A SURVEY OF METHODS USED FOR DETERMINING NOVEL PSYCHIATRIC RESEARCH DIAGNOSES IN CHILDREN AND ADOLESCENTS AFTER ACQUIRED BRAIN INJURY, AND THEIR LIMITATIONS

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Abstract

Objective: To survey the methods used for determining novel psychiatric research diagnoses in children and adolescents after acquired brain injury, and their limitations.

Method: A literature search was conducted using EMBASE, Medline, PsycInfo, and CINAHL. 61 papers were identified, of which 18 met the inclusion criteria. The 18 papers were analysed in terms of their focus, participant characteristics, psychiatric disorders studied, evidence level, and the methods used for diagnosing novel psychiatric disorders. Any limitations identified in the papers were classified.

Results: The majority of studies focussed on specific psychiatric disorders or symptoms. Most studies included participants with a broad range of ages and injury severity. Mood disorders, anxiety disorders and secondary ADHD were commonly studied. All studies used standardised assessment measures for determining psychiatric diagnoses. Most studies used structured clinical interviews, predominantly K-SADS. Limitations were identified relating to general study design, the participant group, the assessment of psychiatric disorders, and the interpretation of results.

Conclusions: Studying novel psychiatric disorders after paediatric ABI is a highly important but challenging area. Further research is needed to assess the validity of current diagnostic criteria and assessment methods, and to develop new tools for specific use in this population. Researchers in this area should be mindful of the multiple limitations faced.

Key words: acquired brain injury, novel psychiatric disorders, adolescents, diagnosis, assessment

Declaration of interest: none

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Introduction

In the United States, 473,947 emergency department visits for traumatic brain injury (TBI) are made annually by children aged 0 to 14 years (Faul et al. 2000). A Swedish birth cohort study found 9.1% sustained at least one TBI before the age of 25 (Sariaslan et al. 2016). When non-traumatic causes of acquired brain injury (ABI) are included the problem increases. The World Health Organisation places TBI as the leading cause of morbidity and mortality under the age of 45 (World Health Organisation. 2006), and TBI is associated with a wide range of both medical and social outcomes (Sariaslan et al. 2016). Psychiatric disorders that develop after an acquired brain injury in the absence of a pre-injury psychiatric disorder, or the development of a psychiatric disorder that is distinct from any pre-injury disorder, are termed novel psychiatric disorders (Max et al. 1998a). A clear association has been shown between acquired brain injury and the development of novel psychiatric disorders in children and adolescents (Max et al. 1997, Schwartz et al. 2003). Novel psychiatric disorders cover the spectrum of psychiatric diagnoses, but particular research emphasis has been given to anxiety disorders including post-traumatic stress disorder (PTSD) (Hajek et al. 2010, Max et al. 2015), depressive disorders (Luis et al. 2002, Max et al. 2012) and secondary attention-deficit/hyperactivity disorder (S-ADHD) (Levin et al. 2007, Sinopoli et al. 2011).

The high rates of psychiatric disorders after paediatric ABI (Max et al. 1997, Schwartz et al. 2003), and the significant cost burden (Rockhill et al. 2010) associated with them makes this an important area of research. However, the findings of research into novel psychiatric disorders after paediatric ABI are mixed and inconclusive. The results of prospective studies have varied widely from 32% (Schwartz et al. 2003) to 61% (Max et al. 1997) of children developing novel psychiatric disorders after ABI. Studies have reached conflicting conclusions around the associations between age at injury (Max et al. 2011, Max et al. 2015) and injury severity (Luis and Mittenberg 2002, Max et al. 2015) and the development of novel psychiatric disorders for example. Multiple confounding factors (Rosema et al. 2014), a lack of consistency in how the severity of brain injury is defined (Max et al. 2012, McKinlay et al. 2009, Emery et al. 2016), and comorbidity between anxiety, depression, and personality change (Max et al. 2011, Max et al. 2015) pose further challenges for researchers.

The assessment of novel psychiatric disorders after paediatric ABI is complicated by poor consensus around how psychiatric difficulties after ABI are conceptualised and defined (McKinlay et al. 2009, Ornstein et al. 2013, Soo et al. 2014). It is unclear whether novel psychiatric

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disorders after ABI are equivalent in aetiology, presentation or course to disorders that occur in the absence of ABI, and this has particularly been questioned for S-ADHD (Ornstein et al. 2013) and PTSD (Hajek et al. 2010, Mather et al. 2003). The ways in which psychiatric disorders are assessed impacts on results (Ornstein et al. 2013). Despite this there is a lack of standardised assessment measures specifically designed for use in the paediatric ABI population (Soo et al. 2014), and few studies have sought to assess the validity of existing tools in this population (Golos and Bedell 2016, Wassenberg et al. 2004a). Conducting structured clinical interviews, such as the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS) (Kaufman et al. 1997), is labour and resource heavy (Wassenberg et al. 2004a), so studies have commonly used self-report and caregiver-report measures. However, parental reports have been found to be insufficiently sensitive to detect posttraumatic emotional changes (Bloom et al. 2001), there is a lack of association between child and parental reporting of psychiatric symptoms (Mather et al. 2003), and a high symptom number may not necessarily translate into a clinically significant disorder (Emery et al. 2016).

Given the well-recognised challenges of assessing for psychiatric disorders in children and adolescents after ABI, a survey of methodology and limitations to help guide further research was felt to be overdue. This paper therefore aimed to:

1) Characterise the methods used in research for determining psychiatric diagnoses in children and adolescents after ABI.
2) Identify the limitations and challenges faced when determining psychiatric diagnoses in children and adolescents after ABI.

Methods

Search strategy

A literature search was conducted using EMBASE, Medline, PsycInfo, and CINAHL, for studies published in English between 2000 and 2016 using the following title word search: ((acquired brain inj* OR acquired head inj* OR traumatic brain inj* OR traumatic head inj*) AND (child* OR adolescent OR paediatric OR pediatric) AND (psych* OR emotional disorder OR depression OR anxiety OR post-traumatic stress disorder OR PTSD OR ADHD OR OCD OR attention deficit hyperactivity disorder OR obsessive compulsive disorder OR conduct disorder OR oppositional defiant disorder OR ODD OR CD OR psychosis OR schizo*)). The search was performed on 24.08.16 and yielded 87 results. After removal of duplicates there were 61 references.

The titles and abstracts were reviewed using the following inclusion criteria: (1) all participants were aged 18 years or younger, (2) the study included a specified method for diagnosing psychiatric disorders post ABI, (3) the time post injury was specified, (4) the age of injury was specified, (5) the severity of brain injury was specified, (6) the paper was peer reviewed. The following studies were excluded: (1) mixed sample of adults and children, (2) animal studies, (3) review articles, (4) studies reporting only cognitive or psychosocial outcomes that did not meet the criteria for a psychiatric diagnosis.

