Predicting Posttraumatic Stress Following Pediatric Injury: A Systematic Review

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Objective To review the recent empirical literature concerning development of posttraumatic stress symptoms following pediatric injury and summarize risk and predictive factors that will inform clinical practice and research. Methods A systematic search of online databases such as PsycInfo, PILOTS, MedLine, and PubMed was performed. Further studies were identified through the reference lists of selected articles. Results Pre-injury psychological problems, the child’s subjective experience of trauma severity/life threat, elevated heart rate immediately following the trauma, beliefs regarding initial symptoms, active thought suppression, and parental posttraumatic stress appear to be consistent predictors of persisting posttraumatic stress in children following injury. Conclusions Specific variables may be useful in predicting posttraumatic stress following injury, which are discussed in terms of existing models of pediatric traumatic stress. Methodologies of included studies are also discussed.

Key words accidents and injuries; adjustment; posttraumatic stress; risk; systematic review.

Introduction

Pediatric injury is currently a major health problem. It is estimated that over nine million children and adolescents aged ≤19 years were injured in the United States in 2008 (National Center for Injury Prevention and Control, 2008). In 2007, approximately 18.5% of emergency room visits for children aged 14 years or younger and 18.1% of adolescents and young adults aged 15–24 years were due to injury (Niska, Bhuiya, & Xu, 2010). Injuries in children and adolescents occur due to many different circumstances, such as motor vehicle collisions, burns, falls, and domestic or community violence.

Along with the obvious physical suffering and distress of the injury and subsequent medical interventions, pediatric injuries often cause emotional and psychological outcomes for both children and parents. The most notable of these outcomes are symptoms of posttraumatic stress disorder (PTSD) or acute stress disorder (ASD). In fact, injuries may result in higher levels of posttraumatic stress in children than other serious pediatric health problems such as diabetes and cancer (Landolt, Vollrath, Ribi, Gnehm, & Sennhauser, 2003). Yet this aspect is often overlooked, and many injured children do not receive the psychological care that they need postinjury (Sabin, Zatzick, Jurkovich, & Rivara, 2006). A recent survey also found that the majority of pediatric emergency health care providers drastically underestimate the likelihood that children may develop posttraumatic stress symptoms following traumatic injury (Zeigler, Greenwald, DeGuzman, & Simon, 2005). Moreover, many of these health care providers were not aware of factors that are associated with posttraumatic stress in injured children and few of them assessed these children for possible posttraumatic stress reactions.
Posttraumatic Stress Symptoms

Symptoms of posttraumatic stress are grouped into three clusters: reexperiencing the traumatic event, avoidance of stimuli associated with the trauma or emotional numbing, and hyperarousal (American Psychiatric Association, 2000). For a diagnosis of PTSD, these symptoms must persist for longer than 1 month. For a diagnosis of ASD, the individual must also experience dissociative symptoms and symptom duration must be <1 month. Identifying risk and protective factors for developing symptoms of these disorders (i.e., posttraumatic stress symptoms) is important to enable mental health professionals working with injured children and adolescents to determine who will most likely require and benefit from psychological intervention. Furthermore, to the extent that these risk factors can be tempered by clinicians, they can help inform the composition of interventions. For example, if certain cognitive or family functioning processes are identified as risk factors, an intervention that specifically targets these factors may be developed.

Previous work has attempted to identify such risk factors. A recent meta-analysis (Cox, Kenardy, & Hendrikz, 2008), for example, also reviewed risk factors for posttraumatic stress following unintentional pediatric injury. They concluded that the child’s perceived threat to life during the event and pre-trauma psychopathology are the most consistent predictors of symptomatology. This analysis was limited, however, in that the majority of the studies analyzed used traffic injury samples. This makes it difficult to generalize results to youth with other types and mechanisms of injuries. Furthermore, Cox et al. (2008) included a small number of potential risk factors in their analysis.

Kazak and colleagues (Kazak et al., 2006) have developed a model of posttraumatic stress for children within the pediatric health care setting that includes three phases of symptom development. The first phase includes the child’s response to the trauma during and immediately following the potentially traumatic event. During the second phase, these immediate responses develop into acute stress symptoms. In the third and final phase, the child begins to develop chronic posttraumatic stress symptomatology. A different perspective on symptom development following pediatric injury was presented by Le Brocque, Hendrikz, and Kenardy (2010), who observed three categories of symptom trajectories over time: resilient (never develop posttraumatic stress), recovery (initially experience distress but recover during the weeks following injury), and chronic (continue to experience symptoms of posttraumatic stress in the months and years following injury) groups of children. Although they use different approaches, both of these models track symptom development over time in pediatric patients. The current review largely draws from the Kazak et al. (2006) model in organizational structure to facilitate discussion of the relationship between risk factors and psychological outcomes following injury. The current review refers to Le Brocque et al.’s (2010) model when relevant as well.

The Current Review

The purpose of the current paper was to critically review the most recent literature that examines posttraumatic stress following pediatric injury and summarize findings concerning risk and protective factors for developing these sequelae. Such a review can inform clinical intervention and prevention efforts by helping to identify youths who are at greater risk for developing posttraumatic stress as a result of injury.

