealed the relation of poor overall outcome to social, financial, and legal problems to have persisted (Mayou et al. 2002).

Using data from a sample of 115 patients who were admitted to a Level I trauma center, Norman et al. (2008) examined the relations among variables representing injury severity, peri-injury pain, peri-injury stress reactions (i.e., dissociation and acute stress disorder), and PTSD. Patients completed a pain questionnaire within 48 hours of injury and underwent a PTSD diagnostic interview at 4 and 8 months post-injury. The investigators indicated that even after controlling for a number of risk factors, peri-injury pain was associated with an increased risk of PTSD. Most impressive was the finding that an increase of half a standard deviation in peri-injury pain ratings increased the odds of PTSD by fivefold at 4 months post-injury and by sevenfold at 8 months post-injury. In addition, a single item reflecting the amount of pain at the time of hospitalization correctly classified PTSD status in 65% of patients. Peri-injury dissociation and acute stress disorder were predictive of PSTD.

Taken together, these studies suggest that pain and psychological distress are powerful predictors of recovery from physical injuries. The persisting physical consequences of injury and the associated compromises in function and quality of life may be more important to long-term post-injury adjustment than the severity of the original injury.

The Influence of Pre-, Peri-, and Post-Injury Physical and Psychological Health on Injury-Related Impairment and Disability

All efforts to comprehensively evaluate and manage physical injuries are undertaken in the hope of reducing suffering, restoring function, and limiting the long-term negative impacts of injuries on quality of life. As a part of increasing the efficiency of injury management and restoration of function efforts, a number of theoretical models have been forwarded that purport to identify those factors that are most relevant to transition from physical injury to functional impairment to disability. Included among the most well-known and well-regarded models are: the Haddon Matrix (Haddon 1968); the International Classification of Functioning, Disability and Health (ICF, World Health Organization 1980; 2001a; b); and the Enabling-Disabling Process Model (Brandt and Pope 1997). These models will be briefly reviewed. Also reviewed is the Model of Physical Injury, Trauma, and Disability, a more recent model of disability occurring in the context of MVC-related physical injury that has been forwarded by Iezzi and Duckworth (Iezzi 2008). This model will be used as a framework for identifying already established pathways to disability and for emphasizing pathways that require additional research and clinical attention.

Haddon Matrix

Haddon (1968) developed one of the first etiological models of disability, which has been used extensively in injury epidemiology and prevention research and has influenced the development of other etiological models. This model was first used in the MVC context. The Haddon Matrix is a two-dimensional model. The first dimension consists of three injury factors: host (e.g., person-related variables such as fatigue or alcohol use); agent/vector (e.g., vehicle-related variables such as age or weight of vehicle); and environment (e.g., physical and social-related variables such as roads conditions or public attitudes about drinking and driving). The second dimension consists of three injury phases: pre-event (e.g., pre-collision); event (i.e., collision); and post-event (e.g., post-collision). This model has considerable intuitive appeal and is relatively simple in its conceptualization. Although not explicitly acknowledged, the second dimension of the matrix has been used effectively to organize the empirical literature related to the prediction of PTSD (Brewin et al. 2000; Ozer et al. 2003) and whiplash/neck pain (Miro et al. 2008).

International Classification of Functioning, Disability, and Health (ICF)

The ICF model is designed to accompany the International Classification of Diseases and Related Health Problems, Tenth Edition (ICD-10; World Health Organization 1992). While the ICD-10 provides an etiological classification of health conditions, the ICF provides a model conceptualizing functioning and disability associated with health conditions. The ICF model relies on language that is universal, culturally sensitive, and interactive, and represents an integration of medical and social models of disability. The various components (body functions and structures, activity, and participation) and contextual factors (environmental and personal factors) contained within the ICF model are dynamic and reciprocal. The ICF model has received considerable support and endorsement from various journals (e.g., Disability and Rehabilitation, 2003; Rehabilitation Psychology, 2005). However, researchers should be aware that the complexity of the model is better

captured by the model description provided in the ICF manual than the figural representation of the model that is familiar to so many researchers and clinicians. The description of the ICF model that is forwarded in the manual would serve as a very useful template for constructing a testable model of health and disability (Johnston and Pollard 2001).

Enabling–Disabling Process Model

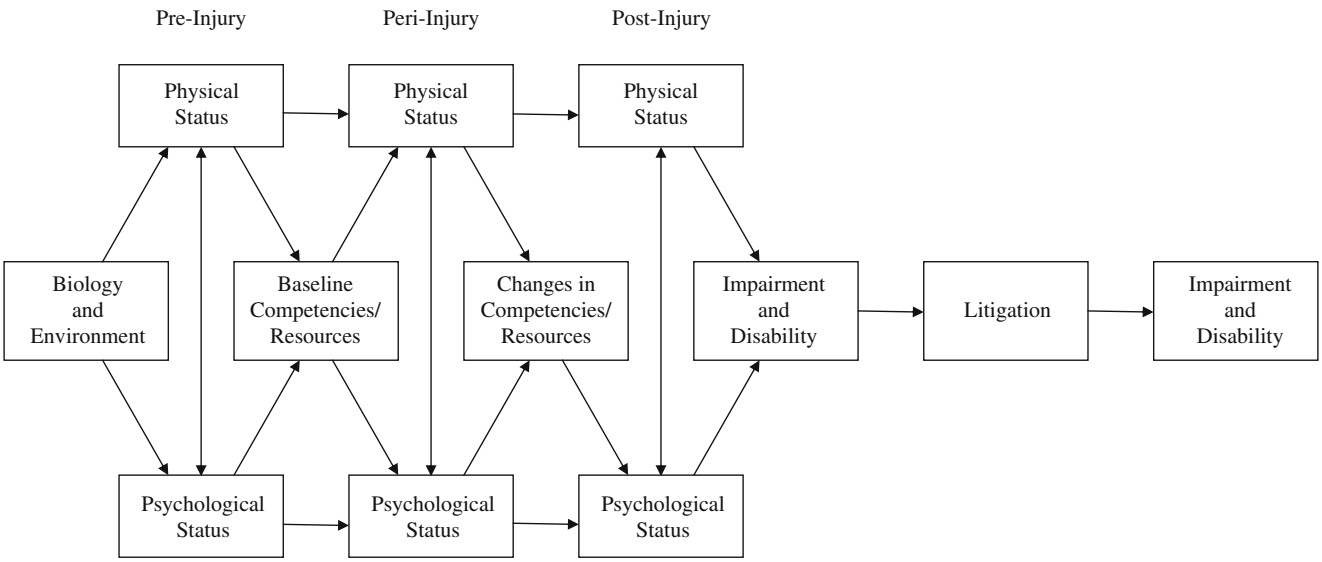
The Enabling–Disabling Process Model borrows heavily from Nagi's Disablement Model (1965). Nagi's model posits that disabling physical injury can be explained by four components: pathology (molecular or tissue changes caused by disease or trauma); impairment (loss of mental, physiological, or biochemical function); functional limitation (an inability to perform a specific task); and disability (limitations in a person's ability to fulfill certain roles and tasks). The Enabling–Disabling Process Model elaborates on Nagi's model by emphasizing that biological, psychological, and social factors contribute to the disablement process, with resulting changes in the quality of life. It enhances Nagi's model by including bidirectional influences and including the possibility of full recovery from a previous disabled state. Although this model has been well-recognized, it has not undergone extensive empirical evaluation.

Model of Physical Injury, Trauma, and Disability

The Model of Physical Injury, Trauma, and Disability chronicles the interplay of physical and psychological factors that exert their influences from pre- to peri-injury and from peri- to post-injury. The model is presented in Fig. 1. It is important to recognize that pre-injury physical risk factors (e.g., previous physical injuries, previous medical conditions, or physiological over-reactivity) and pre-collision psychological risk factors (e.g., childhood abuse, loss of significant others, or personal and familial history of depression occurring prior to the index injury) will influence baseline competencies and resources. Most serious injury-causing events will involve physical concomitants (e.g., fractures or soft-tissue injuries) and psychological concomitants (e.g., depression or anxiety) that will alter the status of baseline competencies and resources (e.g., the ability to work or activities of daily living) and influence post-injury recovery and function. Over time, the injured person's experience of post-injury pain, distress, and functional impairment will precipitate involvement in litigation related to pain and suffering and disruptions in function across multiple quality of life domains. Although conceived to explain MVC-related functional impairments and disability (Iezzi 2008), the Model of Physical Injury, Trauma, and Disability can be easily applied to the broader physical injury context. As is true for other more established models of injury-related disability, the Model of Physical Injury, Trauma, and Disability awaits empirical support. However, because of the model's emphasis on pre-, peri-, and post-injury factors relevant to disability, the model will be used to highlight those factors that have been established as relevant to impairment and disability following an index injury.

Included among the factors that are considered relevant to post-injury impairment and disability are the following:

- Age. Younger age confers an increased risk for both intentional and unintentional injuries; the experience of injury at younger age is associated with post-injury psychological distress; older age confers a greater risk of unintentional injuries that are sufficient to require ED attendance and hospitalization.
- Gender. Male gender is associated with a greater risk for both intentional and unintentional injuries; male gender is associated with greater lethality of injury and greater injury-related mortality; female gender confers greater risk of interpersonal victimization; female gender is associated with greater psychological distress and poorer quality of life post-injury.
- Education. Lower educational attainment is associated a greater risk of injury.
- Culture, ethnicity, and economic status. Non-Caucasian ethnicity is associated with increased risk of trauma exposure; lower income level is associated with greater risk of injury; lower income level is associated with poorer access to healthcare and fewer resources.
- Pre-injury physical and psychological status. Experience of physical injury is associated with greater risk for re-injury and post-injury psychological distress; a history of depression and substance use and abuse are associated with greater risk of injury, greater post-injury psychological distress, and greater post-injury disability.
- Peri-injury physical and psychological status. Hospitalization, ICU placement, surgery, complications associated with injury management, pain, and emotional distress are all associated with poorer physical and psychological outcomes post-injury.
- Post-injury physical and psychological status. Severe injury, persisting pain, occupational disruption, marked financial strain, emotional distress, and problems with cognitive function are all associated with increased disability post-injury.
- Litigation. The impact of litigation continues to be argued; however, litigation does appear to be associated with disability.



Note. Model of physical, psychological, and resource variables that predict injury-related impairment and disability. Adapted from *Motor Vehicle Collisions: Medical, Psychosocial, and Legal Consequences* (p. 529), by M. P. Duckworth, T. Iezzi, & W. T. O'Donohue (Eds.), 2008, New York, NY: Academic Press/Elsevier. Copyright 2008 by Elsevier Publishing.

Fig. 1 Model of physical injury, trauma, and disability

Conclusions

Physical injuries are significant in terms of the limitations in physical function that are often associated with them and in terms of the multiple ways in which they can impact psychological health and overall quality of life. Efforts to manage injuries and promote functional outcomes require that treating professionals, at all stages of injury management, consider all of the interacting personal and environmental factors that determine the course of recovery. Even when emergency stabilization and medical management of injuries is the priority, medical care providers should consider and evaluate those physical factors (e.g., residual effects of prior injuries or disease conditions) and psychological factors (e.g., pre-injury depression and peri-injury traumatic stress reactions) that will impact the course of recovery.

When trying to limit the occurrence of chronic functional impairments consequent to injury, medical care providers should act in a manner consistent with the empirical literature that suggests the importance of the provider in imparting knowledge related to the expected course of recovery (e.g., early return to normal activities is beneficial while extended rest is detrimental); in calming anxieties related to re-injury and/or pain (e.g., efforts to re-establish function will result in some level of discomfort); in motivating participation in physical as well as occupational rehabilitation programs; and in normalizing other distress reactions and ensuring timely evaluation and treatment of those distress reactions should their presence warrant doing so.

When injuries are associated with chronic functional impairments, significant lifestyle disruptions, and clinically significant psychological distress, medical and psychological care providers should work in tandem to identify the effects of lifestyle disruptions and psychological distress on physical recovery (e.g., depression influencing compliance with medical care recommendations, occupational disruptions contributing to increased stress, which in turn contributes to increased pain sensitivity and sleep problems) and to identify the effects of continuing physical limitations and their sequelae on psychological health and quality of life (e.g., pain at the site of a gunshot triggering memories of the violent assault and those memories contributing to the maintenance of a PTSD response, financial problems caused by inability to work secondary to injury contributing to a decision to delay participation in a physical rehabilitation program). Although the structure of healthcare provision sometimes distances the provider from the financial realities faced by the injured party, it is often the case that injured persons view healthcare providers as resources for information, advice, and referrals related to the pursuit of compensation for injury-related economic and non-economic (i.e., pain and suffering) losses. Healthcare providers should consider their role in this process, particularly when compensation involves litigation and when the care provider may be called upon to make determination regarding degree of impairment and

permanence of disabilities. When all pre-, peri-, and post-injury factors are considered, the most satisfactory outcomes are achieved through early, coordinated, and collaborative management of the physical, psychological, occupational, social, interpersonal, and intrapersonal consequences of injury. This approach of treating the injured person rather than treating only the injury is optimal and results in the highest level of recovery of overall quality of life.

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