Twenty-eight papers were reviewed in detail, of which 18 papers continued to meet the inclusion criteria. These studies were divided into three groups: (1) studies focussing on assessment tools for diagnosing psychiatric disorders in children after ABI, (2) studies looking at specific psychiatric disorders or psychiatric symptoms (3) studies looking at general psychiatric or psychosocial outcomes. Studies were further classified by the type of psychiatric disorder studied, but could come under more than one category: (1) mood disorders, (2) anxiety disorders, (3) S-ADHD, (4) other. The severity of brain injury, participant ages, and the time post-injury were reviewed. The level of evidence for each study was determined using the criteria suggested by the Oxford Centre for Evidence Based Medicine (Oxford Centre for Evidence Based Medicine 2011).

Review of limitations identified

The 18 papers meeting all criteria were further reviewed for any limitations identified. The limitations were then counted and classified into groups.

Results

Studies found

Of the 18 studies found, only one focussed on assessment tools for diagnosing psychiatric disorders in children after ABI (**table 1**). This study assessed the convergence between the K-SADS and the Child Behaviour Checklist (CBCL) (Achenbach 1991) for the diagnosis of psychiatric disorders in children after TBI.

Fifteen (75%) studies looked at specific psychiatric disorders or psychiatric symptoms (**table 2**).

Of these studies (**figure 2**) over half were focussed (although several studies also included an assessment of other psychiatric disorders that were not the main focus of the paper) on S-ADHD. Of the remainder, three

Figure 1. *Search strategy*

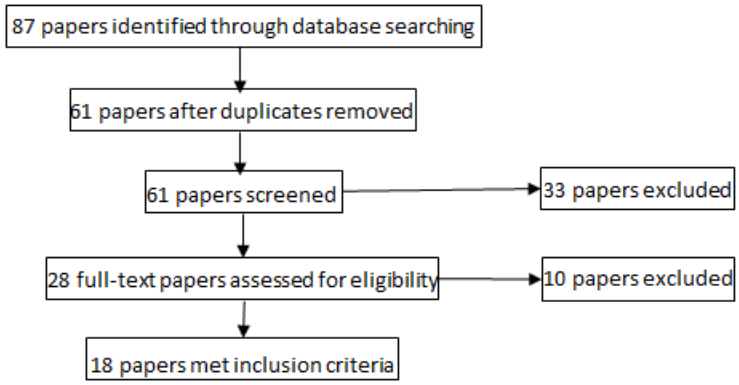
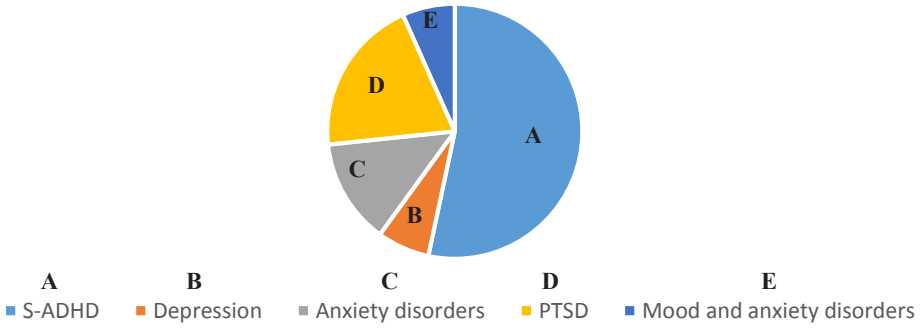


Table 1. *Studies focusing on assessment for diagnosing psychiatric disorders in children after ABI*

Author	Psychiatric disorders studied	n of brain injury sample	Age at injury (years)	Time post injury	Severity of brain injury	Assessment procedure	Classification system
Wassenberg et al. 2004	Any	24	5-14	1.95(0.93)-2.39(1.1) years (Mean (SD)	Mild or severe	- K-SADS - CBCL	DSM-III-R

Figure 2. *Focus of studies assessing or specific psychiatric disorders*



studies looked at PTSD, two at anxiety disorders, one at depression, and one at mood and anxiety disorders.

Two studies looked at general psychiatric or psychosocial outcomes (**table 3**).

Thirteen papers included participants with a range of brain injury severity from mild to severe. Three studies only included mild brain injuries and two only included severe or moderate to severe brain injuries. The follow up periods were up to six months in five studies, up to a year in three, up to three years in seven studies, and over three years in three studies. McKinlay et al. (2009) was the only study to only include children who had suffered a brain injury under the age of 5 years. All other studies included a broad range of age at injury, incorporating both children and adolescents. All papers scored either a three or four for their level of evidence, meaning that no studies reached the level of evidence of a systematic review or randomised control trial (RCT) (Oxford Centre for Evidence Based Medicine 2011).

Mood disorders

Six papers included an assessment of mood disorders (**table 4**).

All papers used standardised psychometric/psychiatric tools. Three (50%) studies used a combination of parent and child structured clinical interviews to diagnose mood disorders. Luis and Mittenberg (2002) reached a diagnosis based on a telephone structured clinical interview with the child, whilst two (33.3%) studies used a combination of parent and child questionnaires. Diagnosis was made based on the Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria (Third Edition Revised through to Fourth Edition Revised) (American Psychological Association 1987, 1994, 2000) in five of the studies. Mather et al (2003) classified depression as a score above 20 in the Child's Depression Inventory (CDI) (Kovacs and Beck 1977).

The assessment methods used are shown in **figure 3**.

The structured clinical interviews used were the K-SADS, the Neuropsychiatric Rating Schedule (NPRS) (Max et al. 1998b) and the Diagnostic Interview Schedule for Children (DISC). For child questionnaires, the CDI was used, with one study using the Beck Depression Inventory-Youth (BDI-Y) (Beck 2001) in children under 15 years. Soo et al. (2014) used standardised scores to allow for the use of different questionnaires, and Mather et al. (2003) removed one item that related to suicidality from the CDI as it was felt to be too sensitive. Studies including parental questionnaires used the CBCL.

Anxiety disorders

Ten papers included an assessment of anxiety disorders (**table 5**).

In all studies standardised psychometric/psychiatric tools were used. In five (50%) studies a diagnosis of an anxiety disorder was based upon a combination of parent and child structured clinical interviews. Eight (80%) studies included a structured clinical interview with the child. One (10%) study combined parental interview with parent and child questionnaires. Two (20%) studies reached a diagnosis based on questionnaires, and one study relied on parent-report measures.

Diagnosis was made based on DSM (DSM-III-R to DSM-IV-TR) criteria in eight of the studies. In two studies post-traumatic stress symptoms were analysed as a continuum. In Mather et al. (2003) significant anxiety was defined as a score more than 1SD above the mean of the normal population on the Revised Children's Manifest Anxiety Scale (RCMAS) (Reynolds and Richmond 1978). To allow for the use of different questionnaires Soo et al. (2014) created standardised scores to allow analysis of the study population as a whole.

The assessment methods used are shown in **figure 4**.

Four studies using structured clinical interviews used K-SADS, three used NPRS, one used DISC, and one used the Clinician-Administered PTSD Scale for Children and Adolescents (CAPS-CA) (Nader et al. 1996). Mather et al. (2003) assessed parental report of their child's PTSD symptomatology using the PTSD module of the Anxiety Disorders Interview Schedule-

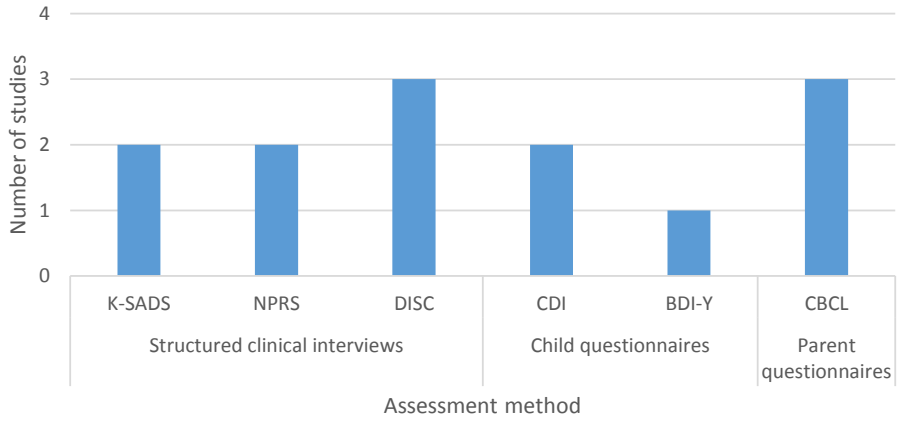
Table 2. *Studies focusing at specific psychiatric conditions or psychiatric symptoms*

Author	Psychiatric disorders studied	n of brain injury sample	Age at injury (years)	Time post injury	Severity of brain injury	Assessment procedure	Classification system
Max et al. 2015	Anxiety disorders	125	5-14	6-12 months (mo)	Mild - Severe	- KSADS - NPRS	DSM-IV-TR
Brown et al. 2014	PTSD	195	6-15	3-18mo	Mild - Severe	- CAPS-CA	DSM-V
Max et al. 2012	Depression Anxiety disorders	177	5-14	0-6mo	Mild - Severe	- KSADS - NPRS	DSM-IV-TR
Max et al. 2011	Anxiety disorders	177	5-14	0-6mo	Mild - Severe	- KSADS - NPRS	DSM-IV-TR
Hajek et al. 2010	PTSD	167	8-15	1wk-12mo	Mild	- PCL-C/PR	DSM-IV
Mather et al. 2003	PTSD Anxiety disorders Depression	43	6-16	6-13wk	Mild	- CPTS-RI - Parental report of PTSD symptoms based on the PTSD module of the Anxiety Disorders Interview Schedule–Child Version - Revised Children's Manifest Anxiety Scale - CDI - CBCL	DSM-IV
Luis and Mittenberg 2002	Mood disorders Anxiety disorders	64	6-15	0-6mo	Mild-severe	- DISC-IV via telephone	DSM-IV
Ornstein et al. 2013	S-ADHD	103	6-14	>2 years	Mild - Severe	- PICS	DSM-III-R
Sinopoli et al. 2011	S-ADHD	63	6.5(2.5)-8.9(2.6) (Mean(SD))	1-6y	Mild - Severe	- Conners 3	DSM-IV-TR
Levin et al. 2007	S-ADHD	148	5-15	0-24mo	Moderate-severe	- K-SADS	DSM-IV
Max et al. 2005	S-ADHD	143	5-14	0-6mo	Mild-severe	- K-SADS - NPRS - Survey diagnostic instrument completed by teacher	DSM-IV
Max et al. 2005	S-ADHD	143	5-14	6-24mo	Mild-severe	- K-SADS - NPRS - Survey diagnostic instrument completed by teacher	DSM-IV
Slomine et al. 2005	S-ADHD	82	6-16	0-12mo	Severe	- DICA - DICA-P	DSM-III-R
Wassenberg et al. 2004	S-ADHD	42	6-14	0-24mo	Mild - Severe	- K-SADS	DSM-III-R
Max et al. 2004	S-ADHD	81	5-14	2.07 (0.77) (Mean (SD))	Mild - Severe	- K-SADS - NPRS	DSM-III-R

Table 3. *Studies looking at general psychiatric or psychosocial outcomes*

Author	Psychiatric disorders studied	n of brain injury sample	Age at injury (years)	Time post injury	Severity of brain injury	Assessment procedure	Classification system
Soo et al. 2014	Depression Anxiety disorders	35	10.3(3.1) (Mean (SD))	26.2(6.7)mo (Mean (SD))	Mild-severe	- BDI-Y <15, CDI >15 - BAI-Y <15, MASC >15 - CBCL	DSM-IV
McKinlay et al. 2009	S-ADHD CD Anxiety disorder Mood disorder Alcohol or illicit substance abuse/dependence	66	0-5	0-16 years	Mild	- DISC – child and parent versions - Early Delinquency Scale – self and parent report - Survey on illicit substance and alcohol abuse – self and parent report - Rutgers Alcohol Problem Index - Revised Behaviour Problems checklist - DISC - parent	DSM-III-R

Figure 3. *Methods used to assess mood disorders*



Child Version (Albano and Silverman 1996). Child questionnaires used were the Beck Anxiety Inventory-Youth (BAI-Y) (Beck 2001) or the Multidimensional Anxiety Scale for Children (MASC) (March 1997) depending on the child's age, the RCMAS, and the Children's Post-Traumatic Stress Reaction Index (CPTS-RI) (Frederick et al. 1992). Parent questionnaires used were the CBCL, and the PTSD Checklist for Children/ Parent Report (PCL-C/PR) (Daviss et al. 2000).

S-ADHD

Ten of the papers included an assessment for S-ADHD (**table 6**), and in eight cases S-ADHD was the focus of the study.

Standardised psychometric/psychiatric tools were used in all 10 studies. Eight (80%) studies combined structured clinical interviews with the child and, and in two (20%) cases this was supplemented by a teacher

questionnaire. Two (20%) studies relied on parent/teacher reports only; Ornstein et al. (2013) used a structured clinical interview, and Sinopoli et al. (2011) relied on questionnaires.

The assessment methods used are shown in **figure 5**.

Of the studies using structured clinical interviews with the parent and child, six used K-SADS, three used NPRS in addition to K-SADS, one used the Diagnostic Interview for Children and Adolescents (DICA) and the Diagnostic Interview for Children and Adolescents parent version (DICA-P) (Welner et al. 1987), and one used DISC. The CBCL, survey diagnostic instrument (SDI) (Boyle et al. 1996) and Revised Behaviour Problems checklist (RBPC) (Quay and Peterson 1987) were used in addition to clinical interviews. Ornstein et al. (2013) conducted parent/teacher interviews using the Ontario Child Health Survey Scales-Revised (OCHS-R) (Boyle et al. 1996), whilst Sinopoli et al. (2011) exclusively used the Conners 3rd Edition Rating Scales (Conners 2008) to reach a diagnosis.

Final diagnosis was based on DSM (DSM-III-R to DSM-IV-TR) criteria, but in six studies there were specified adaptations made to diagnostic criteria. Four studies (Levin et al. 2007, Max et al. 2004, Sinopoli et al. 2011, Wassenberg et al. 2004a) were explicit in removing the age criteria for ADHD when diagnosing S-ADHD, but this was something all studies must have done based on the ages of the children studied and the classification systems used. To allow for their follow up period Max et al. (2005a) waivered the one year symptom duration criteria. Two studies removed the requirement for ADHD symptoms to be present in two environments (Ornstein et al. 2013, Sinopoli et al. 2011).

Other disorders

Two studies included an assessment of other psychiatric disorders not previously mentioned (McKinlay et al. 2009, Wassenberg et al. 2004a). These disorders included psychotic disorder (Wassenberg et al. 2004a), substance abuse (McKinlay et al. 2009), organic personality syndrome (Wassenberg et al. 2004a), and conduct disorder/oppositional defiant disorder (CD/

Table 4. *Studies assessing mood disorders*

Author	n of brain injury sample	Age at injury (years)	Time post injury	Severity of brain injury	Assessment procedure	Classification system	Type of assessment
Soo et al. 2014	35	10.3(3.1) (Mean (SD))	26.2(6.7)mo (Mean (SD))	Mild-severe	- BDI-Y <15, CDI >15 - CBCL	DSM-IV	- Child questionnaire - Parent questionnaire
Max et al. 2012	177	5-14	0-6mo	Mild - Severe	- KSADS - NPRS	DSM-IV-TR	- Structured clinical interview with parent - Structured clinical interview with child
McKinlay et al. 2009	66	0-5	0-16 years	Mild	- DISC – child and parent versions	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child
Wassenberg et al. 2004	24	5-14	1.95(0.93)-2.39(1.1) years (Mean (SD))	Mild or severe	- K-SADS - CBCL	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child - Parent questionnaire
Mather et al. 2003	43	6-16	6-13wk	Mild	- CDI - CBCL	- Score above 20 in the Child's Depression Inventory (CDI)	- Parent questionnaire - Child questionnaire
Luis and Mittenberg 2002	64	6-15	0-6mo	Mild-severe	- DISC-IV via telephone	DSM-IV	- Structured clinical interview with child

ODD) (McKinlay et al. 2009, Wassenberg et al. 2004a). Wassenberg et al. (2004a) used structured clinical interviews with the child and parent, supplemented by parent questionnaires, whilst McKinlay et al. (2009) used parent and child questionnaires.

Wassenberg et al. (2004a) used K-SADS, and supplemented this with the CBCL. McKinlay et al. (2009) assessed CD/ODD using the Self-Report Early Delinquency scale (Moffitt and Silva 1988) given to parent and child. Illicit substance and alcohol abuse was assessed with parent and child survey questions, and the child completing Rutgers Alcohol Problem Index (White and Labouvie 1989).

Limitations

After reviewing the data, 14 limitations falling into four groups were identified (**figure 6**).

Limitations were related to; general study design, the participant group, the assessment of psychiatric

Table 5. *Studies assessing anxiety disorders*

Author	n of brain injury sample	Age at injury (years)	Time post injury	Severity of brain injury	Assessment procedure	Classification system	Type of assessment
Max et al. 2005	125	5-14	6-12mo	Mild - Severe	- KSADS - NPRS	DSM-IV-TR	- Structured clinical interview with parent - Structured clinical interview with child
Brown et al. 2014	195	6-15	3-18mo	Mild - Severe	- CAPS-CA	PTSD symptoms measured as a continuum	- Structured clinical interview with child
Soo et al. 2014	35	10.3(3.1) (Mean (SD))	26.2(6.7)mo (Mean (SD))	Mild-severe	- BAI-Y <15, MASC >15 - CBCL	DSM-IV	- Child questionnaire - Parent questionnaire
Max et al. 2012	177	5-14	0-6mo	Mild - Severe	- KSADS - NPRS	DSM-IV-TR	- Structured clinical interview with parent - Structured clinical interview with child
Max et al. 2011	177	5-14	0-6mo	Mild - Severe	- KSADS - NPRS	DSM-IV-TR	- Structured clinical interview with parent - Structured clinical interview with child
Hajek et al. 2010	167	8-15	1wk-12mo	Mild	- PCL-C/PR	DSM-IV	- Parent questionnaire
McKinlay et al .2009	66	0-5	0-16 years	Mild	- DISC – child and parent versions	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child
Wassenberg et al. 2004	24	5-14	1.95(0.93)-2.39(1.1) years	Mild or severe	- K-SADS - CBCL	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child - Parent questionnaire

Table 5. *Continued*

Mather et al. 2003	43	6-16	6-13wk	Mild	- CPTS-RI - Parental report of PTSD symptoms based on the PTSD module of the Anxiety Disorders Interview Schedule–Child Version - Revised Children's Manifest Anxiety Scale - CBCL	- PTSD symptoms measured as a continuum. -Significant anxiety indicated by a score 1 S.D. above the mean in the Revised Children's Manifest Anxiety Scale	- Structured clinical interview with parent - Parent questionnaire - Child questionnaire
Luis and Mittenberg 2002	64	6-15	0-6mo	Mild-severe	- DISC-IV via telephone	DSM-IV	- Structured clinical interview with child

disorders, and the interpretation of results. Limitations were identified relating to study design in 61% of papers, participant group in 67% of papers, the assessment of psychiatric disorders in 78%, and the interpretation of results in 67% of papers (**table 7**).

The most commonly identified limitations were the presence of confounding factors (50% of papers), small sample sizes (50% of papers), the subjectivity of assessment measures (39% of papers), issues around defining psychiatric disorders after paediatric ABI (39% papers), diversity within the participant group (39% of papers), and retrospective bias in making pre-injury assessments (28% of papers).

Discussion

This survey examined the procedures for diagnosing novel psychiatric disorders after paediatric ABI in 18 papers. 33% of papers included an assessment for mood disorders, 56% assessed for anxiety disorders, 56% for S-ADHD, and 11% also included other psychiatric disorders. Consequently, the assessment and diagnostic procedures of some of the most common novel psychiatric disorders after paediatric ABI (Max et al. 1998a, Max et al. 1998c) was examined. As most papers assessed children across a range of injury severity, and at a variety of times post injury, the findings of can be seen as indicative of the methods used for diagnosing novel psychiatric disorders across the paediatric ABI population.

All studies used standardised assessment measures for determining psychiatric diagnoses. Despite being labour intensive (Wassenberg et al. 2004a), structured clinical interviews with parent and child were used in most studies. Structured clinical interviews have been demonstrated to have a high sensitivity for detecting novel psychiatric disorders after paediatric ABI (Max et al. 1997, Wassenberg et al. 2004a), and should be considered the single best current assessment measure for research. K-SADS was most commonly used. K-SADS is a well-known and well validated (Kaufman et al. 1997, Wassenberg et al. 2004a) assessment measure, and its current use within the paediatric ABI population makes it an attractive tool for researchers.

Figure 4. *Methods used to assess anxiety disorders*

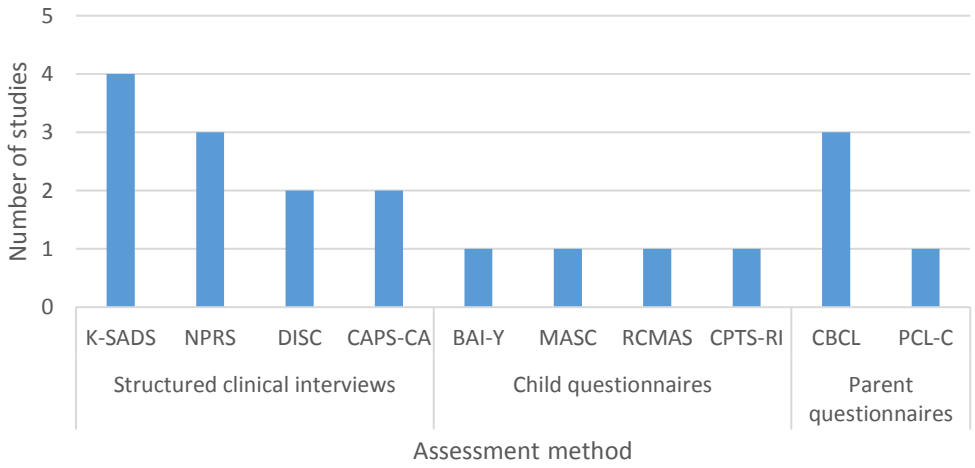


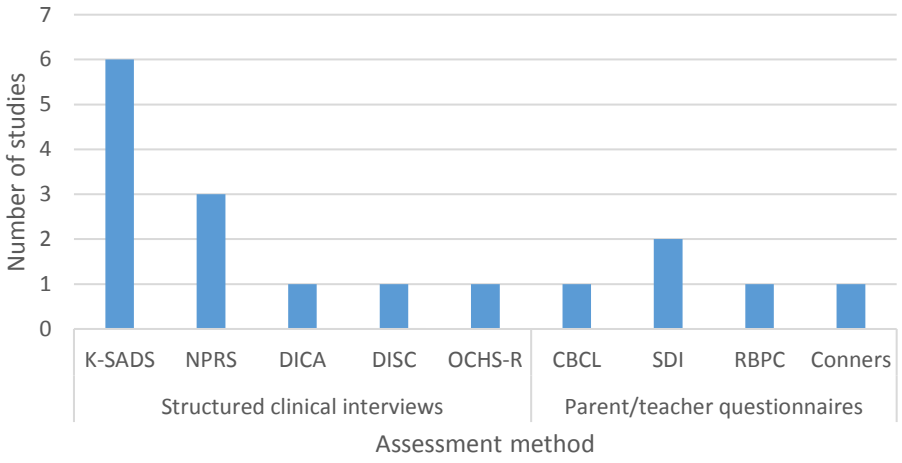
Table 6. *Studies assessing A-ADHD*

Author	n of brain injury sample	Age at injury (years)	Time post injury	Severity of brain injury	Assessment procedure	Classification system	Type of assessment
McKinlay et al. 2009	66	0-5	0-16 years	Mild	- DISC – child and parent versions - Revised Behaviour Problems checklist	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child
Wassenberg et al. 2004a	24	5-14	1.95(0.93)-2.39(1.1) years	Mild or severe	- K-SADS - CBCL	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child - Parent questionnaire
Ornstein et al. 2013	103	6-14	>2 years	Mild – Severe	OCHS-R completed by parent and teacher	DSM-III-R	- Structured clinical interview with parent/teacher
Sinopoli et al. 2011	63	6.5(2.5)-8.9(2.6) (Mean(SD))	1-6y	Mild - Severe	Conners 3	DSM-IV-TR	- Parent /teacher questionnaire
Levin et al. 2007	148	5-15	0-24mo	Moderate-severe	K-SADS	DSM-IV	- Structured clinical interview with parent - Structured clinical interview with child
Max et al. 2005a	143	5-14	0-6mo	Mild-severe	K-SADS NPRS Survey diagnostic instrument completed by teacher	DSM-IV	- Structured clinical interview with parent - Structured clinical interview with child - Teacher questionnaire
Max et al. 2005b	143	5-14	6-24mo	Mild-severe	K-SADS NPRS Survey diagnostic instrument completed by teacher	DSM-IV	- Structured clinical interview with parent - Structured clinical interview with child - Teacher questionnaire

Table 6. *Continued*

Slomine et al. 2005	82	6-16	0-12mo	Severe	DICA DICA-P	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child
Wassenberg et al. 2004b	42	6-14	0-24mo	Mild - Severe	K-SADS	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child
Max et al. 2004	81	5-14	2.07 (0.77) (Mean (SD))	Mild - Severe	K-SADS NPRS	DSM-III-R	- Structured clinical interview with parent - Structured clinical interview with child

Figure 5. *Methods used to assess S-ADHD*



However, the prevalent use of the K-SADS could reflect publication bias, and current assessment measures have not been developed specifically for use in the paediatric ABI population, so their validity requires further review. Twenty-eight percent of studies recognised inter-rater reliability as a potential limitation when using structured clinical interviews. Conducting multiple interviews to directly test inter-rater reliability may not be realistic or feasible. In all studies where this limitation was recognised interviewers received close supervision, and this may be the most practical approach. Whilst it is necessary to use standardised assessment measures in research, it is important to remember that these assessment measures will be less sensitive and specific than ongoing clinical assessment. Using additional parental report measures to gain collateral history was an approach used in over half the studies, and may be an effective method to improve reliability.

Only four studies relied entirely on questionnaires. This method of diagnoses has been shown to be lacking in sensitivity (Bloom et al. 2001, Wassenberg et al. 2004a) and clinical reliability (Emery et al. 2016), so should not be recommended. The subjectivity of parental and self-report measures was identified as a common limitation in 39% of papers. Several studies supplemented the use of structured clinical interviews with questionnaires. This would appear to be the most comprehensive assessment method. However, there is a lack of questionnaires specifically developed for the paediatric ABI population (Soo et al. 2014). Soo et al. (2014) and McKinlay et al. (2009) both commented that the scales used had demonstrated suitability in the population, although this is based more on historical

Figure 6. *Limitations identified*

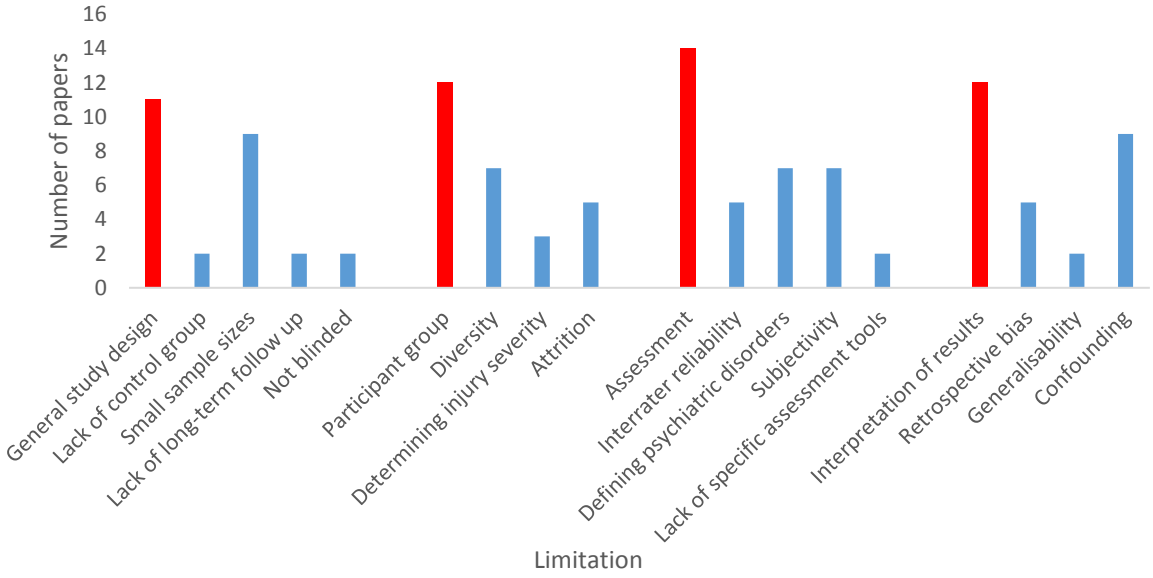


Table 7. *Limitations identified*

General study design		
Limitation	Studies	% of studies
Small sample size	Luis and Mittenberg 2002, Mather et al. 2003, Max et al. 2004, Max et al. 2012, McKinlay et al. 2009, Ornstein et al. 2013, Sinopoli et al. 2011, Wassenberg et al. 2004a, Wassenberg et al. 2004b	50
Lack of a control group	Max et al. 2012, Levin et al. 2007	11
Lack of long-term follow up	Slomine et al. 2005, Mather et al. 2003	11
Researchers not blinded	Wassenberg et al. 2004b, Luiset al. 2002	11
Participant group		
Limitation	Studies	% of studies
Diverse group	Hajek et al. 2010, Max et al. 2004, Max et al. 2011, Max et al. 2012, Sinopoli et al. 2011, Soo et al. 2014, Wassenberg et al. 2004a	39
Attrition rates	Max et al. 2015, Max et al. 2012, Max et al. 2011, Max et al. 2005a, Max et al. 2005b	28
Lack of clear definition for injury severity	Max et al. 2012, McKinlay et al. 2009, Slomine et al. 2005	17
Assessment of psychiatric disorders		
Limitation	Studies	% of studies
Lack of clear framework and criteria for defining psychiatric outcomes	Hajek et al. 2010, Mather et al. 2003, Max et al. 2004, Max et al. 2005b, Ornstein et al. 2013, Soo et al. 2014, Wassenberg et al. 2004b	39
Subjectivity of assessment tools	Hajek et al. 2010, Luis and Mittenberg 2002, Mather et al. 2003, Max et al. 2005b, Sinopoli et al. 2011, Soo et al. 2014, Wassenberg et al. 2004a	39
Interrater reliability	Max et al. 2015, Max et al. 2011, Levin et al. 2007, Max et al. 2005a, Max et al. 2005b	28
Lack of specific assessment tools	Soo et al. 2014, Wassenberg et al. 2004a	11
Interpretation of results		
Limitation	Studies	% of studies
Confounding factors	Brown et al. 2014, Luis and Mittenberg 2002, Mather et al. 2003, Max et al. 2004, Max et al. 2011, Max et al. 2015, McKinlay et al. 2009, Ornstein et al. 2013, Slomine et al. 2005	50
Retrospective bias in identifying pre-injury psychiatric diagnoses	Levin et al. 2007, Luis and Mittenberg 2002, Max et al. 2004, Max et al. 2005b, Wassenberg et al. 2004b	28
Generalisability	Brown et al. 2014, Slomine et al. 2005	11

use than tested validity. The only paper focussed on assessment tools (Wassenberg et al. 2004a) analysed the convergence between the CBCL and the K-SADS in the paediatric ABI population, and demonstrated that the CBCL underestimated psychiatric problems in this group.

Regardless of the assessment methods used the nature of the paediatric ABI population poses several challenges for both research in general, and the assessment of psychiatric disorders. Thirty-nine percent of studies recognised the heterogeneity of the population as a limitation. Age poses a particular issue as children are undergoing continuous neurodevelopment; it cannot be appropriate to use the same assessment measures across age ranges. Only one study (Soo et al. 2014) used different assessment measures based on the age of the child, so further research is needed around the validity and comparability of assessment measures across the age ranges in children with ABI. Issues around defining injury severity was a recognised limitation in 17% of studies. Injury severity has been shown to be an important factor in the development of novel psychiatric disorders (Luis and Mittenberg 2002, Wassenberg et al. 2004b), and ongoing research and guidance is needed to determine the most accurate way of defining it. However, designing studies with more narrowly defined populations may only be possible for large multi-centre studies; small sample size was a recognised limitation in 50% of studies. The presence of confounding factors affects the conclusions that can be drawn about the relationship between novel psychiatric disorders and ABI (Rosema et al. 2014), and 50% of studies recognised this as a limitation. It may not be possible to control for these factors, but further research into confounding factors may aid our interpretation of results.

As more is learnt about the differences between psychiatric disorders in the paediatric ABI and non-ABI populations, ongoing scrutiny of the diagnostic criteria used to diagnose novel psychiatric disorders after paediatric ABI is required. Thirty-nine percent of papers identified a lack of clarity around how novel psychiatric disorders after paediatric ABI should be defined and understood as a limitation. This is reflected in the fact that six of the studies assessing S-ADHD made modifications to DSM criteria. Despite DSM-V (American Psychiatric Association 2013) relaxing the requirement for symptoms to be present before the age of 7 to the age of 12, studies assessing S-ADHD will still need to remove this age criteria, as by definition S-ADHD can only occur after the age of injury. To ensure consistency in the way that novel psychiatric disorders are diagnosed and studied, further research is needed into the nature of these disorders. The validity of current DSM and ICD diagnoses is questionable, for example fatigue and impaired concentration are common post-brain injury symptoms and would not necessarily point to a diagnosis of depression in this population. Ensuring that psychiatric disorders are novel is a further challenge; 28% of studies acknowledged limitations around retrospective bias in assessing for pre-injury psychiatric disorders. Care must also be taken when making assumptions around causality, as a proportion of subjects may have developed a psychiatric disorder in the absence of an ABI.

Whilst there is diagnostic uncertainty around novel psychiatric disorders after paediatric ABI, the construct validity of current assessment measures is questionable. The high rates of psychiatric research diagnoses may not translate into clinically significant cases (Emery et al. 2016), and this requires further study. To ensure validity there is a need to develop, or at least identify, specific tools for assessing novel psychiatric disorders after paediatric ABI (Soo et al. 2014). Based on Wassenberg et al's (2004a) findings that convergence between a K-SADS diagnosis and the different CBCL scales is variable, conducting a Rasch analysis of the CBCL may improve its utility as a screening tool for novel psychiatric disorders after ABI. Rasch analysis has been demonstrated to be an effective method of developing tools for use in the adult ABI population (Simblett and Bateman 2011, Simblett et al. 2012, Simblett et al. 2015), and may also provide a means for identifying factors that discriminate between general post-ABI symptoms, and those indicative of a novel psychiatric disorder.

Limitations

This survey is limited by the fact that only studies written in English were included. Only studies since the year 2000 were included, but this ensures that the review is an accurate reflection of current practice. In keeping with other reviews around the subject (Lax Pericall and Taylor 2014) the papers identified received an evidence level of either three or four (Oxford Centre for Evidence Based Medicine 2011), meaning no studies reached the level of evidence of a systematic review or RCT.

Conclusions

Studying novel psychiatric disorders after paediatric ABI is a highly important but challenging area. Researchers in this area should be mindful of the multiple limitations faced, and address or acknowledge these where possible. Current studies use standardised assessment measures to assess for psychiatric diagnoses, with most studies using the current best available method of structured clinical interviews (most commonly K-SADS). Supplementing interviews with parental report measures may improve the accuracy of assessment, but in clinical practice there is no substitute for ongoing clinical assessment.

Diagnostic uncertainty around what constitutes a novel psychiatric disorder after paediatric ABI is a significant problem for research. More work is needed to develop our understanding of the nature of novel psychiatric disorders and to assess the validity of current diagnostic criteria. Whilst there is a lack of clarity on this issue the construct validity of current assessment measures remains questionable. The development of specific tools for the assessment of novel psychiatric disorders in the paediatric ABI population is an important area for further research.

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References

Achenbach TM (1991). *Manual for the Child Behavior Checklist/4-18 and 1991 profile*. Department of Psychiatry, University of Vermont, Burlington.

Albano AM, Silverman WK (1996). *Anxiety Disorders Interview Schedule for DSM-IV: Child Version. Clinician Manual*. The Psychological Corporation, San Antonio.

American Psychiatric Association (1987). *Diagnostic and statistical manual of mental disorders (DSM-III-R), Third Edition Revised*. American Psychiatric Press, Washington DC.

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders (DSM-IV), Fourth Edition*. American Psychiatric Press Washington DC.

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders (DSM-IV-TR), Fourth Edition Revised*. American Psychiatric Press, Washington DC.

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders (DSM-V), Fifth Edition*. American Psychiatric Press, Washington DC.

Beck JS (2001). *Beck Youth Inventories*. Psychological Corporation, San Antonio.

Bloom DR, Levin HS, Ewing-Cobbs L, Saunders AE, Song J, Fletcher JM, Kowatch RA (2001). Lifetime and novel psychiatric disorders after pediatric traumatic brain injury. *Journal of the American Academy of Child and Adolescent Psychiatry* 40, 5, 572-579.

Boyle MH, Offord DR, Racine Y, Szatmari P, Fleming JE, Sanford M (1996). Identifying thresholds for classifying childhood psychiatric disorder: issues and prospects. *Journal of the American Academy of Child and Adolescent Psychiatry* 35, 11, 1440-1448.

Brown EA, Kenardy JA, Dow BL (2014). PTSD perpetuates pain in children with traumatic brain injury. *Journal of Pediatric Psychology* 39, 5, 512-520.

Conners CK (2008). *Conners 3rd Edition*. Multi-health Systems, Toronto.

Costello A, Edelbrock C, Kalas R, Kessler M, Klaric SA (1982). *Diagnostic interview schedule for children (DISC)*. National Institute of Mental Health, Bethesda.

Daviss WB, Mooney D, Racusin R, Ford JD, Fleischer A, McHugo, GJ (2000). Predicting posttraumatic stress after hospitalization for pediatric injury. *Journal of the American Academy of Child and Adolescent Psychiatry* 39, 5, 576-583.

Emery CA, Barlow KM, Brooks BL, Max JE, Villavicencio-Requis A, Gnanakumar V, Robertson HL, Schneider K, Yeates KO (2016). A systematic review of psychiatric, psychological, and behavioural outcomes following mild traumatic brain injury in children and adolescents. *The Canadian Journal of Psychiatry* 61, 5, 259-269.

Faul M, Xu L, Wald MM, Coronado V, Dellinger AM (2010). Traumatic brain injury in the United States: national estimates of prevalence and incidence, 2002-2006. *Injury Prevention* 16, Suppl 1, A268-A268.

Frederick C, Pynoos R, Nader KO (1992). *Childhood PTS Reaction Index (CPTS-RI)*. Unpublished instrument (available from C. Frederick and R. Pynoos, 760 Westwood Plaza, Los Angeles, CA 90024, USA, or K. Nader, P.O. Box 2251, Laguna Hills, CA 92654, USA).

Golos A, Bedell G (2016). Psychometric properties of the Child and Adolescent Scale of Participation (CASP) across a 3-year period for children and youth with traumatic brain injury. *NeuroRehabilitation* 38, 4, 311-319.

Hajek CA, Yeates KO, Gerry Taylor H, Bangert B, Dietrich A, Nuss KE, Rusin J, Wright M (2010). Relationships among post-concussive symptoms and symptoms of PTSD in children following mild traumatic brain injury. *Brain Injury* 24, 2, 100-109.

Kaufman J, Birmaher B, Brent D, Rao UMA, Flynn C, Moreci P, Williamson D, Ryan N (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry* 36, 7, 980-988.

Kovacs M, Beck AT (1977). An empirical-clinical approach toward a definition of childhood depression. In Schulterbrandt JG, Raskin A (Eds.), *Depression in childhood: Diagnosis, treatment, and conceptual models* (pp. 1-25). Raven Press, New York.

Lax Pericall MT, Taylor E (2014). Family function and its relationship to injury severity and psychiatric outcome in children with acquired brain injury: a systematized review. *Developmental Medicine & Child Neurology* 56, 1, 19-30.

Levin H, Hanten G, Max J, Li X, Swank P, Ewing-Cobbs L, Dennis M, Menefee DS, Schachar R (2007). Symptoms of attention-deficit/hyperactivity disorder following traumatic brain injury in children. *Journal of Developmental & Behavioral Pediatrics*, 28, 2, 108-118.

Luis CA, Mittenberg W (2002). Mood and anxiety disorders following pediatric traumatic brain injury: a prospective study. *Journal of Clinical and Experimental Neuropsychology* 24, 3, 270-279.

March JS (1997). *Multidimensional Anxiety Scale for Children*. Multi-Health Systems Inc, North Tonawanda.

Mather FJ, Tate RL, Hannan TJ (2003). Post-traumatic stress disorder in children following road traffic accidents: A comparison of those with and without mild traumatic brain injury. *Brain Injury* 17, 12, 1077-1087.

Max JE, Castillo CS, Lindgren SD, Arndt S (1998b). The neuropsychiatric rating schedule: Reliability and validity. *Journal of the American Academy of Child and Adolescent Psychiatry* 37, 3, 297-304.

Max JE, Keatley E, Wilde EA, Bigler ED, Levin HS, Schachar RJ, Saunders AE, Ewing-Cobbs L, Chapman SB, Dennis M, Yang TT (2011). Anxiety disorders in children and adolescents in the first six months after traumatic brain injury. *The Journal of Neuropsychiatry and Clinical Neurosciences* 23, 1, 29-39.

Max JE, Keatley E, Wilde EA, Bigler ED, Schachar RJ, Saunders AE, Ewing-Cobbs L, Chapman SB, Dennis M, Yang TT, Levin HS (2012). Depression in children and adolescents in the first 6 months after traumatic brain injury. *International Journal of Developmental Neuroscience* 30, 3, 239-245.

Max JE, Koele SL, Smith WL, Sato Y, Lindgren SD, Robin DA, Arndt S (1998c). Psychiatric disorders in children and adolescents after severe traumatic brain injury: a controlled study. *Journal of the American Academy of Child and Adolescent Psychiatry* 37, 8, 832-840.

Max JE, Lansing AE, Koele SL, Castillo CS, Bokura H, Schachar R, Collings N, Williams KE (2004). Attention deficit hyperactivity disorder in children and adolescents following traumatic brain injury. *Developmental Neuropsychology* 25, 1-2, 159-177.

Max JE, Lopez A, Wilde EA, Bigler ED, Schachar RJ, Saunders A, Ewing-Cobbs L, Chapman SB, Yang TT, Levin HS (2015). Anxiety disorders in children and adolescents in the second six months after traumatic brain injury. *Journal of Pediatric Rehabilitation Medicine* 8, 4, 345-355.

Max JE, Robin DA, Lindgren SD, Smith Jr WL, Sato Y, Mattheis PJ, Stierwalt JAG, Castillo CS (1997). Traumatic brain injury in children and adolescents: psychiatric disorders at two years. *Journal of the American Academy of Child and Adolescent Psychiatry* 36, 9, 1278-1285.

Max JE, Robin DA, Lindgren SD, Smith Jr WL, Sato Y, Mattheis PJ, Stierwalt JAG, Castillo CS (1998a). Traumatic brain injury in children and adolescents: psychiatric disorders at one year. *The Journal of Neuropsychiatry and Clinical Neurosciences* 10, 3, 290-297.

Max JE, Schachar RJ, Levin HS, Ewing-Cobbs L, Chapman SB, Dennis M, Saunders A, Landis J (2005a). Predictors of attention-deficit/hyperactivity disorder within 6 months after pediatric traumatic brain injury. *Journal of the American Academy of Child and Adolescent Psychiatry* 44, 10, 1032-1040.

Max JE, Schachar RJ, Levin HS, Ewing-Cobbs L, Chapman SB, Dennis M, Saunders A, Landis J (2005b). Predictors

of secondary attention-deficit/hyperactivity disorder in children and adolescents 6 to 24 months after traumatic brain injury. *Journal of the American Academy of Child and Adolescent Psychiatry* 44, 10, 1041-1049.

McKinlay A, Grace R, Horwood J, Fergusson D, MacFarlane M (2009). Adolescent psychiatric symptoms following preschool childhood mild traumatic brain injury: evidence from a birth cohort. *The Journal of Head Trauma Rehabilitation* 24, 3, 221-227.

Sariaslan A, Sharp DJ, D'Onofrio BM, Larsson H, Fazel S (2016). Long-term outcomes associated with traumatic brain injury in childhood and adolescence: A nationwide Swedish cohort study of a wide range of medical and social outcomes. *PLoS Med* 13, 8, e1002103.

Moffitt TE, Silva PA (1988). Self-reported delinquency: Results from an instrument for New Zealand. *Australian and New Zealand Journal of Criminology* 21, 4, 227-240.

Nader K, Kriegler JA, Blake DD, Pynoos RS, Newman E, Weather FW (1996). *Clinician administered PTSD scale, child and adolescent version.* National Center for PTSD, White River Junction.

Ornstein TJ, Max JE, Schachar R, Dennis M, Barnes M, Ewing-Cobbs L, