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Health-Related Quality of Life in Children and Adolescents Following Traumatic Injury: A Review

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Abstract

This paper comprehensively reviews the published literature investigating HRQOL following general traumatic injury in individuals between birth and 18 years. Studies were not considered if they primarily compared medical treatment options, evaluated physical function but not other aspects of HRQOL, or focused on non-traumatic wounds. Specific injury types (e.g., burn injury) were also not included.

A total of 16 studies met criteria. Participants were age 1 to 18 years, with 12 studies considering children 5 years of age or older. Males were overrepresented. Injury severity averaged mostly in the moderate range.

HRQOL deficits were noted in injured samples in all studies except the two with the longest time to follow-up (6–11 years). Some improvement was seen 6 months to 2 years after injury. Factors associated with HRQOL deficits were investigated, with acute and posttraumatic stress symptoms showing the strongest relationship.

Research to date in this area is impressive, particularly the number of studies using prospective longitudinal investigations and validated measures. Challenges remain regarding methodologic differences, assessment of preinjury status, retention of participants and management of missing data. Suggested future directions include extension of follow-up duration, utilization of pediatric self-report when possible, inclusion of younger children, and development of intervention programs.

Keywords

Health-related quality of life; Injury; Pediatric; Trauma

Introduction

As early as 1946, the concept of quality of life (QOL) was included as one of the basic principles in the World Health Organization's Constitution through the statement, "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization 1949, p. 1). Historically, the management of pediatric traumatic injuries, such as multisystem injuries sustained in motor vehicle accidents (MVA), burn injury, orthopedic injuries, or traumatic brain injury (TBI), has focused on survival as the primary goal. Prior to advances in trauma and critical care management that took place in the 1970s and the following two decades, the long-term

survival rates for many of these injuries were low. Once survival rates improved, however, the physical health, mental health and QOL sequelae of traumatic injury began to appear. It became clear that a shift in focus was necessary in the field to include investigation of the functional outcome, emotional well-being and long-term QOL of pediatric traumatic injury survivors.

This realization persists in current trauma care settings, where factors such as QOL have become a major focus. Some of this work has been injury-specific (e.g., only including children with traumatic brain injury), while other studies focus on the population of pediatric patients who experience general traumatic injury, including those with multiple injury types or less common injuries. Winthrop (2010) recently provided a brief, medically-focused review that highlights the growing interest in this area and gives specific attention to traumatic brain injury, orthopedic injuries, family stress and posttraumatic stress disorder (PTSD). She notes in particular the need for evidence-based interventions and additional resources for screening. Difficulties related to variability in participant characteristics, health-related quality of life (HRQOL) measures, and duration of follow-up across studies were also noted (Winthrop, 2010). In fact, studies in this area vary in terms of the age of participants and their injury severity, the subscales included in the measurement tool utilized (e.g., whether mental health is specifically queried or not), the reporter (i.e., self- vs. parent-report), the length of time between injury and HRQOL assessment and whether or not a longitudinal design was utilized to investigate change in HRQOL over time. Studies also differ in the variables considered as possible contributors to poorer HRQOL. Unfortunately, the field currently lacks a thorough summary to integrate findings across studies and a detailed critique to assist in resource allocation, determination of areas for future investigation and development of interventions. For these reasons, the current paper sought to review the published literature investigating HRQOL in children and adolescents following a general traumatic injury.

The manuscript first reviews some key terminology and briefly describes the measures most commonly used to assess HRQOL in the included studies. The methods of the review are then outlined. Details of HRQOL findings in the pediatric general traumatic injury literature are then given followed by a discussion, analysis and critique. The final sections consist of future directions and concluding remarks.

Terminology

Many terms are used to describe QOL including QOL, well-being, life satisfaction, health status, functional status and health-related quality of life (HRQOL). Although each may have its own connotations within a field, these terms are also often used interchangeably (Bjornson et al. 2008; Ville and Ravaud 2001), leading to measures that may assess somewhat varied constructs. Such differences can obviously complicate interpretation of findings and make comparisons across studies difficult. It has been suggested that consideration should be given to the researchers' conceptualization and operationalization of QOL when reading studies in this field (Dijkers 2005). All papers in the current review are considered to evaluate HRQOL by investigating an illness or disability's (i.e., traumatic injury) impact on personal functioning (Patrick and Chiang 2000).

In studies of traumatic injury, injury severity is typically described using the Injury Severity Score (ISS; Baker et al. 1974). The ISS was developed as a way of describing overall injury severity when more than one body region is involved. It is calculated by transforming International Classification of Disease Ninth Revision (ICD-9; Commission on Professional and Hospital Activities 1978; World Health Organization 1977) codes to the Abbreviated Injury Scale (American Association for the Advancement of Automotive Medicine 1990) from which the ISS (Baker et al. 1974) is calculated. The ISS is the sum of squares of the highest abbreviated injury scale grade for the three body areas with the most severe injuries (Baker et al. 1974). ISSs range from 0 to 75, with a score of 75 indicating a virtually unsurvivable injury. Although this range is very large, the range of injury severity commonly seen in studies of children and adolescents after general traumatic injury is much smaller. In this literature, injuries with ISS under 3 or 4 are considered minor, those between this level and 8 are considered moderate, and injuries with ISS greater than 9 to 16 are considered severe. The Modified Injury Severity Scale (MISS; Mayer et al. 1980) is an alternative injury severity rating scale with good reliability. Like the ISS, MISS scores range from 0 to 75. Scores of 25 or above are considered severe.

In the current article, “injury mechanism” refers to the way the injury happened. Common injury mechanisms include MVA, pedestrian injuries in road-traffic accidents, bicycle-related injuries and other sports injuries. “Injury type” will be used to refer to the location or nature of an injury, such as abdominal injury, lower extremity injury, TBI or burn injury.

Commonly Utilized Measures

There are a host of measures available for assessing pediatric HRQOL and at least three recent review papers have discussed them (Janssens et al. 2009; McCarthy 2007; Solans et al. 2008). The four pediatric measures for HRQOL assessment utilized in the reviewed literature are a version of the Child Health Questionnaire (CHQ; e.g., Landgraf and Abetz 1994; Landgraf et al. 1996; Raat et al. 2002, 2005), the TNO AZL Child Quality of Life Parent and Child Forms (TACQOL; Vogels et al. 1998, 2000), the Pediatric Quality of Life Inventory (PedsQL 4.0; Varni et al. 2001), and the Quality of Well-Being (QWB) scale (Kaplan et al. 1976, 1979).

The CHQs (e.g., Landgraf and Abetz 1994; Landgraf et al. 1996; Raat et al. 2002, 2005) are a series of measures of various lengths, both self-report and parent-report. Those utilized in studies in the current review include four parent-report measures: the 50-item CHQ parent form (CHQ-PF50), an Australian version of this measure (Waters et al. 2000), the 28-item CHQ parent form (CHQ-PF28), and the Infant-Toddler Quality of Life Questionnaire (CHQ-IT). The adolescent-report 87-item CHQ-87 was also utilized in one study. Item stems vary among subscales. All CHQs except the CHQ-IT have two summary scores, the physical health summary score (PHS) and the psychosocial summary score (PSS), as well as multiple subscales. All CHQ versions have been rigorously validated and found to be reliable. These measures have been extensively utilized in the health outcomes literature.

The TACQOL (Vogels et al. 1998, 2000) was developed in the Netherlands to assess HRQOL in 6- to 15-year-olds. Both parent- and child-report forms are available, with the child-report form being designed for administration to children ages 8 years and older. Both

forms contain 56 items divided into seven equally sized subscales. Each item is initially asked with response options of “never,” “occasionally,” or “often.” If the answer is either occasionally or often, the child’s emotional response to the experience is also queried with possible answers including “good,” “not so well,” “rather bad,” or “bad.” Emotional responses are not investigated for either the positive or negative emotions subscales. The scale has been shown to have acceptable reliability and moderate interscale correlations. It is used frequently in the international literature on pediatric HRQOL.

The PedsQL 4.0 (Varni et al. 2001) is a 23-item measure with both child self-report and parent-report forms. The self-report forms are valid for ages 8 to 18 years, while parent-report forms extend down to 2 years. The measure assesses factors in four domains: physical, emotional, social and school functioning. Items query how problematic an area has been on a 5-point Likert-type scale ranging from “never a problem” to “almost always a problem.” The measure has been shown to have good reliability and internal consistency as well as adequate construct validity.

The fourth measure used in several of the reviewed studies was the QWB scale (Kaplan et al. 1976, 1979). This measure was originally designed for use with adults but was utilized in an adolescent sample in this case. The measure assesses 23 symptoms over a wide range of severity, from being dead or comatose to wearing glasses or contact lenses, and has three function scales: mobility, physical activity and social activity. Only total scores are reported in the reviewed studies. Total scores are calculated as a preference-weighted average of the scales queried for the past 6 days. The measure is reported to have adequate convergent and divergent validity (Kaplan et al. 1976) and is noted to have sensitivity and predictive value exceeding 0.90. When compared with the adult 36-item Medical Outcomes Study, Short Form (MOS SF-36; Ware and Sherbourne 1992), the QWB scale has been reported to be less extensive in its review of overall health but to not have problems with ceiling effects reported with the MOS SF-36. The QWB scale is reported to have a distribution close to normal in the adult population. Quite small differences, 1% to 2%, have been reported to be clinically meaningful (Holbrook et al. 2001b).

These four measures differ in the areas assessed by their subscales. The CHQ appears to be the broadest of the three, investigating role functioning, self-esteem, parent impact and family factors, none of which are included in the other three measures. In addition, the CHQ, TACQOL, and PedsQL contain mental health assessments, called mental health in the CHQ, positive and negative emotions in the TACQOL and emotional functioning in the PedsQL. This area is not investigated directly in the QWB scale, although it has been argued that the QWB scale is valid with patients with mental health problems and is sensitive to changes in mental health (Kaplan et al. 1998).

A fifth measure was utilized in one study that followed study participants into adulthood, 7 to 11 years following their initial injury (van der Sluis et al. 1997). The RAND-36 Short Form Health Survey contains the same 36 items as the well-validated and reliable MOS SF-36 (Ware and Sherbourne 1992) but has a slightly different scoring protocol (Hays et al. 1993). The MOS SF-36 is an extensively utilized measure of HRQOL in adults and has a structure similar to the CHQ.

Method

Search Criteria

Studies for review were found through computerized searches in PubMed, PsycINFO and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) through the week of September 12, 2011. PubMed search terms included ((quality of life[MeSH Major Topic]) OR (functional disability [Mesh]) AND (wounds and injury[MeSH Major Topic])) with the limits English, Human, and Child (0-18). The initial search revealed 214 potential studies. PsycINFO search terms included ((DE "Quality of Life" OR DE "Quality of Work Life") or(DE "Activities of Daily Living" and DE "Ability Level" and DE "Disabilities" OR DE "Developmental Disabilities" OR DE "Learning Disabilities" OR DE "Multiple Disabilities" OR DE "Reading Disabilities")) and (DE "Traumatic Brain Injury" OR DE "Brain Concussion" and DE "Head Injuries" OR DE "Brain Concussion" and DE "Electrical Injuries" and DE "Injuries" OR DE "Birth Injuries" OR DE "Burns" OR DE "Electrical Injuries" OR DE "Head Injuries" OR DE "Spinal Cord Injuries" OR DE "Wounds" and DE "Spinal Cord Injuries" OR DE "Whiplash" and DE "Brain Concussion") with limits English, Human, and Child 0-12 yrs or Adolescent 13-18 years. Sixty-six potential studies were located through this search. The CINAHL search included the terms ((MH "Quality of Life +") or (MH "Health and Life Quality (Iowa NOC) (Non-Cinahl)+") or (MH "Quality of Life (Iowa NOC)")) and (MH "Wounds and Injuries+") with limits of English and 0 to 18 years. A total of 270 papers were found in this manner. Many of the studies obtained in these searches dealt with adults, non-traumatic wounds, aspects of specific injury care or were duplicates of studies found in previous searches, thus reducing the overall number of studies for initial review. Additional studies of interest were also selected through review of citations in the studies themselves.

Inclusion Criteria

Studies were only considered if they reported original research and evaluated quality of life after traumatic injury in individuals between birth and age 18 years. Studies containing both adult and pediatric participants were considered only if detailed separate analyses had been completed on the pediatric group. None of the combined pediatric-adult manuscripts investigating HRQOL after general traumatic injury ($n = 6$) met this criterion. Because this review focused on HRQOL after injury compared to HRQOL in the non-injured population, studies were also not considered if they primarily compared two forms of medical management following a specific traumatic injury (e.g., comparing two treatment options for a specific fracture repair). It was felt that HRQOL outcomes in these cases might be differentially impacted by the medical management and not be reflective of the general population. Studies evaluating postinjury physical functioning without reference to or assessment of other aspects of HRQOL and those of HRQOL in individuals with non-traumatic wounds (e.g., dehiscence of a surgical wound) were also not considered. Finally, there is a growing separate literature on HRQOL after pediatric TBI and burn injury and a smaller collection of studies regarding HRQOL following pediatric spinal cord injury (SCI). Recovery from these injuries often involves long hospitalizations and rehabilitation phases, which frequently preclude the inclusion of pediatric patients with these diagnoses in the general traumatic injury studies targeted for this review. In addition, each of these groups

may experience a different and, perhaps more homogeneous, HRQOL outcome than that of participants in general traumatic injury studies. For this reason, studies including participants with only one specific type of injury were not considered alongside those investigating general traumatic injury.

Studies Reviewed

The final selection included 16 relevant studies, which are outlined in Tables 1 and 2. All studies that reported on the years of data collection were conducted or had follow-up between 1996 and 2008. Four studies did not report this information. Studies were conducted in the United States, western Europe, Australia and Iran. Only five studies mentioned the ethnicity of study participants. Aitken et al. (2002) described their sample as 81% white, 17% black and 2% other races. Winthrop et al. (2005) reported a sample of 85% white, 11% black and 4% other participants, while Holbrook et al. (2007) described their sample as 53% white, 34% Hispanic and 13% other. Davey et al. (2005) noted their sample contained 3% Aboriginal participants, and Zatzick et al. (2008b) reported their sample to be 73% white.

Results

Throughout this section, see Tables 1 and 2 for additional study details.

General Traumatic Injury

Overall HRQOL—Six studies reported on overall HRQOL in children and adolescents after traumatic injury (Holbrook et al. 2007; Janssens et al 2009; Landolt et al. 2009b; Sturms et al. 2002; van der Sluis et al. 1997; Vollrath and Landolt 2005). Of these, all except two (Janssens et al. 2009; van der Sluis et al. 1997) found reductions in overall HRQOL in their injured samples at at least their initial evaluation point. Additionally, Soori and Abachizadeh (2008) found significant associations between overall HRQOL and having experienced a traumatic injury in the previous year. Specifically, they found a significant linear trend of increasing injury with decreasing categorical HRQOL, as well as significantly lower median TACQOL total scores in injured as compared to uninjured children. Sturms et al. (2002) further found that those with injury-related problems had significantly lower overall HRQOL than those with other or no health issues. Finally, Aitken et al. (2002) compared overall HRQOL in their injured sample to published means for chronically ill children and found that their sample of injured adolescents had deficits that were similarly substantial to all of the available populations (Aitken et al. 2002). Importantly, the two studies reporting no significant difference were conducted the longest time after injury, 6 to 8 (Janssens et al. 2009) and 7 to 11 (van der Sluis et al. 1997) years, respectively.

HRQOL Domains and Subscales—Twelve of the reviewed studies investigated domain or subscale scores (Aitken et al. 2002; Davey et al. 2005; Janssens et al. 2009; Landolt et al. 2009b; Schweer et al. 2006; Soori and Abachizadeh 2008; Sturms et al. 2002, 2003, 2005; Vollrath and Landolt 2005; Winthrop et al. 2005; Zatzick et al. 2008b). All but the one study conducted 6 to 8 years after injury (Janssens et al. 2009) reported deficits at their initial evaluation. In studies using a version of the CHQ, all found significant HRQOL deficits on

the PHS and the PSS 1 month after injury (Aitken et al. 2002; Schweer et al. 2006; Winthrop et al. 2005). PHS deficits remained in all three studies 6 months after injury, whereas PSS deficits were detected in only one study at this time point (Schweer et al. 2006).

With respect to subscale scores, deficits were reported in multiple subscales of the CHQ and the TACQOL from the time of injury through 2.4 years postinjury (Aitken et al. 2002; Davey et al. 2005; Landolt et al. 2009b; Schweer et al. 2006; Soori and Abachizadeh 2008; Sturms et al. 2002, 2003; Vollrath and Landolt 2005; Zatzick et al. 2008b). Between baseline and 1 month postinjury, worse HRQOL was reported in all CHQ subscales in at least one study, including general health (Aitken et al. 2002), physical functioning (Aitken et al. 2002; Schweer et al. 2006), bodily pain (Aitken et al. 2002; Schweer et al. 2006), role/social-physical (Aitken et al. 2002; Schweer et al. 2006), role/social-emotional (Aitken et al. 2002; Schweer et al. 2006), general behavior (Aitken et al. 2002), mental health (Aitken et al. 2002; Schweer et al. 2006), self-esteem (Aitken et al. 2002; Schweer et al. 2006), parent impact-emotional (Aitken et al. 2002; Schweer et al. 2006), parent impact-time (Aitken et al. 2002; Schweer et al. 2006), family activities (Aitken et al. 2002; Schweer et al. 2006) and family cohesion (Aitken et al. 2002). TACQOL subscale deficits in motor functioning, autonomy and positive emotions (Landolt et al. 2009b; Vollrath and Landolt 2005) as well as elevations in negative emotions (Vollrath and Landolt 2005) were also reported 1 month after injury. By 6 months to 1 year after injury, significantly lower HRQOL continued to be found in all CHQ subscales except self-esteem and parent impact-time (Aitken et al. 2002; Zatzick et al. 2008b) as did a reduced level of positive emotion on the TACQOL at 1-year postinjury (Vollrath and Landolt 2005). Soori and Abachizadeh (2008) further found more impairment in children who had been injured on all TACQOL subscales except autonomous functioning. When investigating 1.5 years after injury, Davey et al. (2005) reported deficits in 9 of 12 subscales of the CHQ, with no difference from population norms found on the bodily pain, role/social-physical and mental health subscales. Using parent-report 2.4 years after injury, Sturms et al. (2002) found that injured participants continued to have significantly worse motor functioning, autonomy, cognition, and social functioning and significantly fewer positive emotions than the normative sample. When age, gender, and maternal socioeconomic status (SES) were controlled, the injured sample had significantly lower HRQOL on all subscales with the exception of physical complaints. Of note, the physical complaints subscale of the TACQOL is known to assess more general physical complaints such as headache, which may not be as relevant in the injury context. Child report in the same time frame revealed significantly fewer physical complaints than the reference population but significantly more motor functioning and autonomy deficits. Findings remained similar when age, gender and the presence of a chronic illness were controlled (Sturms et al. 2003).

Change in HRQOL over Time—When change in overall HRQOL over time was investigated, two authors reported improvement in overall HRQOL to normative levels between 1 month and 1 year after injury (Landolt et al. 2009b; Vollrath and Landolt 2005), while Holbrook et al. (2007) noted continued deficits up to 24 months after injury. Interestingly, the first two samples included children between 6 and 14.5 years of age and the latter had adolescent participants aged 12 to 19 years.

Studies utilizing the CHQ summary scales suggest ongoing physical deficits 6 months after injury (Aitken et al. 2002; Schweer et al. 2006; Winthrop et al. 2005) and improvement in psychosocial functioning between 1 and 6 months in two of the three studies (Aitken et al. 2002; Winthrop et al. 2005). Regarding CHQ subscale findings, some improvement was seen over time, but deficits remained in all studies whether 1 month (Aitken et al. 2002; Schweer et al. 2006), 6 months (Aitken et al. 2002; Schweer et al. 2006), 1 year (Zatzick et al. 2008b) or 1.5 years (Davey et al. 2005) after injury. In general, Aitken et al. (2002) found that fewer CHQ-PF50 subscales were significantly lower than population norms at the 6-month follow-up point than at discharge or 1 month after injury, although additional deficits remained in the areas of role/social-emotional functioning and behavior. In the Winthrop et al. (2005) study, younger children, ages 1 to 4 years, showed significant improvement in the physical ability subscale of the CHQ-IT between 1 and 6 months after injury but not in the behavior overall or change in health subscales. Of note, no available norms for this measure existed at the time of study, so it was not possible to conclude that deficits existed.

Utilizing the TACQOL, Sturms et al. (2005) reported few differences between the reference group and retrospective recall of preinjury HRQOL by the study sample. Repeated-measures analysis found significantly more motor function concerns in participants at 3 months postinjury than either prior to or 6 months postinjury. Autonomy scores were also shown to improve between 3 and 6 months postinjury, while negative emotions decreased over time with significant decreases between baseline and 6 months. Improvements have also been reported in the TACQOL subscales of motor functioning and autonomy between 1 month and 1 year after injury (Landolt et al. 2009b; Vollrath and Landolt 2005).

Variables Potentially Associated with HRQOL after Traumatic Injury

Many of the reviewed studies also investigated factors that could be associated with HRQOL deficits. Those related to the personal characteristics of the study participants will be discussed first followed by those related to the injury.

Participant characteristics

Acute and posttraumatic stress symptoms: The most robust findings appear to be in the area of acute and posttraumatic stress disorder symptoms. In their study specifically investigating the impact of acute stress disorder symptoms, Holbrook et al. (2005a) found an overall postinjury acute stress disorder rate of 40%. Higher rates were found in females than males (47% vs. 36%), in those who had experienced an intentional or violence-related injury and in those who perceived a threat to their life (Holbrook et al. 2005a). Participants with clinically significant acute stress disorder symptoms at hospital discharge had significantly lower overall HRQOL than those without such symptoms at all assessed time points up to 24 months after injury.

Three studies investigated the impact of posttraumatic stress disorder symptoms (PTSS) on HRQOL, and all report a significant negative relationship between PTSS and overall HRQOL (Holbrook et al. 2005b; Landolt et al. 2009b) or multiple subscales of a HRQOL measure (Zatzick et al. 2008b). Holbrook et al. (2005b) reported 27% of participants were categorized as having long-term PTSD. Overall HRQOL was significantly reduced at all

time points following discharge in those participants (Holbrook et al. 2005b). Landolt et al. (2009b) found just over 16% reported what the researchers considered “moderate to severe” PTSS at 1 month postinjury, and this number increased to 17.6% 1 year after injury. Significant PTSS 1 month after injury was the only significant contributor to explanation of variance in HRQOL 1 year after injury and alone explained 32% of the variance. Calculated effect sizes for this relationship were mostly in the medium range. Finally, Zatzick et al. (2008b) found adolescents with elevated PTSD at their initial evaluation had significantly decreased subscale scores in several areas, including general health, role/social-behavioral, role/social-physical, bodily pain, general behavior and mental health.

Gender: Males are disproportionately represented in injury populations (Schwebel and Gaines 2007), and this was also generally true in the reviewed studies. Nine studies involved over 60% males, and only one study involved fewer than 50% males. Six studies investigated the relationship between gender and HRQOL. Two found that females had significantly worse HRQOL outcomes than males at a minimum of one time point (Holbrook et al. 2007; Vollrath and Landolt 2005). Vollrath and Landolt (2005) further reported that this finding could not be explained by differences in injury severity or functional status. In addition, Landolt et al. (2009b) found girls to have significantly lower HRQOL than boys 1 month after injury, but gender did not contribute to explaining the variance in overall HRQOL in their final regression model. In contrast, Davey et al. (2005) found that boys were significantly below population norms on more subscales of the CHQ-PF50 (Landgraf et al. 1996) than girls, although again, gender did not predict either the PHS or the PSS in subsequent multiple regression analysis. Finally, two studies by the same research group did not detect differences in HRQOL based on gender (Sturms et al. 2003, 2005).

Age: The relationship between age at time of injury and HRQOL was investigated in six studies. Two of these found a significant relationship between age and overall HRQOL for at least one time point, with older age being associated with lower HRQOL (Holbrook et al. 2007; Schweer et al. 2006). Four studies did not detect a relationship between age and HRQOL (Davey et al. 2005; Sturms et al. 2003, 2005; Vollrath and Landolt 2005).

Socioeconomic status: Four studies investigated the relationship between SES and HRQOL. Considering both mother's and father's highest education level as a proxy for SES, Sturms et al. (2002) found that maternal education contributed significantly, along with ISS and stressful life events, to explain 14% of the variance in overall HRQOL. The father's education level contributed significantly only when the mother's education level was not included in the model. In a substudy involving only those children whose parents associated their current deficits with the traffic-related injury, children whose fathers had low education levels were five times as likely to have lower HRQOL as those whose fathers had high education levels. Three other studies failed to detect a relationship between SES and overall HRQOL (Landolt et al. 2009b; Sturms et al. 2005; Vollrath and Landolt 2005). Of note, Landolt et al. (2009b) reported a somewhat restricted SES range, with mostly middle- and upper-class participants, potentially limiting their ability to detect an effect.

Depressive symptoms: Only one study investigated the relationship between depressive symptoms and HRQOL. Zatzick et al. (2008b) found that elevated baseline depression scores were associated with poorer baseline CHQ-87 role/social-emotional, role/social-behavioral, general behavior, mental health, self-esteem, and general health subscale scores. In addition, mixed model regression analysis adjusting for baseline CHQ-87 subscale scores, sex, race/ethnicity, preinjury trauma experience and preinjury Alcohol Use Disorders Identification Test (AUDIT) scores (Babor and Grant 1989) revealed elevated depressive symptoms at baseline to be associated with significantly reduced physical function, role/social-emotional functioning, bodily pain, mental health, self-esteem and family cohesion 1 year after initial injury.

Injury-related variables

Injury severity: The relationship between injury severity and HRQOL was investigated in several studies, with the majority finding reductions in HRQOL with higher ISS at least at one time point. Schweer et al. (2006) found that ISS included as part of a regression model was a significant predictor of CHQ-PF50 PHS scores at both 1 month and 6 months after injury. Sturms et al. (2002) found ISS contributed significantly to explaining the variance in parent-report HRQOL in a larger regression model. In a subsample whose symptoms were specifically attributed to their injury, children with ISS = 9 were 11 times as likely to have low HRQOL as children with ISS = 3 (Sturms et al. 2002). Utilizing child-report, this research group also reported ISS to be significantly related to motor functioning, with those with severe injury (ISS = 9) having significantly more and more severe motor problems than those with minor (ISS = 3) or moderate (ISS = 4-8) injury. No significant differences in autonomy by ISS category were detected (Sturms et al. 2003). Vollrath and Landolt (2005) also found modest correlations between ISS and HRQOL at 1 month but not 1 year after injury. In addition, two studies found greater HRQOL deficits in those with ISS above 16 than those with lower ISS at either discharge (Aitken et al. 2002) or 18 months after injury (Holbrook et al. 2007), and one found lower HRQOL scores in those with injury to three or more body regions (Holbrook et al. 2007). Finally, in their study of 1- to 4-year-olds, Winthrop et al. (2005) found a significant negative correlation between ISS and both the physical ability and behavior overall subscales of the CHQ-IT 6 months after injury, although this relationship was not present at the 1-month evaluation nor was it detected in the same study's investigations of 5- to 18-year-olds. The researchers suggest caution in interpreting these findings due to a small sample and scoring differences between the CHQ-PF28 and CHQ-IT. In contrast, three other studies did not detect a relationship between ISS and HRQOL (Davey et al. 2005; Landolt et al. 2009b; Sturms et al. 2005).

Injury mechanism and Injury type: Four studies investigated the possible relationship between mechanism of injury and HRQOL. Holbrook et al. (2007) found that being a pedestrian struck in a traffic-related event lead to poorer overall HRQOL than other injury mechanisms. Sturms et al. (2005) reported that those injured in a motor vehicle had reduced motor functioning when compared with those whose traffic-related injury did not involve a motor vehicle (e.g., bicycle crash). It does not appear that injury severity was controlled for in this analysis. Two other studies by this research group did not detect a significant relationship between the traffic-related mechanism and the motor functioning or autonomy

subscales of the TACQOL (Sturms et al. 2003) or overall HRQOL (Sturms et al. 2002). No consistent trends in ISS were found in studies investigating injury mechanism.

The type of injury was investigated in only three studies. Schweer et al. (2006) found that an extremity injury predicted lower CHQ-PF50 PHS scores at both 1 month and 6 months postinjury when included as part of a larger regression model. In addition, significant predictors of PSS at 1 month postinjury were head/neck injury or extremity injury, and at 6 months, included head/neck or abdominal injury. Sturms et al. (2005) reported that a lower extremity fracture was associated with significantly worse motor functioning and autonomy scores than either an upper extremity injury or no extremity fracture. In an earlier parent-report study, however, Sturms et al. (2002) found that neither head nor lower extremity injury contributed significantly to HRQOL findings.

Hospitalization: Two studies suggest that hospitalization or its length may be related to HRQOL outcomes. Sturms et al. (2005) found that motor functioning and autonomy scores on the TACQOL were significantly lower in those who had been hospitalized than in those who had not. Using the CHQ-PF50, Davey et al. (2005) found lower physical functioning, general health, parent impact-emotional and family activity scores in those hospitalized less than 24 hours compared to the normative sample. A longer hospitalization (> 24 hrs) was further associated with deficits in all subscales except bodily pain and physical functioning. However, length of hospitalization did not predict either postinjury PHS or PSS in a multiple regression analysis (Davey et al. 2005). In separate studies, length of hospital stay was also not significantly correlated with HRQOL at either 1 month or 1 year after road-traffic accident (Landolt et al. 2009b) or significantly related to scores on the autonomy or motor subscales of the TACQOL (Sturms et al. 2003).

Stressful life events: Two studies investigated the impact of other stressful life events. Landolt et al. (2009b) found the number of major life events experienced prior to an injury to be significantly correlated with HRQOL 1 year later. However, this variable was not a significant contributor to explaining variance in 1-year HRQOL scores in subsequent analysis. When stressful life events occurring after the injury were considered, they were found to contribute significantly to lower overall HRQOL 2.4 years after injury in one study (Sturms et al. 2002) but to not correlate with HRQOL at either 1 month or 1 year after a road-traffic accident in another (Landolt et al. 2009b).

Discussion

General Traumatic Injury

Despite some inconsistencies, the reviewed literature supports at least a short-term negative impact of general traumatic injury on HRQOL in children and adolescents. In fact, HRQOL deficits after general traumatic injury have been found to be similar to those of children with chronic illnesses (Aitken et al. 2002). Parent impact-emotional scores were actually lower for children with traumatic injuries than for those with juvenile rheumatoid arthritis (JRA) or a seizure disorder, and physical functioning scores were the same or lower than all compared chronic illnesses with the exception of JRA (Aitken et al. 2002). A growing adult literature further supports the presence of reduced HRQOL following traumatic injury (e.g., Aitken et

al. 2007; Holbrook et al. 1999; Polinder et al. 2007; Sluys et al. 2005). Improvements over the first few years after injury do seem to occur but may not result in return to baseline levels of functioning. The van der Sluis et al. (1997) and Janssens et al. (2009) studies suggests that improvement to normative HRQOL may occur over an extended period of time after injury, but additional studies with a similarly long duration of follow-up are needed.

Variables Potentially Associated with HRQOL after Traumatic Injury

Participant characteristics

Acute and posttraumatic stress symptoms: Perhaps most clearly, it does appear that acute stress and PTSS are negatively related to HRQOL (Holbrook et al. 2005a, 2005b; Landolt et al. 2009b; Zatzick et al. 2008b). In fact, an earlier review paper of psychiatric issues after pediatric injury noted PTSD to be the most clearly documented diagnosis (Stoddard and Saxe 2001). Outside the general traumatic injury literature, deficits in HRQOL have been reported in children and adolescents with PTSD after burn injury (Landolt et al. 2009a) and adolescents with PTSD in community and clinical settings (Alisic et al. 2008; Clark and Kirisci 1996). In addition, the adult trauma literature lends support to the relationship between PTSD and reduced HRQOL, with prospective cohort studies showing reduced HRQOL in those with PTSD compared to those without PTSD following traumatic injury (Holbrook et al. 1999, 2001b; Johansen et al. 2007; Kiely et al. 2006; Zatzick et al. 2002a, 2008b). Several additional studies evaluating adults with medical conditions rather than traumatic injury have also detected this relationship (e.g., Kapfhammer et al. 2004; Meeske et al. 2001; Noble et al. 2008; Schwartz and Drotar 2006; Stein et al. 2005). Promisingly, there is at least some preliminary evidence in adults that reduction in PTSD symptoms may be associated with improvements in HRQOL (Schnurr et al. 2006).

Gender: The findings reviewed here, although they are far from conclusive, suggest that girls may have poorer HRQOL outcomes than boys. Three of the studies reviewed found such a relationship; however, one found more HRQOL deficits in boys (Davey et al. 2005), and two detected no gender differences. Interestingly, the one study finding more deficits in boys was the only one utilizing parent report. It is certainly possible that parents differentially rate the impact of injury on HRQOL for their boys, perhaps based on gender-biased expectations related to functioning or physical skill. Several studies in the adult literature have found women to have worse HRQOL outcomes after injury than men (Holbrook and Hoyt 2004; Holbrook et al. 2001a, 2002). Higher rates of PTSD and PTSS have also been reported in girls (Mirza et al. 1998; Stallard et al. 2001, 2004; Winston et al. 2003; Zatzick et al. 2006) and women (Ehlers et al. 1998; Holbrook et al. 2002; Zatzick et al. 2002b) after traumatic injury, which in turn may predispose females to poorer HRQOL. To our knowledge, a formal investigation of gender in the relationship between PTSD and HRQOL has not been conducted with children or adolescents following general traumatic injury, but such work would likely provide important information toward developing appropriate screening and intervention programs.

Age: A relationship between age and HRQOL in this population seems less likely based on this review. Interestingly, however, three of the four studies that did not detect a relationship also did not include older adolescents, with a maximum age of 14.5 years compared to 17

and 19 years for the two studies that did find significant age effects (Sturms et al. 2003, 2005; Vollrath and Landolt 2005). It is possible that older adolescents are more at risk for poor HRQOL outcomes after injury, perhaps due to a maturing injury response as suggested by Holbrook et al. (2007) or the disruptive impact of the injury on the developing independence of older adolescents. Further work in this area across the full age range is warranted, particularly as researchers begin including younger (e.g., preschool-aged) children in investigations.

Socioeconomic status: Interpretation of the literature on SES and HRQOL in pediatric injury is complicated by variation in what is used as a proxy for SES (e.g., parental education level, parental occupation and maternal education level, paternal occupation and maternal education). Only one of the four reviewed studies investigating SES detected a relationship with HRQOL (Sturms et al., 2002). Appropriately, these researchers note that low SES may be associated with lower HRQOL even prior to an injury (Sturms et al., 2002). In fact, income has been reported to be associated with both HRQOL (Jiang & Hesser, 2006) and subjective evaluation of life (Kahneman & Deaton, 2010) in the general adult population. More globally, a country's per capita gross domestic product has also been shown to be significantly positively related to life satisfaction in its citizens (Deaton, 2008). Family SES prior to an injury event can likely be accurately assessed and warrants continued attention, particularly as it may be associated with other variables such as race and social support. SES may also change during the evaluation period of a longitudinal study as the family copes with lost work time and expenses related to medical care. Thus, if SES is to be assessed, including a longitudinal variable investigating financial stress may prove beneficial.

Depressive symptoms: Only one of the reviewed studies investigated the relationship between depression and HRQOL. Zatzick et al. (2008b) reported poorer 1-year HRQOL on 6 subscales of the CHQ in those with elevated baseline depressive symptoms. The adult literature supports the finding that depression following a traumatic injury is associated with HRQOL deficits (Holbrook et al. 1999; Zatzick et al. 2008a). Given that reliable diagnosis and efficacious treatments for depression are available, this seems an area in which further investigation could lead rapidly to beneficial interventions for children and adolescents at risk after injury.

Injury-related variables

Injury severity: While it may make intuitive sense that injury severity would be associated with long-term outcome, the literature reviewed here is suggestive but not conclusive. Two studies showed associations only with physical aspects of HRQOL, including PHS (Schweer et al. 2006) and motor functioning (Sturms et al. 2003), suggesting that injury severity may impact physical more than psychosocial outcomes. Similarly, Winthrop et al. (2005) found a relationship between ISS and total scores on the FIM/WeeFim measures of functional outcome (Keith et al. 1987) but no significant relationship between ISS and overall HRQOL. An additional four studies found a significant relationship between ISS and overall HRQOL (Aitken et al. 2002; Holbrook et al. 2007; Sturms et al. 2002; Vollrath and Landolt 2005); however, three detected no relationship at all (Davey et al. 2005; Landolt et al. 2009b;

Sturms et al. 2005). Average ISS of study participants did not seem to be a factor in these findings, as there was a great deal of overlap among studies that did find a relationship and ones that did not. In addition, the two studies with the lowest average ISS both detected a significant relationship (Sturms et al. 2002, 2003). Given that ISS is readily available information in the injury setting and may be associated with poorer HRQOL outcomes, it continues to warrant attention in future research.

Injury mechanism and injury type: The literature evaluating the relationships of injury mechanism and injury type to HRQOL is limited. This area is further complicated by the fact that both variables can have multiple possible categories, that the categories can encompass each other (e.g., MVA and bicycle crash can both fall under road-traffic accident), and that individuals can have multiple injury types. Based on the reviewed studies, it seems that further investigation of motor vehicle crashes and lower extremity injuries as possible risk factors for reduced HRQOL may be warranted. The latter is particularly true in light of two studies specific to fractures that suggest longer-term HRQOL deficits in those with lower extremity fractures than those with other fracture locations (Ding et al. 2006; Stancin et al. 2001). The adult literature lends further support to this finding (Butcher et al. 1996; Holbrook et al. 1999).

Hospitalization: Further research would be necessary to evaluate the impact of hospitalization on HRQOL outcomes. This investigation would be complicated, however, by the fact that hospitalization can be significantly related to ISS and may differ across health care systems, and thus the nation, in which a study is conducted. Given the likelihood of variability in length of hospitalization unrelated to the injury, it may be more effective to take hospitalization duration into consideration in analysis without studying it as a predictor of outcome.

Stressful life events: Research investigating the impact of stressful life events in injured children and adolescents is scarce. However, the burden of stressful life events in this population may be disproportionately high. In a study by Zatzick et al. (2006), injured adolescents reported an average of 2.5 stressful life events prior to their injury, and 30% reported at least four such preinjury experiences (Zatzick et al. 2006). To put this in context, the researchers note that only 11% of non-military Americans between 15 and 54 years of age have experienced four or more such events (Kessler et al. 1995). Daviss et al. (2000) also found that fully two-thirds of their sample of injured 7- to 17-year-olds had experienced a prior traumatizing event, and Sturms et al. (2002) reported that 45% of their sample experienced an additional stressful life event in the 2.4 years following their injury. Stressful life events have been implicated as a risk factor for adolescent unintentional injury (Slap et al. 1991), which may be why so many of these events are being reported in this injured population. Negative life events have also been associated with poorer HRQOL in children and young adults with HIV (Howland et al. 2007) and increased PTSS in children with cancer (Currier et al. 2009). Even low-level stressors have recently been associated with development of PTSS in a community pediatric sample (Copeland et al. 2010). Because preinjury stressful life events may serve as a marker of increased risk and intervention

strategies could be developed to reduce stressful life events following pediatric injury, it seems important to continue work in this area.

Analysis and Critique

Although limited in number, the literature on HRQOL in children and adolescents following general traumatic injury is impressive in the volume of longitudinal cohort studies and largely consistent use of age-appropriate validated measures. Eleven of the 16 studies reviewed were prospective longitudinal cohort studies. One study also chose to utilize a prospective longitudinal cohort study design with a population-based sampling frame (Zatzick et al. 2008b). Soori and Abachizadeh (2008) also used a population-based sampling method by randomly selecting children from randomly selected schools stratified by size and private/public status. Such techniques can improve the generalizability of findings. Nevertheless, there remain challenges to be addressed.

Study sample sizes were respectable, ranging from 68 to 358 in the prospective longitudinal studies; however, both effect sizes and clinical relevance of HRQOL mean differences were infrequently discussed. Four studies mentioned effect sizes for the differences in overall HRQOL between study participants and comparison groups (Landolt et al. 2009b; Sturms et al. 2002, 2003; Vollrath and Landolt 2005). In two studies, Sturms et al. (2002, 2003) mentioned small effect sizes, ranging from 0.11 to 0.25 in the earlier study, and noted mean differences between the study group and the normative sample of less than one point on the TACQOL subscales. Vollrath and Landolt (2005) reported a modest effect size (Cohen's $d = 0.25$) one month after injury. In contrast, Landolt et al. (2009b) found larger effect sizes at 1-month postinjury (Cohen's $d = 0.26$ - 0.74 on subscales significantly different from the reference sample), which the researchers suggest may reflect the higher overall injury severity in their study than in Sturms et al. (2002). Mean differences in subscale scores between the study sample and the reference sample were still fairly small in this study, however, ranging from 0.4 to 2.0.

An attempt was made to calculate effect sizes for HRQOL (injured sample vs. comparison group) in the remaining studies in this review; however, insufficient information was available in 10 of the 12 publications. For the remaining two studies, effect sizes were small to medium. Cohen's d ranged from an absolute value of 0.04 to 0.32 for the CHQ subscales in one study (Davey et al. 2005) and between 0.14 and 0.49 for the PedQL scales in the other (Janssens et al. 2009). The highest effect sizes were found for the physical functioning (Cohen's $d = -0.49$) and school functioning (Cohen's $d = -0.41$) subscales of the PedsQL (Janssens et al. 2009). Future research should, ideally, report effect sizes and consider a priori sample size calculations. Including confidence intervals will also provide important information, particularly when findings are negative (Colegrave and Ruxton 2003). Finally, a focus on what constitutes a clinically and functionally relevant change in HRQOL across measures would also be useful to the field.

Statistical analysis methods varied across studies, with several conducting multivariate analyses of variables that may be associated with HRQOL outcomes. In some cases, correlated variables were no longer significant in multivariate analyses. In addition, when Zatzick et al. (2008b) adjusted for demographic and preinjury factors through multivariate

analysis, depressive symptoms were found to be significantly associated with physical (e.g., physical function, bodily pain) as well as psychosocial aspects of HRQOL whereas only the psychosocial aspects were detected prior to this adjustment. Future investigations would likely benefit from the use multivariate techniques so long as they are appropriately utilized and sufficiently powered to detect an effect.

A traumatized population is obviously difficult to study and is at high risk of missing data and loss to follow-up. Overall, reported response rates in the studies reviewed ranged from 55% to 100%, with six studies having response rates under 70%. Follow-up rates in several longitudinal or long-term studies were good, ranging from 70% to 88% (Aitken et al. 2002; Holbrook et al. 2005a; Janssens et al. 2009; van der Sluis et al. 1997; Zatzick et al. 2008b), although two studies reported low 6-month follow-up rates of 36% and 50%, respectively (Schweer et al. 2006; Winthrop et al. 2005). A few authors chose to include only those participants with complete data in their analyses (Holbrook et al. 2005b, 2007; Landolt et al. 2009b; Sturms et al. 2005; Vollrath and Landolt 2005), which lead to calculated response rates of 60% (Vollrath and Landolt 2005), 59% (Landolt et al. 2009b), and 36% (Sturms et al. 2005) in three studies. No systematic differences were noted in results between studies with low response or retention rates as compared to those with better rates. Nonetheless, these findings raise concern about possible differences between these samples and the larger population which may limit their generalizability. Retention will be an ongoing problem in longitudinal trauma research. Low retention rates might be addressed in some cases by utilization of statistical analysis techniques that allow for inclusion of all participants even when some data are missing (Gibbons et al. 1993). Development of retention strategies and enhanced follow-up techniques tailored to the injured population will likely also be important.

Eight studies reported potential differences between the study sample and eligible nonparticipants (Aitken et al. 2002; Landolt et al. 2009b; Sturms et al. 2002, 2003, 2005; Vollrath and Landolt 2005; Zatzick et al. 2008b), or census data (Davey et al. 2005). Of those, six found a difference that related directly to injury characteristics. In all but one, participants had characteristics that suggested they might have been more severely impacted than nonparticipants, including more frequent reports of disability at the discharge interview (Aitken et al. 2002), higher mean ISS (Sturms et al. 2002, 2003) and hospitalization rates (Sturms et al. 2002), longer hospitalizations (Zatzick et al. 2008b) and more intracranial injuries (Sturms et al. 2005). In contrast, Vollrath and Landolt (2005) found more road-traffic accidents in non-participants than participants. The other two differences were related to parental demographics. Davey et al. (2005) found that parents in their sample were more likely to be married and have higher education than local census data would suggest. Similarly, Landolt et al. (2009b) found that their sample had a high representation of upper- or middle-class families, and 83% of participants resided with two parents. All of these differences have the potential to reduce the generalizability of findings and suggest that additional attention to characteristics of nonparticipants and consideration of the reasons why individuals refuse participation or drop out would be helpful in future work.

The use of multiple measures across studies can complicate comparison and summarization. As discussed above, the TACQOL and PedsQL have more limited role functioning and

parental/family impact queries than the CHQ, and the QWB scale has no specific mental health or emotional subscales. It is, therefore, unclear whether psychosocial aspects of HRQOL are being equivalently assessed in all studies. Considering physical and psychosocial aspects of HRQOL separately, most studies showed continued deficits over time in the physical aspects of HRQOL (Aitken et al. 2002; Davey et al. 2005; Schweer et al. 2006; Sturms et al. 2002, 2003; Winthrop et al. 2005; Zatzick et al. 2008b). A few studies found deficits in the overall psychosocial domain (Schweer et al. 2006), children's experience of positive emotions (Landolt et al. 2009b; Sturms et al. 2002; Vollrath and Landolt 2005), emotional or behavioral roles (Davey et al. 2005), behavior in general (Davey et al. 2005), self-esteem (Davey et al. 2005), social functioning (Sturms et al. 2002), and the emotional impact of the injury on parents (Aitken et al. 2002; Davey et al. 2005; Schweer et al. 2006), but these areas were not where the burden of long-term deficit appears to be reported. These findings may reflect differences in the measurement tools, but they are also particularly interesting in light of the fact that adults with physically limiting disabilities often report good overall QOL (Patrick and Chiang 2000) as do children with cerebral palsy (Bjornson et al. 2008). As defined by the World Health Organization, QOL is a broader construct than HRQOL and includes investigation of psychosocial, cultural and environmental areas along with an associated reduction in emphasis on the physical aspects of illness (WHOQOL Group 1995, p. 1405). It is plausible that adjustment in psychosocial areas occurs over time after injury, even when full physical recovery does not. Further investigation of this area may provide important information about the impact of general traumatic injury in this population.

Studies differed in who reported on the child or adolescent's HRQOL. Eight studies utilized exclusively self-report from the child, adolescent or young adult participant. One used self-report but allowed parents to assist children less than 12 years of age (Janssens et al. 2009). Six studies included parent report only; and one included both child and parent forms of the same measure (Sturms et al. 2003). Several questions arise related to potential differences in self- vs. parent-proxy reporting.

First, at what age might a child be able to accurately self-report HRQOL? In pain assessment, there is growing agreement that children above the age of 4 years can accurately self-report their own pain intensity (McGrath et al. 2008); however, the concepts involved in HRQOL assessment are more abstract and may be more difficult for young children to understand. In validating the child version of the TACQOL, Vogels et al. (1998, 2000) chose the age of 8 years as the lowest age when self-report could be accurately obtained. Some self-report forms are now in use with children as young as 5 years of age (Varni et al. 2007), although typically with a verbal interview format and/or some illustrations (Solans et al. 2008). Two of the reviewed studies utilized the child-report TACQOL with children as young as 6 years of age (Landolt et al. 2009b; Vollrath and Landolt 2005); however, both utilized an interview format of the measure (Vogels et al. 1998, 2000). In addition, the age range for these studies was broad (6 or 6.5 years to 14.5 years) making it unlikely that the limited number of participants at the youngest ages would have significantly impacted the study outcome if they had difficulty completing the form.

A second topic for consideration is how accurate parents are in their assessment of their child's HRQOL. In general, agreement between children and their parents has been reported as low to moderate (Sturms et al. 2003; Theunissen et al. 1998) and found to be better on observable subscales (e.g., physical activity) than in areas that are not readily visible (e.g., social functioning, mood, and some physical symptoms including pain; Eiser and Morse 2001; Ocampo and Dawson 1997; Parsons et al. 1999; Verrips et al. 2000). In one of the reviewed studies, intraclass correlation coefficients revealed low parent-child agreement on the autonomy (ICC = 0.35) and positive emotions subscales (ICC = 0.45) and moderate agreement on all other subscales. Parents were found to report more positive emotions, fewer physical complaints and overall better motor functioning and autonomy for their children than the children reported for themselves (Sturms et al. 2003). Across studies, parents have been shown to report both better (Parsons et al. 1999; Sturms et al. 2003; Theunissen et al. 1998) and worse (Parsons et al. 1999) HRQOL depending on the group sampled and the subscale under investigation. There is growing consensus that pediatric self-report of HRQOL should be utilized whenever allowed by the individual's medical or cognitive status (Bjornson et al. 2008; Edwards et al. 2002; Eiser and Morse 2001; Parsons et al. 1999; Sturms et al. 2003). Parent-report can also be included as an additional evaluation tool. As Varni et al. (2007) noted, parent-report should not be considered a substitute for child or adolescent self-report when the latter is possible to obtain. In addition, expanding our understanding of differences between parent and child report will benefit the important work that should continue with younger children and more severely injured youth who are not able to self-report.

Finally, how may the choice of reporter have impacted the findings of studies in this review? As noted previously, there is the potential that parental expectations of boys' physical functioning played a role in their more negative evaluation of their sons' HRQOL. In fact, the specific areas in which parents reported below normative HRQOL for boys but not girls included physical functioning and both the physical and emotional/behavioral aspects of role functioning. A study involving parent report was also the only one to find a significant association between SES and HRQOL. As discussed, there is data to suggest that adults with lower SES might self-report poorer HRQOL. The current finding raises the possibility that parents of low SES may rate their child's HRQOL as lower as well. Finally, 57% of studies that reported a significant relationship between injury severity and HRQOL involved parent report, whereas only 33% of those that did not detect this relationship did so. While many factors may be involved here, one possible contributor is that parents of children with more severe injuries expect a greater impact on their children than the children actually experience. Other variables, including age at the time of injury, injury mechanism and hospitalization did not appear to differ systematically by reporter. As work in this area moves forward, it will be important to consider the reporter in study design and interpretation.

By its nature, this research takes place after an injury, making assessment of preinjury status retrospective and at risk for bias associated with the significant functional change brought about by a traumatic injury. Of the three studies that collected and reported baseline HRQOL, one appears to have assessed current postinjury HRQOL through parent report (Aitken et al. 2002), while two queried self-report retrospective recall of preinjury status

(Sturms et al. 2005; Zatzick et al. 2008b). Looking at current functioning, Aitken et al. (2002) found significant deficits in 11 of 12 CHQ-PF50 subscales and both the PHS and PSS. In contrast, when Zatzick et al. (2008b) asked adolescents to rate their preinjury status on the CHQ-87 at a similar time point, they found no difference between study participants and population norms on five subscales, and subscale scores were significantly above population norms on the general health perceptions, self-esteem, bodily pain and role/social-physical subscales. This indicates that adolescents recalled themselves to have been doing better in these areas prior to their injury than the general adolescent population. Scores were significantly lower on the general behavior subscale (Zatzick et al. 2008b), indicating self-assessed worse preinjury behavior than the general adolescent population. Sturms et al. (2005) also asked for retrospective recall and found that study participants were similar to the reference group on five subscales of the TACQOL and reported significantly fewer physical complaints and more positive emotions preinjury than the reference sample. Again, this suggests a better than normative self-evaluation in these areas. Taken together, these findings are reassuring in that retrospective recall of HRQOL does appear to be different than reports of current HRQOL assessed at the same time point. Importantly, it is not possible to fully rule out an influence of parents as reporters in the first study.

The findings of the two studies investigating retrospectively recalled HRQOL also raise additional questions. Are children reporting elevated preinjury physical functioning (general health perceptions, bodily pain, role/social-physical and physical complaints) and mental health (self-esteem and positive emotions) because of a perspective change brought about by the serious injury, or might they truly have a self-perception of high physical functioning/ability combined with difficult behavior? If the latter is true, then it seems likely that this self-assessment could lead to an increase in injury risk. In support of this, one adult study that compared retrospective self-report HRQOL ratings to national norms immediately following injury found retrospective ratings to be consistently higher than the norms (Watson et al. 2007). Interestingly in the subsample that fully recovered, retrospective recall also more closely matched HRQOL ratings 12 months after injury. The researchers concluded that the injured population may be a novel group for which the use of retrospective self-report is more appropriate than national norms. These areas are difficult to investigate but might be possible to address in epidemiologic injury-prevention studies that follow large numbers of children and adolescents over time looking for factors that may contribute to injury risk.

There has been a recent focus on injury- or disease-specific HRQOL, and the debate continues as to whether injury-specific measures will provide substantively more and more useful information. While TBI and other areas (e.g., SCI and burns) may benefit from a specific measure, there will also continue to be children with general traumatic injuries that require a somewhat more general evaluation of HRQOL. Utilization of broader measures also allows for comparison across injury groups. In particular, the literature on the impact of pediatric TBI is rapidly expanding, and a comparative investigation of HRQOL after general traumatic injury and following TBI may be helpful in the future.

Two final issues to consider from this literature remain. First, there is the possibility of a cohort effect, due to varying years of data collection. Most studies were conducted between

1996 and 2008, although enrollment in one of the two long-term follow-up studies took place between 1985 and 1989. No systematic differences in HRQOL outcomes were noted based on the year of study enrollment, suggesting a cohort effect does not exist. Second, HRQOL could differ based on the country in which the study was conducted. Such differences might predate the injury (e.g., poorer life satisfaction in countries with lower gross domestic product) or relate to variability in injury management and follow-up (e.g., availability of rehabilitation services or insurance coverage). As noted previously, studies were conducted in the United States (n=7), western Europe (n=7), Australia (n=1) and Iran (n=1). Despite the potential for significant differences across region, the general findings of the studies were remarkably similar in terms of both initial deficits and long-term, often incomplete, improvement. Of note, the two studies investigating HRQOL many years after injury were both conducted in The Netherlands and both found no residual HRQOL deficits 6 to 8 (Janssens et al. 2009) or 7 to 11 (van der Sluis et al. 1997) years after injury. Replication of these findings in other countries will be important, particularly given the limited number of studies following children so long after traumatic injury.

Future Directions

The work investigating HRQOL in children and adolescents after general traumatic injury is impressive, yet not complete. In particular, the topics outlined in the preceding section will be important as this work moves forward. Several additional areas also warrant attention.

First, ethnicity has not been a focus of most studies; however, recent research with adults suggests poorer life satisfaction and well-being in ethnic minority adults following specific traumatic injury (Arango-Lasprilla et al. 2009; Krause et al. 2009). Further investigation of HRQOL outcomes across racial and ethnic groups seems prudent, particularly when considered in conjunction with other factors such as SES.

In addition, we agree with Landolt et al. (2009b) that closer investigation of preinjury psychiatric morbidity and HRQOL, family structure and functioning, and aspects of parental mental health both pre- and post-injury will likely provide important information. The finding of significant impact on parental emotion in two studies is concerning (Aitken et al. 2002; Schweer et al. 2006) and is consistent with findings that between 11% and 52% of parents have significant PTSS following a traumatic injury to their child (Ghesquiere et al. 2008; Hall et al. 2006; Kassam-Adams et al. 2009; Murray et al. 2008; Sturms et al. 2005; Zatzick et al. 2006). Parental postinjury functioning will likely be important for child and adolescent recovery. In fact, children of mothers with probable PTSD and depression after a traumatic event exposure have been shown to have more problems with emotionally reactive and aggressive behavior (Chemtob et al. 2010). In addition, it has been suggested that parents with significant distress may have a reduced ability to create a safe and secure environment (Langeland and Olff 2008) or the feeling that the setting is safe (Chemtob et al. 2010) for their child. Further work in this area has the potential to lead to improvements in parental and pediatric outcomes.

It will also be important to begin including younger children in studies as was done by Winthrop et al. (2005). Although literature in this area following traumatic injury is sparse, several investigations following disaster exposure have shown that younger children

experience a greater psychological impact than older children or adolescents (Kronenberg et al. 2010; McDermott and Palmer 2002; Shannon et al. 1994). The chronicity of psychological symptoms in young children after injury is also a concern, with PTSD shown to persist in 69% of 2- to 10-year-olds 6 months after injury in a motor vehicle accident (Meiser-Stedman et al. 2008) and 50% of 20-month- to 6-year-olds with mixed trauma types 2 years following initial assessment (Scheeringa et al. 2005). While one might imagine that a single injury experience in a young child would not result in significant psychological sequelae, recent literature suggests that PTSS can develop in children even following less extreme stressors than traumatic injury (Copeland et al. 2010) and, as noted earlier in this review, it appears that at least some injured children are experiencing multiple life stressors. It is likely that increased PTSS will be associated with poorer HRQOL for young children as well. While this work will be complicated by the necessity for parental- and/or other adult proxy-report of child symptoms, the fact that 2.2 million U.S. children between the ages of birth and 4 years experienced non-fatal injuries in 2007 alone (Centers for Disease Control and Prevention 2009) emphasizes its importance.

Finally, an interrelationship between postinjury mental health and physical recovery has been reported in the adult literature (Ramchand et al. 2008) and intervention studies in adults after traumatic injury have begun to show promise (Zatzick et al. 2004). Given available data on factors associated with HRQOL deficits after traumatic injury, it seems time to begin to conceptualize and conduct intervention studies, particularly for children and adolescents with significant acute stress symptoms or early signs of PTSD. It also seems prudent to inform families of potential psychological and HRQOL difficulties that their child or adolescent may face during recovery from a general traumatic injury.

Conclusions

We have long known that traumatic injury to a child or adolescent had significant and potentially long-term physical consequences. More recent work, such as that reviewed here, begins to reveal patterns of psychosocial and familial challenges which may be particularly prevalent in the early phases of recovery. While the work in this area to date is impressive, more research is clearly needed to develop and implement strategies that will lessen the long-term impact of general traumatic injury on the HRQOL of children and adolescents.

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Table 1

Demographics, Study Design and Findings of Reviewed Studies

Study Country Type of injury	Age at Injury (M ± SD)	% Male	HRQOL measure Design (reporter)	Comparison group	Time of Assessment	N (response; retention rate) ^a	Findings (study vs. comparison group)	Variables Associated with worse HRQOL
Aitken et al. (2002) USA General traumatic injury	3-18 years median 9.6	66%	CHQ-PF50 Longitudinal (Parent-report)	Healthy sample of 391 children from national surveys	At discharge, 1 month and 6 months after injury	Baseline: 195 (63%); 88%-1 month, 73%-6 months	<ul style="list-style-type: none"> Baseline: worse PSS, PHS and 11 of 12 subscales 1 month: worse PHS, PSS and all subscales 6 months: worse PHS, GH, PF, BE, RSP, PIE, FA 	<ul style="list-style-type: none"> ISS > 16
Davey et al. (2005) Australia General traumatic injury	5-18 years (11.3 ± 3.0)	65%	CHQ-PF50 Australian version Cross-sectional (Parent-report)	Australian population norms	Range 0.8-2.1 years after injury (M ± SD; 1.5 ± 0.3)	241 (57%)	<ul style="list-style-type: none"> Deficit in PF, REB, BE, SE, GH, PIE, PIT, FA, FC 	<ul style="list-style-type: none"> Boys below norms on more scales Hosp. < 24 hr vs. none, worse PF, GH, PIE, FA Hosp. > 24 hr vs. < 24 hr, worse BP, PF
Holbrook et al. (2005a) USA General traumatic injury	12-19 years (15 ± 2.3)	62%	QWB scale Longitudinal (Adolescent-report by interview)	Compared adolescents with and without Acute Stress Disorder	At discharge and 3, 6, 12, 18 and 24 months after injury	401 (100%); 96%-3 months 90%-6 months 90%-12 months 90%-18 months 88%-24 months	<ul style="list-style-type: none"> Significantly lower HRQOL at all times in those with predischARGE acute stress disorder than those without 	<ul style="list-style-type: none"> Acute stress disorder at discharge
Holbrook et al. (2005b) USA General traumatic injury	12-19 years (15 ± 2.3)	71%	QWB scale Longitudinal (Adolescent-report by interview)	Compared adolescents with and without Posttraumatic Stress Disorder	At discharge and 6, 12, and 18 months after injury	381 (95%) 100% at 6, 12, and 18 months Analyzed only those with complete follow-up	<ul style="list-style-type: none"> Significantly lower HRQOL at all times in those with PTSD than those without 	<ul style="list-style-type: none"> Long-term PTSD
Holbrook et al. (2007) USA General traumatic injury	12-19 years (15 ± 2.3)	71%	QWB scale Longitudinal (Adolescent-report by interview)	National Health Interview Study QWB data 1994-1996	At discharge and 3, 6, 12, 18 and 24 months after injury	356 (89%); 100% at 6, 12, 18 and 24 months Analyzed only those with complete follow-up	<ul style="list-style-type: none"> Significantly lower overall HRQOL at all time points 	<ul style="list-style-type: none"> Older age Female ISS > 16 at 18 months Pedestrian hit in traffic accident
Janssens et al. (2009) Netherlands Severe traumatic injury	8.2 ± 4.7 years	61%	PedsQL 4.0 Cross-sectional (Child-report)	Dutch pediatric general population group	6 to 8 years after injury (M ± SD: 7.3 ± 0.7 years)	28 (70%) Analyzed only those with complete PedsQL 4.0 (n=25)	<ul style="list-style-type: none"> No significant differences between median scores 	
Landolt et al. (2009b) Switzerland and Traffic-related General traumatic injury	6.5-14.5 years (9.8 ± 2.6)	54%	TACQOL Longitudinal (Child-report by interview)	Community sample of Dutch children	1 month and 1 year after injury	68 (58.6%); 100% at 1 month & 1 year Analyzed only those with data at both time points	<ul style="list-style-type: none"> 1 month: lower overall HRQOL, MF, A, PE, but fewer PC, NE 1 year: no overall HRQOL deficits, fewer PC and SF problems, but lower PE 	<ul style="list-style-type: none"> Female at 1 month More preinjury SLE at 1 year High PTSS at 1 month, poor HRQOL at 1 year No SES, hosp. or postinjury SLE associations
Schweer et al. (2006) USA General	5-17 years (49% 5-9, 51% 10-17)	85%	CHQ-PF50 Longitudinal (Parent-report)	Normative sample of 5- to 18- year-olds	1 month and 6 months after injury	358 (62%); 45%-1 month, 36%-6	<ul style="list-style-type: none"> Significantly lower PHS and PSS at 	<ul style="list-style-type: none"> Higher ISS at 1 and 6 months Older age, worse PHS at 6 months

Study Country Type of injury	Age at Injury ($\bar{M} \pm \text{SD}$)	% Male	HRQOL measure Design (reporter)	Comparison group	Time of Assessment	N (response; retention a rate)	Findings (study vs. comparison group)	Variables Associated with worse HRQOL
traumatic injury						months Analyzed only those with follow-up at both time points.	both time points • 1 month: worse BP, PF, MH, RSP, REB, FA, PIE PIT, SE • 6-months: worse PF, MH, REB, FA, PIE	• Extremity injury, worse PHS at 1 and 6 months
Soori and Abachizadeh (2008) Iran General injury	6-10 years (7.9 $\pm$ 1.5)	49%	TACQOL – Persian language translation Cross-sectional (Parent-report)	Non-injured study participants	One time point with retrospective report of injury in past 12 months	3375 (89%)	• Poorer median HRQOL, PC, MF, PE, NE, CF, SF	
Sturms et al. (2002) Netherlands Traffic- related General traumatic injury	4-13 years at time of injury	58%	TACQOL Cross-sectional (Parent-report)	2 randomly sampled groups of Dutch children (6- to 11-year- olds; 12- to 15-year-olds)	On average 2.4 years after injury (1.5 to 3.4 years)	214 (67%)	• Poorer overall HRQOL, MF, A, CF, SF, PE	• ISS>9 • Lower SES • More postinjury SLE • No injury mechanism or head/lower extremity injury associations
Sturms et al. (2003) Netherlands Traffic- related General traumatic injury	8-15 years (12 $\pm$ 2.4)	57%	TACQOL Cross-sectional (Child- and Parent-report)	2 randomly sampled groups of Dutch children (8- to 11-year- olds; 12- to 15-year-olds)	2.4 $\pm$ 0.6 years after injury (1.5 to 3.4 years)	157 (62%)	• Poorer MF, A, but lower PC	• ISS>9 vs. 4-8 or 3 • No effect of mechanism or hosp. on MF or A
Sturms et al. (2005) Netherlands Traffic- related General traumatic injury	8-15 years (12.2 $\pm$ 2.1)	53%	TACQOL Longitudinal (Child-report)	Published reference data from 8- to 15-year-olds in general Dutch population	Shortly after injury, 3 and 6 months after injury	79 (55%); 85%-3 months 65%-6 months Analyzed only those with data at all time points	• Retrospective recall of preinjury status: fewer PC, more PE • 3 months: lower MF compared to preinjury • Resolved by 6 months	• Hospitalized, worse MF, A • Motor vehicle involved, worse MF, A • Lower extremity, worse MF than upper or no extremity injury • No gender, age or SES associations
van der Sluis et al. (1997) Netherlands Severe polytrauma	6-15 years (11)	54%	RAND-36 Longitudinal (Self-report)	Healthy Dutch sample of 18- to 24-year-olds	7 to 11 years after injury	Baseline: 59 (80% deceased); Follow-up: 50 (85%)	• No significant differences in HRQOL	
Vollrath and Landolt (2005) Switzerland Unintentional general traumatic injury	6-14.5 years (9.8)	65%	TACQOL – short form German version Longitudinal (Child-report by interview)	Healthy Dutch reference sample of 8- to 11-year-olds	1 month and 1 year after injury	138 (78%); 78%-1 month, 78%-1 year Analyzed only those with follow-up at both time points	• 1 month: lower overall HRQOL, MF, A, PE and fewer PC • 1 year: normalized overall HRQOL, continued PE deficits, fewer PC, better SF	• Female • ISS at 1 month • No age or SES associations
Winthrop et al. (2005) USA General traumatic injury	1-18 years (median 9.3)	68%	CHQ-PF28 Longitudinal (Parent-report 5-18 years) CHQ-IT (Parent-report 1-4 years)	CHQ-PF28 norms for 5- to 18-year-olds No norms available for CHQ- IT	1 month and 6 months after injury	162 (90%); 80%-1 month, 50%-6 months	• For 5- to 18- year-olds: • 1-month: PHS and PSS deficits • 6 months: PHS deficits	• For 1- to 4-year- olds: higher ISS, lower PA, BE at 6 months • For 5- to 18- year-olds: no ISS associations
Zatzick et al. (2008b) USA General traumatic injury	12-18 years (15.9 $\pm$ 1.9)	67%	CHQ-87 Longitudinal (Adolescent-report)	Published norms	At discharge, 2, 5, and 12 months after injury	108 (70%) 87%-2 months 83%-5 months 82%-12 months	• Retrospective recall of preinjury: worse BE and better GH, BP, SE, RSP • 12 months: poorer PF, RSP, BP, GH,	• Elevated baseline PTSS, poorer GH, REB, RSP, BP, BE, MH over 1 st year • Higher Depressive symptoms, worse REB, BE, MH,

Study Country Type of injury	Age at Injury ($\bar{M} \pm \text{SD}$)	% Male	HRQOL measure Design (reporter)	Comparison group	Time of Assessment	N (response; retention ^a rate)	Findings (study vs. comparison group)	Variables Associated with worse HRQOL
							FC and better SE	SE, GH over 1 st year

Retention is the percentage of participants who remained in the study over time.

Note: HRQOL = Health-related Quality of Life; CHQ-PF50 = Child Health Questionnaire – Parent Form 50 (Landgraf et al. 1996); CHQ Domain Scores: PHS = Physical Summary Score, PSS = Psychosocial Summary Score; CHQ Subscales: PF = Physical functioning, REB = Role/Social-Emotional/Behavioral, RSP = Role/Social-Physical, BP = Bodily pain, BE = General Behavior, MH = Mental Health, SE = Self-esteem, GH = General Health, PIE = Parent Impact-Emotional, PIT = Parent Impact-Time, FA = Family Activities, FC = Family Cohesion, CH = Change in Health; Baseline = first assessment after injury; ISS = Injury Severity Score (Baker et al. 1974; Senkowski and McKenney 1999); hosp. = hospitalization; hr = hours; QWB = Quality of Well-being scale (Anderson et al. 1989; Kaplan et al. 1976, 1979); PTSD = Posttraumatic Stress Disorder; PedsQL 4.0 = Pediatric Quality of Life Inventory 4.0 (Varni et al. 2001, 2002); TACQOL = TNO AZL Child Quality of Life Parent Form (Vogels et al. 1998, 2000); TACQOL Subscales: PC = physical complaints, MF = motor function, A = autonomy, PE = positive emotion, NE = negative emotion, CF = cognitive function, SF = social function; SLE = stressful life events; SES = socioeconomic status; RAND-36 Health Status Inventory (Hays et al. 1993) = This measure contains the same items as the Medical Outcome Study Short Form-36 (Hays et al. 1993) with slightly different scoring algorithm; CHQ-PF28 = Child Health Questionnaire – Parent Form 28 (Raat et al. 2005); CHQ-IT = Infant-Toddler Quality of Life Questionnaire; CHQ-IT subscales: PA = physical ability; BE = behavior overall; CH = change in health; CHQ-87 = Child Health Questionnaire, 87-item (Landgraf et al. 1996; Raat et al. 2002)

^aResponse rate is the percentage of eligible participants who enrolled in the study.

Table 2

Injury-Related Variables of Reviewed Studies

Study	Length of Hospitalization Range ($\bar{M} \pm \text{SD}$)	Injury Severity Range (Percentage or ($\bar{M} \pm \text{SD}$) as available)	Injury Mechanism (%)	Injury Type ^a (%)
Aitken et al. (2002)	1 to 125 days (9 days)	ISS 4 - 50 48% < 9 37% 9-15 15% 16	Motor vehicles (29%) Falls (23%) Bicycle rider (6%) Pedestrian (7%) ATV (12%) Other (24%)	Head Injury (44%) Extremity Injury (50%) Abdominal Injury (11%) Chest Injury (9%)
Davey et al. (2005)	50% < 24 hours 50% > 24 hours	ISS for those admitted > 24 hours: 1 - 35 (8.7 $\pm$ 7.8) 19% > 16	Falls (28%) Cycle-related (14%) Remainder not noted	Fractures (47%) Intracranial Injury (14%) Remainder not noted
Holbrook et al. (2005a)			MVA (22%) Recreational (16%) Bike (13%) Intentional (13%) Falls (12%) Pedestrian (10%) Motorcycle (6%) Other (8%)	
Holbrook et al. (2005b)			MVA (22%) Recreation (16%) Bicycle (13%) Intentional (13%) Fall (12%) Pedestrian (10%) Motorcycle (6%) Burn (0.2%) Other (7.2%)	
Holbrook et al. (2007)	4.8 $\pm$ 6.7 days	ISS: 10.8 $\pm$ 7.4 20% > 17	MVA (22%) Recreational (16%) Bike (13%) Intentional (13%) Falls (12%) Pedestrian (10%) Motorcycle accident (6%) Burn (0.2%) Other (7.2%)	3 or more body regions (27%) Serious injury (AIS 3): Head/Neck Injury (30%) Face Injury (3%) Chest Injury (10%) Abdomen Injury (12%) Extremity Injury (20%) External Injury (1%)
Janssens et al. (2009)	21.3 $\pm$ 24.8 days	ISS: 24.7 $\pm$ 11.7	Traffic-related (68%) Home (14%) Sports (7%) Other (11%)	Head (36%) Thorax (17%) Abdomen (17%) Lower extremity (15%) Upper extremity (8%) Spinal cord (4%)
Landolt et al. (2009b)	8.1 $\pm$ 7.4 days 3% still in hospital at 1 month	MISS: 10.2 $\pm$ 7.6 Median 9	Pedestrian (44%) Bicycle or motorcycle (31%) Motor vehicle passenger (15%) Other (10%)	Multiple Injuries (49%) Minor Head Injury (59%) Lower Extremity Fracture (16%) Upper Extremity Fracture (15%) Non-extremity Fracture (37%) Internal Injury (16%)
Schweer et al. (2006)		ISS: 50% < 10 28% 10-14 22% 15	Motorized vehicle-related (34%) Bicycle-related (27%) Fall (13%) Pedestrian (12%) Injury by object (6%) Sports (5%) Firearms (3%)	External Injury (74%) Extremity injury (40%) Abdominal injury (38%) Head/Neck injury (33%) Chest Injury (20%) Face Injury (19%) Multisystem Injury (> 75%)
Soori and Abachizadeh (2008)			Falls (51.6%) Transport accidents (25.1%) Struck by object (11.2%) Poisoning (5.1%)	ICD-10 "Injury" (S00-T98) and "External Causes of Morbidity and Mortality" (V01-Y98)

Study	Length of Hospitalization Range ($M \pm SD$)	Injury Severity Range (Percentage or ($M \pm SD$) as available)	Injury Mechanism (%)	Injury Type ^a (%)
			Burns/Scald (4.7%)	
Sturms et al. (2002)	25% hospitalized	ISS: 80% < 4	Bicyclist (57%) Bicycle passenger (19%) Pedestrian (13%) Motor vehicle passenger (11%)	Only one injury type (63%) Lower Extremity Injury (35%) Upper Extremity Injury (23%) Face Injury (22%) Head and Neck Injury (12%) Abdomen and Pelvis Injury (4%) Chest Injury (3%)
Sturms et al. (2003)	24% hospitalized	ISS: 4.3 $\pm$ 6.1	Bicyclist (65%) Pedestrian (11%) Motor vehicle passenger (11%) Bicycle passenger (10%) Other (3%)	Extremity Injury (58%) Face Injury (18%) Head Injury (15%) Thorax or Abdomen Injury (8%)
Sturms et al. (2005)	29% hospitalized	ISS: 38% 1-3 36% 4-8 26% > 9	Bicyclist (57%) Motor vehicle involved (47%)	Intracranial Injury (29%) Upper Extremity Fracture (33%) Lower Extremity Fracture (8%)
van der Sluis et al. (1997)		ISS 16	Traffic Accidents (85%) Cyclists (50%) Pedestrians (23%)	Severe polytrauma (100%) Head and Neck Injury (80%) Chest Injury (32%) Extremity Injury (32%)
Vollrath and Landolt (2005)	1 to 104 days (10.6 $\pm$ 14.1)	MISS: 1 - 50 (8.8 $\pm$ 7.3) 5% > 25	Road-traffic accident (57%) Leisure time accident (43%)	Minor Head injury (48%) Nonextremity Fracture (27%) Lower extremity Fracture (18%) Upper extremity Fracture (10%) Internal Injury (14%) Burns (12%) Combined Injury (36%)
Winthrop et al. (2005)	6.6 $\pm$ 6.0 days	ISS: 9 - 43 (14.3 $\pm$ 7.4) 32% 16	Motor vehicle (43%) Falls (22%) Recreation/Sports (20%) Burns (9%) Other (6%)	Femur Fracture (45%) Abdomen Injury (18%) Burn Injury (11%) Extremity Injury (10%) Head (7%) Pelvic fracture (6%) Thorax Injury (3%)
Zatzick et al. (2008b)	100% hospitalized	ISS: 9.7 $\pm$ 6.6		

Note. ISS= Injury Severity Score (Baker et al. 1974; Senkowski and McKenney 1999); MISS = Modified Injury Severity Score (Mayer et al. 1980)

^aSome participants may have had multiple injury types.