For the present review, included articles were identified via PsycInfo, PILOTS, MedLine, and PubMed databases using the following search terms: pediatric injury, child injury, posttraumatic stress, acute stress, PTSD, ASD, and risk factors. Further studies were identified through the reference lists of selected articles. Studies included in this review met the following inclusion criteria: (a) empirical studies published in 2000 or later, (b) utilized a sample of pediatric injury patients, (c) examined posttraumatic stress symptoms (including PTSD or ASD diagnoses, or continuous symptom severity ratings of these disorders), and (d) reported data on variables associated with these outcomes. When more than one paper presented data from the same study sample, only the paper with the strongest methodological or statistical design was included unless the inclusion of multiple papers provided information for additional associated variables. Articles were excluded if they used an adult sample, studied a pediatric condition or trauma other than injury, or if they indicated that a sizable portion of their sample sustained a traumatic brain injury. Characteristics of the included studies as well as information about variables they examined are summarized in Table 1.

Risk factors and variables associated with traumatic stress after injury are organized into three categories in the current review: demographic and pre-existing variables, injury characteristics and trauma variables, and family variables. These largely inform the first two phases of Kazak et al.’s (2006) model of pediatric medical traumatic stress since they are present prior to or in the initial weeks following injury. Variables in each of these categories are discussed in turn.
Table I. Description of Studies Included in the Review

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample characteristics</th>
<th>Mechanism of injury</th>
<th>Outcome</th>
<th>Time points of post-traumatic stress assessment</th>
<th>Child versus parents report</th>
<th>Statistics</th>
<th>Variables associated with post-traumatic stress outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryant et al. (2007)</td>
<td>N = 76 (34% female); ages 7–12 years</td>
<td>Variety of mechanisms of injury</td>
<td>PTSD, sub syndromal PTSD (2 of 3 symptom clusters)</td>
<td>2.5 days and 6 months</td>
<td>Child</td>
<td>Logistic regression</td>
<td>Age, injury severity, resting HR in hospital, length of hospital stay</td>
</tr>
<tr>
<td>Delahanty et al. (2005)</td>
<td>N = 58 (31% female); ages 8–18 years (M = 13.04, SD = 3.05)</td>
<td>Variety of mechanisms of injury</td>
<td>PTSS</td>
<td>6 weeks</td>
<td>Child</td>
<td>Regression, ANOVA</td>
<td>Age, race, parent education, parental income, female gender, depression symptoms, urinary cortisol/epinephrine levels</td>
</tr>
<tr>
<td>De Young et al. (2007)</td>
<td>N = 101 (33% female); ages 6–16 years (M = 10.8, SD = 2.4)</td>
<td>Variety of mechanisms of injury</td>
<td>PTSD, sub syndromal PTSD (1 symptom from each cluster)</td>
<td>6 months</td>
<td>Parent</td>
<td>Regression</td>
<td>HR on admission, HR at 24 h post-admission, age, gender, injury severity</td>
</tr>
<tr>
<td>Ehlers et al. (2003)</td>
<td>N = 86 (43% female); ages 5–16 years (M = 12.27, SD = 2.86)</td>
<td>Traffic injuries</td>
<td>PTSS, PTSD</td>
<td>2 weeks, 3 months, 6 months</td>
<td>Child</td>
<td>χ², t-test</td>
<td>Age, gender, type of traffic injury, injury severity, pre-injury psychological functioning, perceived threat of trauma</td>
</tr>
<tr>
<td>Fein et al. (2002)</td>
<td>N = 69 (47% female); ages 12–24 years (M = 1.5)</td>
<td>Violently/intentionally inflicted injuries</td>
<td>PTSD, sub syndromal PTSD</td>
<td>While in ED, 1–5 months</td>
<td>Child</td>
<td>t-test, correlation, ANOVA</td>
<td>Age, gender, time since injury, type of injury, acute stress symptoms</td>
</tr>
<tr>
<td>Hollbrook et al. (2005)</td>
<td>N = 381 (29% female)</td>
<td>Variety of mechanisms of injury</td>
<td>Categorical PTSS cutoff</td>
<td>3, 6, 12, 18, and 24 months</td>
<td>Child</td>
<td>χ²</td>
<td>Age, gender, perceived life threat, violent/intentional injury</td>
</tr>
<tr>
<td>Kasam-Adams et al. (2005)</td>
<td>N = 190 (24.7% female); ages 8–17 years (M = 11.2, SD = 2.4)</td>
<td>Traffic injuries</td>
<td>PTSD, partial PTSD (1 symptom from each cluster), PTSS</td>
<td>At least 3 months postinjury (M = 6.4 months)</td>
<td>Child</td>
<td>Regression</td>
<td>Elevated HR on ED arrival, female gender, age, injury severity</td>
</tr>
<tr>
<td>Kasam-Adams and Winston (2004)</td>
<td>N = 243 at T1 (ages 8–17 years (M = 11.3, SD = 2.5)</td>
<td>Traffic injuries</td>
<td>ASD, sub syndromal ASD, PTSD, sub syndromal PTSD, PTSS</td>
<td>1 month and 3–12 months (M = 6.5 months)</td>
<td>Child</td>
<td>χ²</td>
<td>ASD: younger age group, gender, race, injury severity, admission to ICU, PTSD: age, gender, race, injury severity, admission to ICU</td>
</tr>
<tr>
<td>Keppel-Brenson et al. (2002)</td>
<td>N = 50 (42% female); ages 7–16 years (M = 11.6, SD = 3.2)</td>
<td>Traffic injuries</td>
<td>PTSS, PTSD</td>
<td>2–18 months (M = 9.5, SD = 4.9)</td>
<td>Child and parent</td>
<td>Regression</td>
<td>Age, gender, SES, previous motor vehicle incident, injury severity, type of traffic incident, social support</td>
</tr>
<tr>
<td>LeBroque et al. (2010)</td>
<td>N = 190 (36.8% female); ages 6–16 years (M = 10.7, SD = 2.3)</td>
<td>Unintentional injuries</td>
<td>Categorical PTSS cutoff</td>
<td>6 days, 4–7 weeks, 6 months, 24 months</td>
<td>Child</td>
<td>Trajectory regression</td>
<td>Female gender, age, complex fracture or burn, premorbid internalizing, premorbid externalizing</td>
</tr>
<tr>
<td>Meier-Siedman et al. (2007)</td>
<td>N = 93 (33.5% female); ages 10–16 years</td>
<td>Traffic injury or assault</td>
<td>ASD, “early PTSD” (meeting PTSD criteria except time requirement), acute stress symptoms</td>
<td>Days following injury</td>
<td>Child</td>
<td>t-test, χ², correlation</td>
<td>Age, gender, prior trauma exposure, prior mental health, mechanism of injury, subjective threat of trauma, sensory quality of memories, fear of anxiety, rumination, positive beliefs about worry</td>
</tr>
<tr>
<td>Nugent et al. (2006)</td>
<td>N = 82 (31.7% female); ages 8–18 years (M = 13.21, SD = 2.94)</td>
<td>Variety of mechanisms of injury</td>
<td>PTSS</td>
<td>6 weeks and 6 months</td>
<td>Child</td>
<td>Regression</td>
<td>Age, race, injury severity, gender, parental income, depression, HR at admission/discharge, HR during EMS, HR average EMS, HR average during first 20 min of admission</td>
</tr>
<tr>
<td>Nugent et al. (2007)</td>
<td>N = 76 (31% female); ages 8–17 years (M = 13.19)</td>
<td>Variety of mechanisms of injury</td>
<td>PTSS</td>
<td>6 weeks and 6 months</td>
<td>Child</td>
<td>Regression</td>
<td>Age, race, mechanism of injury, injury severity, parental education, gender, parental income, parental PTSS, parental cortisol levels, parental HR</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample characteristics</th>
<th>Mechanism of injury</th>
<th>Outcome</th>
<th>Time points of post-traumatic stress assessment</th>
<th>Child versus parents report</th>
<th>Statistics</th>
<th>Variables associated with post-traumatic stress outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>O’Kearney et al. (2007)</td>
<td>N=80 (40% female); ages 7–16 years (M=10.14, SD=2.28)</td>
<td>Variety of unintentional injuries</td>
<td>PTSS</td>
<td>4–7 weeks</td>
<td>Child</td>
<td>Analysis of covariance, χ², regression</td>
<td>Age, emotional references, sensory references, trauma severity, gender, injury severity</td>
</tr>
<tr>
<td>Olsson et al. (2008)</td>
<td>N=79 (33% female); age M=10.8, SD=2.4</td>
<td>Variety of mechanisms of injury</td>
<td>PTSD, subsyndromal PTSD and more symptom from each cluster</td>
<td>4–6 weeks and 6 months</td>
<td>Parents</td>
<td>χ², t-tests</td>
<td>Age, gender, injury severity, length of hospital stay, HR in ED</td>
</tr>
<tr>
<td>Sanders et al. (2003)</td>
<td>N=400 (35.3% female); ages 8–16 years (M=11)</td>
<td>Variety of mechanisms of injury</td>
<td>Categorical PTSS cutoff</td>
<td>36 days</td>
<td>Child</td>
<td>χ², t-tests</td>
<td>Pre-burn life stress, TBSA, body image, pulse, parental ASD</td>
</tr>
<tr>
<td>Soxe et al. (2005)</td>
<td>N=72 (33% female); ages 7–17 years (M=11.2, SD=3.31)</td>
<td>Burn injuries</td>
<td>ASD</td>
<td>2–26 days (M=10 days)</td>
<td>Child</td>
<td>Path analysis</td>
<td>Age, race, gender, witnessing a threat to caregiver, pre-trauma externalizing/interacting, prior trauma, interaction between caregiver threat and pre-trauma externalizing symptoms</td>
</tr>
<tr>
<td>Scheeringa et al. (2006)</td>
<td>N=62 (29% female); ages 0–18 years</td>
<td>Variety of mechanisms of injury</td>
<td>PTSD</td>
<td>In hospital, 2 months</td>
<td>Parents, child for ages 11–18 years (N=24)</td>
<td>Regression</td>
<td>Archive, HR in ED, parental PTSD, pre-marital psychological functioning, parental PTSS, parental depression, intensity of stress</td>
</tr>
<tr>
<td>Schreier et al. (2003)</td>
<td>N=83 (26% female); ages 7–17 years (M=10.6, SD=2.6)</td>
<td>Variety of mechanisms of injury</td>
<td>PTSS</td>
<td>In hospital, 1 month, 6 months, and 18 months</td>
<td>Child and parent</td>
<td>Correlation</td>
<td>Age, gender, race, injury severity, hospital stay, parental employment, parental PTSD, family cohesion, family expressiveness</td>
</tr>
<tr>
<td>Stoddard et al. (2006)</td>
<td>N=52 (42.3% female); ages 12–48 months</td>
<td>Burn injuries</td>
<td>Acute stress symptoms</td>
<td>Within 1 month</td>
<td>Parent</td>
<td>Path analysis</td>
<td>HR during hospitalization, parental acute stress symptoms, TBSA, pain</td>
</tr>
<tr>
<td>Winston et al. (2003)</td>
<td>N=171 (23.4% female); ages 8–17 years</td>
<td>Traffic injuries</td>
<td>PTSS (PTSD or sub syndrome PTSD: 1 symptom from each cluster)</td>
<td>3–13 months (M=6.5 months)</td>
<td>Child</td>
<td>χ²</td>
<td>Age, gender, race, injury severity, time since injury, HR in ED, baseline depression, parents pre-injury trauma, family cohesion</td>
</tr>
<tr>
<td>Zatzick, Grossman, et al. (2006)</td>
<td>N=108 (32% female); ages 12–18 years (M=15.9, SD=1.9)</td>
<td>Variety of mechanisms of injury</td>
<td>PTSS</td>
<td>11.7 days, 2 months, 5 months, and 12 months</td>
<td>Child</td>
<td>Repeated measures regression</td>
<td>Age, gender, gender, race, injury severity, HR in ED, subjective response to injury, pre-injury trauma, pre-trauma alcohol use, pre-morbid psychological functioning, parental PTSD, parental depression, intentionality</td>
</tr>
<tr>
<td>Zatzick, Russo et al. (2006)</td>
<td>N=97 (33% female); ages 12–18 years</td>
<td>Variety of mechanisms of injury</td>
<td>PTSS</td>
<td>0–30 days (M=7 days)</td>
<td>Child</td>
<td>Regression, t-tests</td>
<td>Age, female gender, race, injury severity, HR in ED, subjective response to injury, pre-injury trauma, pre-trauma alcohol use, pre-morbid psychological functioning, parental PTSD, parental depression, intentionality</td>
</tr>
<tr>
<td>Zink and McCain (2003)</td>
<td>N=143 (40% female); ages 7–15 years (M=10.8, SD=2.6)</td>
<td>Traffic injuries</td>
<td>PTSD</td>
<td>2 and 6 months</td>
<td>Child</td>
<td>Logistic regression</td>
<td>Age, gender, race, type of injury, type of traffic event</td>
</tr>
</tbody>
</table>

Note: Boldface denotes variables significantly associated with the posttraumatic stress outcome. M = mean; SD = standard deviation; PTSS = posttraumatic stress symptoms; HR = heart rate; ED = emergency department; ICU = intensive care unit; SES = socioeconomic status; TBSA = percentage of total body surface area burned.

1 Studies with the same superscript utilize samples that are not independent from each other.
2 Unless otherwise noted, ages are reported in years.
3 PTSS and ASD refer to meeting diagnostic criteria for these disorders; PTSS refers to symptom severity as a continuous variable, unless otherwise noted.
Factors Associated with Posttraumatic Stress Following Injury

Demographic and Pre-existing Contextual Factors

Demographic and pre-existing contextual factors, such as child age, gender, race or ethnicity, pre-injury psychological functioning, and pre-injury trauma history are important to examine as potential predictors of posttraumatic stress symptoms because they can be easily and quickly assessed when an injured child presents for treatment. According to Kazak et al.’s (2006) model of pediatric medical traumatic stress, these factors would exert their impact during the first phase of symptom development because they influence how the child subjectively experiences the traumatic event.

Female Gender

Nugent and her colleagues (Nugent, Christopher, & Delahanty, 2006; Nugent, Ostrowski, Christopher, & Delahanty, 2007) found that female gender was associated with higher levels of posttraumatic stress when assessed 6 weeks after injury but that this association disappeared when assessed 6 months following the injury. In contrast, Kassam-Adams, Garcia-España, & Winston (2005) found female gender to be a risk factor for posttraumatic stress at an average of approximately 6 months postinjury. These studies utilized a continuous outcome variable (e.g., number and severity of symptoms) whereas other studies that found no association between gender and posttraumatic stress at these time points tended to use a categorical outcome variable (e.g., symptom presence or absence; De Young, Kenardy, & Spence, 2007; Olsson, Kenardy, De Young, & Spence, 2008; Sanders, Starr, Frawley, McNulty, & Niacaris, 2005; Scheeringa, Wright, Hunt, & Zeanah, 2006; Zink & McCain, 2003). This may have reduced the power of these analyses to detect statistical differences. Alternatively, this perhaps suggests that females may experience a higher number of symptoms but are no more likely to experience clinical levels of distress. In their sample of injured adolescents, Holbrook et al. (2005) reported females to have higher rates of clinically significant posttraumatic stress at some point during the 2 years following injury when compared to males. However, they did not provide detailed information concerning the symptom trajectory over those 2 years, so their results may not contradict the previously mentioned possibility. Furthermore, Cox et al. (2008), in their meta-analysis of prospective studies examining factors predicting posttraumatic stress following unintentional pediatric injury, found female gender to have a statistically significant but weak effect. The statistical significance was more robust during initial assessment than at follow-up assessment for the studies included in the meta-analysis. It should be mentioned that other studies found no association between gender and posttraumatic stress with similar methodological designs and across a range of assessment points (Delahanty, Nugent, Christopher, & Walsh, 2005; Fein et al., 2002; Kassam-Adams & Winston, 2004; Keppel-Benson et al., 2002; Le Brocque et al., 2010; Schreier, Ladakakos, Morabito, Chapman, & Knudson, 2005; Zatzick, Grossman et al., 2006). The inconsistency of the findings across studies suggests that the role of female gender as a reliable risk factor for posttraumatic stress following pediatric injury remains unclear.

Age

Several studies found that younger children displayed more posttraumatic stress symptoms than older children in the initial weeks and months following injury but that this association did not persist. For example, Kassam-Adams and Winston (2004) found that school-age children reported more symptoms than adolescents when assessed 1 month following an injury, but that there was no age difference on follow-up approximately 6 months following the injury. Likewise, Schreier et al. (2005) reported younger age to be associated with more posttraumatic stress symptoms immediately following the injury as well as one and 6 months following, but that there was no association with age when assessed 18 months postinjury. O’Kearney, Speyer, and Kenardy (2007) also found more symptoms in younger children than older children within 2 months of the injury. These findings are consistent the results of Le Brocque et al. (2010), who reported that younger children are more likely to belong to the recovery group than the resilient group. Holbrook et al. (2005), in contrast, reported a higher rate of symptom development in adolescents aged 16 years or older than in adolescents aged 15 years or younger. This association may be an artifact since they did not control for other variables that may have influence, such as intentionality of injury, and they did not specify at which time points these associations existed. Other studies that reported no association between age and posttraumatic stress even within the first few months tended to either use an older sample with a higher proportion of adolescents than those which found younger children to be more at risk (Fein et al., 2002; Meiser-Stedman, Dalgleish, Smith, Yule, & Glucksman, 2007; Nugent et al., 2006) or rely on parental report of symptoms (Olsson et al., 2008; Scheeringa et al., 2006), which may be less valid. The predictive value of younger age for posttraumatic stress, therefore, may be present only for immediate symptoms and not for chronic distress.
Race/Ethnicity

Only one study observed that severely injured adolescents who were members of a minority race exhibited more symptoms than white adolescents within the first few weeks of the injury (Zatzick, Russo et al., 2006). These authors arrived at this result through a t-test, and this variable did not appear in a subsequent regression analysis. The literature is otherwise unanimous in reporting that race and ethnicity are not robust predictors of posttraumatic stress in pediatric injury patients across a wide range of time points, causes of injury, age groups, and injury severities (Kassam-Adams & Winston, 2004; Nugent et al., 2006; Sanders et al., 2005; Scheeringa et al., 2006; Schreier et al., 2005; Zink & McCain, 2003).

Pre-injury Psychological Functioning

Pre-injury psychological and behavioral functioning was examined utilizing a variety of methods. Whereas some studies examined the effects of prior internalizing and/or externalizing symptoms on posttraumatic stress, others used more general constructs such as prior life stress, psychological functioning, and mental health. All studies examining pre-injury externalizing behaviors found a significant (LeBrocque et al., 2010; Winston, Kassam-Adams, Garcia-Espana, Ittenbach, & Cnaan, 2003) or nearly significant (Scheeringa et al., 2006; p = .07) association with posttraumatic stress following an injury across a range of time points. In fact, LeBrocque et al. (2010) observed that children with high pre-injury externalizing symptom severities were more likely to be in either the recovery or the chronic groups than in the resilient group. LeBrocque et al. (2010) and Winston et al. (2003) also found high pre-injury internalizing symptoms to predict more posttraumatic stress symptoms following an injury. Saxe et al. (2005) reported that higher amounts of life stress prior to a burn injury predicted a higher likelihood of developing ASD than lower amounts of life stress through its influence on body image. Whereas these studies assessed prior psychological functioning retrospectively through questionnaires, the studies which found pre-injury psychological functioning to be unrelated to posttraumatic stress development operationalized this construct by asking the child if they had ever previously sought mental health services or used psychotropic medications for a psychiatric diagnosis (Meiser-Stedman et al., 2007; Zatzick, Russo et al., 2006). This method may not be an accurate reflection of the child’s premorbid functioning. Moreover, although studies reviewed by the Cox et al. (2008) meta-analysis assessed pre-injury psychopathology differently, this variable had one of the stronger relative effect sizes of the variables they assessed (average weighted effect size of $r = .22$).

Pre-injury Trauma Exposure

A few studies examined pre-injury trauma exposure with mixed results. Meiser-Stedman et al. (2007) and Scheeringa et al. (2006) reported that a previous experience with a life-threatening traumatic event was unrelated to posttraumatic stress following a variety of injury events, but did not report whether the previous traumatic event was similar to the injury trauma. In contrast, Keppel-Benson (2002) demonstrated that for children who had sustained traffic injuries, children who had previously been involved with a motor vehicle collision had fewer posttraumatic stress symptoms an average of 9.5 months later than those who had not been in a previous motor vehicle collision. These authors suggested that the previous experience had an inoculation effect for these children. Schreier et al. (2005) found that the number of prior traumas experienced was positively correlated with the number of symptoms endorsed 1 month following traumatic injury, but that this relationship did not persist beyond this time. Cox et al. (2008) reported a weak average effect for pre-injury trauma in their meta-analysis of unintentional injury studies. However, only Keppel-Benson et al. (2003) specified that the type of trauma previously experienced was the same as the one which produced the injury. Future research examining pre-injury trauma history should continue to clarify this issue.

In sum, gender and age seem to be moderate predictors of posttraumatic stress development. Females may be at somewhat of a higher risk than males, but this difference may be small and clinically insignificant. Several studies found younger children to be at risk for developing acute stress but that this association dissipates over time. Children who had internalizing or externalizing psychological symptoms prior to their injury appear to be at an increased risk of developing posttraumatic stress symptoms as a result of an injury. The role of pre-injury traumatic experiences, however, remains unclear.

Injury Characteristics and Trauma-Related Factors

We next examined characteristics of the injury itself (i.e., mechanism of injury, injury severity, and type of injury) and factors specific to the trauma experience for the child (i.e., subjective trauma severity, heart rate, and trauma-specific cognitions and memories). These factors are mainly relevant for the first phase of Kazak et al.’s (2006) model because they influence both the objective trauma severity and the child’s subjective experience of the event, but trauma-specific cognitions and memories that develop are more relevant during the second phase of symptom development.
Mechanism of Injury
For the purposes of this review, mechanism of injury refers to the type of traumatic event which produced the injury. A number of studies reported no predictive value for whether a child was injured as a vehicle occupant, bicyclist, or pedestrian for posttraumatic stress following a traffic-related injury (Éhlers, Mayou, & Bryant, 2003; Keppel-Benson et al., 2002; Zink & McCain, 2003). Furthermore, children injured in traffic and children injured from an assault did not differ from each other on acute stress (Meiser-Stedman et al., 2007) and victimized adolescents did not differ from those who actively participated in a fight in posttraumatic stress symptom development (Fein et al., 2002). Nugent et al. (2007) demonstrated that there was no difference in symptoms after a variety of different events such as traffic-related injuries, sports injuries, assaults, burns, and falls. Only Holbrook et al. (2005) reported intentionally injured adolescents (i.e., through assault, gunshot wound, stab wound) were more likely to exceed a clinical cutoff on a measure of PTSD symptom severity at some point during the following 2 years than to never reach this cutoff. However, they did not provide more detailed information with regard to whether this association was specific to certain time points. Future studies using a wider variety of mechanisms of injury would be needed before drawing firm conclusions.

Injury Severity
It follows logically that children who sustain more severe injuries would be more likely to experience posttraumatic stress than children with more mild injuries. One method of quantifying injury severity that appears frequently in the literature is the Injury Severity Score (ISS; see Baker, O’Neill, Haddon, & Long, 1974). The ISS is calculated by adding physician severity ratings for the three most severely injured areas of the body. Although it may seem reasonable that greater injury severity is associated with greater levels of posttraumatic stress, this has not been supported empirically by studies using the ISS across a range of injury populations, time points, and injury severities (Éhlers et al., 2003; De Young et al., 2007; Kassam-Adams & Winston, 2004; Kassam-Adams et al., 2005; Nugent et al., 2006, 2007; O’Kearney, 2007; Schreier et al., 2005; Zatzick, Grossman et al., 2006). Furthermore, the Cox et al. (2008) meta-analysis found a weak overall effect for injury severity across studies of unintentional injuries; most of these studies used the ISS.

Other studies have measured injury severity differently. For burn injuries, greater percentage of the total body surface area burned predicted a greater likelihood of developing ASD (Saxe et al., 2005; Stoddard et al., 2006). This was not a direct influence, however; it was mediated through heart rate upon hospital admission. Other indicators of injury severity, such as admission to the hospital and longer durations of hospital stays, have been demonstrated to predict severe posttraumatic stress even when ISS did not (Bryant, Salmon, Sinclair, Psychol, & Davidson, 2007; Olsson et al., 2008; Sanders et al., 2005). Other studies with similar statistical approaches and injury samples, however, have reported posttraumatic stress to be unassociated with admission to the hospital (Meiser-Stedman et al., 2007) or the pediatric intensive care unit (Kassam-Adams & Winston, 2004) or to length of stay in the hospital (Schreier et al., 2005). This inconsistency is perhaps not surprising since admission to the hospital and length of stay may depend on other factors such as bed availability and insurance status. However, being admitted to the hospital also may indicate more intense and invasive medical interventions, which may also explain significant findings. When Keppel-Benson et al. (2002) included the invasiveness of the medical intervention required into their evaluation of injury severity, they also found greater injury severity to predict more posttraumatic stress symptoms.

Type of Injury
Several studies found that the type of injury sustained was not associated with posttraumatic stress. For example, Meiser-Stedman et al. (2007) and Winston et al. (2003) found that the presence of an extremity fracture was not significantly associated with posttraumatic stress in the weeks and months following injury. Fein et al. (2002) and Zink & McCain (2003) found that following a variety of injuries, including contusions, fractures, head injuries, lacerations, abdominal injuries, and multiple injuries, type of injury did not predict posttraumatic stress several months posttrauma. The only exception was reported by Le Brocque et al. (2010), who observed that children with complex fractures and burns were more likely to be in the chronic group than the resilient group. The inclusion of burns in this category may have played a role in the divergent findings; no other studies compared burns with other injury types.

Subjective Trauma Severity
Éhlers et al. (2003), Holbrook et al. (2005), and Meiser-Stedman et al. (2007) all found that children who rated their injury as more subjectively traumatic had more posttraumatic stress symptoms than those whose subjective experience was less traumatic in the weeks and months following the injury. Winston et al. (2003) found that
children who indicated that they believed they would die during a traffic collision were more likely to develop PTSD symptoms than those who did not believe that they would die. Cox et al. (2008) found that across four studies that assessed the child’s subjective experience of threat to life, this variable had the strongest effect size of all variables included (averaged weighted effect size of $r = .38$). These results support the first phase of Kazak et al.’s (2006) model.

**Heart Rate**

Heart rate is an important psychophysiological marker of anxiety and arousal and is routinely measured by medical staff when a child is injured. Some researchers defined elevated heart rate based on standardized age and gender norms, whereas others simply correlated or regressed the number of beats per minute with posttraumatic stress. Several studies have examined increased or elevated heart rate as a potential predictor for the development of posttraumatic stress. For example, Bryant et al. (2007), Kassam-Adams et al. (2005), Olsson et al. (2008), and Zatzick, Grossman et al. (2006) found that an increased or elevated heart rate upon admission to or within the first day of admission to the emergency department for treatment of an injury predicted more posttraumatic stress symptoms in the months following the injury. Similarly, Nugent et al. (2006) reported heart rate data taken by emergency medical services staff during transport to the hospital to be an even more robust predictor of posttraumatic stress than heart rate measured in the emergency department. Still further, path analyses conducted by Saxe et al. (2005) and Stoddard et al. (2006) on burned children demonstrated that a higher average pulse during the hospital admission directly predicted a higher likelihood of developing ASD than a lower average pulse.

Heart rate may be a psychophysiological marker of the child’s subjective trauma severity as discussed above. Although heart rate seems to be a fairly robust predictor of posttraumatic stress following a traumatic injury, caution must be used because it can be influenced by other factors such as pain and medications received (Nugent et al., 2006).

**Trauma-specific Cognitions and Memories**

Ehlers et al. (2003) found certain trauma-related cognitions to be robust predictors of posttraumatic stress symptoms up to 6 months postinjury in children who had sustained traffic injuries. Specific cognitions that produced more posttraumatic stress symptoms included the child’s beliefs that they were isolated and misunderstood and that the presence of intrusive thoughts indicated that they were becoming crazy. Meiser-Stedman et al. (2007) also found that children who endorsed beliefs that excessive worry is beneficial were more likely to develop ASD than children who did not endorse these beliefs. Furthermore, children who reportedly experienced anger in response to thoughts of the traumatic event and engaged in active thought suppression and dissociation developed more symptoms of posttraumatic stress (Ehlers et al., 2003). These variables accounted for approximately one-third of the variance in symptoms within the Ehlers et al. (2003) study sample.

O’Kearney et al. (2007) also examined memory quality for 80 children who had sustained injuries from a variety of traumatic events during the second month following the injury. After coding the children’s trauma narratives for content, they found that the number of references to their sensory experiences and the amount of emotional content within the trauma narratives did not predict intrusive thoughts or avoidance symptoms. O’Kearney et al. (2007) analyzed and coded trauma narratives that were spontaneously produced by injured children. In contrast, Meiser-Stedman et al. (2007) did report more memories with sensory information to be predictive of developing ASD in the weeks following the trauma. Unlike O’Kearney et al.’s (2007) coding system, however, they assessed this construct through a questionnaire on which respondents endorsed previously worded items regarding sensory memories.

To summarize, objective characteristics of the injury, such as mechanism of injury, type of injury, and injury severity do not appear to be consistent predictors of posttraumatic stress in children. The perceived severity of the trauma as subjectively experienced by the child and elevated heart rate immediately following the injury, however, do appear to predict posttraumatic stress. These latter two variables may influence each other. For example, if a traumatic event is experienced as very frightening and threatening, it will result in an elevated heart rate. These factors are relevant to the first phase of Kazak et al.’s (2006) model of pediatric medical traumatic stress. Children’s cognitions and the way they interpret the emergence of acute symptoms, relevant to the second phase of Kazak et al.’s (2006) model, seem to influence the maintenance of posttraumatic stress symptoms.

**Family Variables**

Family members are often witness to, or involved in, the same traumatic event that produced the injury in the child. Parents in particular often have to cope with their own traumatic experience as well as the additional trauma of watching their child suffer. Furthermore, the context of how family members relate to each other before the
injury may determine if and how symptoms are expressed within the child. Parental posttraumatic symptoms are associated with the second phase of Kazak et al.’s (2006) model because they develop in the acute aftermath of the trauma, and the family environment is associated with the first phase because it informs the pre-existing social context in which the injury occurs.

**Parental Posttraumatic Stress**

Posttraumatic stress symptoms experienced by the parents of injured children have been demonstrated to be predictive of posttraumatic stress in the child. For example, Saxe et al. (2005) and Stoddard et al. (2006) found parental ASD symptoms to directly influence child ASD following a burn injury. Parental symptoms mediated the influence of percentage of total body surface area burned and painful facial expression on child acute stress, respectively. Likewise, Nugent et al. (2007) found that high parental posttraumatic stress following a child’s hospitalization for an injury predicts child posttraumatic stress up to 6 months postinjury (particularly for those with a low in-hospital heart rate) and Schreier et al. (2005) found a correlation between parental and child posttraumatic symptoms up to 18 months postinjury. The Cox et al. (2008) meta-analysis supported this association as well. In constrast, Zatzick, Russo et al.’s (2006) regression analyses did not support a predictive relationship between parental and adolescent acute stress symptoms in the weeks following injury. This sample included only adolescents, whereas the previously mentioned studies and those in the Cox et al. (2008) meta-analysis included younger children as well. It is therefore possible that parental symptoms influence younger children more so than adolescents. It should be noted that among these studies, only Stoddard et al. (2006) relied on parent report of child posttraumatic stress symptoms, and this was only because they utilized a very young sample (all under 48 months of age). The findings with regard to parental posttraumatic stress symptoms are therefore not attributable to parental bias.

**Family Environment**

Few studies examined the predictive value of the family environment on the development of posttraumatic stress symptoms following pediatric injury. Schreier et al. (2005) and Zatzick et al. (2008) found that family cohesion as reported by the parents had no impact on the child’s posttraumatic stress. Schreier et al. (2005) also reported that high family conflict was associated with more child symptoms than low family conflict, but that children from families with low levels of expressiveness and high levels of achievement orientation endorsed more symptoms in the months following traumatic injury. In light of the increasing emphasis on a family systems approach within pediatric psychology (see Kazak, Rourke, & Navsaria, 2009), the literature would benefit from inclusion of family environment variables in future studies.

In sum, posttraumatic stress symptoms exhibited by parents of injured children seem to be predictive of posttraumatic stress in the children during the second phase of Kazak et al.’s (2006) model. The degree to which this association is due to behavioral modeling or shared genetic predisposition is still unclear, but it is present even when children report on their own symptoms. Other family environment variables are understudied in the current literature and thus not well understood; future research should focus more attention on this area.

**Summary and Future Directions**

The purpose of the present paper was to review the recent empirical literature concerning development of posttraumatic stress following pediatric injury and to summarize risk and predictive factors in order to inform clinical assessment. This review demonstrated some clear trends and patterns within the literature, but also highlighted many of the inconsistencies and gaps that currently exist.

Demographic variables such as gender and age seemed to be at best moderate predictors of posttraumatic stress development. Females may be at a somewhat higher risk than males, but this difference may not be large enough to be clinically significant. Several studies found younger children to be at risk for developing acute stress but that this association dissipates over time and they recover quickly (Le Brocque et al., 2010). In terms of Kazak et al.’s (2006) model of pediatric medical traumatic stress, pre-injury psychological and behavioral problems, the child’s subjective experience of trauma severity/life threat, and elevated heart rate immediately following the trauma appear to be robust risk factors associated with the first phase of symptom development. The child’s beliefs regarding initial symptoms, active thought suppression, and parents’ posttraumatic stress seem to be consistent risk factors associated with the second phase. The nature of these risk factors suggests that cognitive behavioral and family-based interventions may be most successful for preventing symptom development. Future research should also clarify the roles of pre-injury trauma history and family environment.

One screening instrument that has been developed for the purpose of identifying youth who are at a high risk of developing posttraumatic stress symptoms following a traumatic injury is the Screening Tool for Early Predictors...
of PTSD (STEPP; Winston, et al., 2003). The STEPP assesses the likelihood for developing posttraumatic stress based on the presence of certain risk factors that have been reported in the literature. This instrument was reported to have fairly high sensitivity but only moderate specificity; it is more accurate at correctly identifying children who are at high risk for developing posttraumatic stress than it is at correctly identifying children who are at low risk (Winston et al., 2003). Items included in tools such as this one may be revised and updated based on more recent literature in order to maximize accurate identification of who is at-risk and who is not.

The majority of the studies in the current review used longitudinal designs. Many also used multiple assessment points to track symptoms over time (see Table I). Despite these overall strengths, a significant portion of the studies determined statistical significance of the associated variables through statistics such as correlation, analysis of variance (ANOVA), t-tests, and \( \chi^2 \). These test statistics do not allow for the same degree of analysis of direct influence on the outcome variables as multiple or linear regression, nor are they conducive to controlling for the influence of possibly confounding variables.

As can be seen in Table I, the majority of the studies included in this report assessed posttraumatic stress symptoms directly from the children as opposed to relying on parental report of child symptoms. This is a strength within the literature because parent and child reports are frequently divergent from each other (Landolt et al., 2003; Schreier et al., 2005; Shemesh et al., 2005), and the child report is likely to be accurate while the parent report may be biased by their own symptoms (Shemesh et al., 2005).

The outcome variables used across studies were quite inconsistent with each other. Among the various outcome variables used were categorical PTSD or ASD diagnoses, partial PTSD or ASD diagnoses, continuous symptom severity scales, and cutoff scores on continuous symptom severity scales. Continuous outcome variables for symptom severity have an advantage over categorical ones in that they increase the power to detect statistically significant differences, but are also at a disadvantage in that they may produce clinically meaningless but statistically significant results. Despite the advantages of using both approaches, this variability complicates the effort to draw clinically useful conclusions from the literature. A recent effort to compile a public and standardized international data archive on child trauma with specific criteria for data contribution (Kassam-Adams, 2010) will perhaps provide a better consistency across studies in future research.

Conflicts of interest: None declared.

References


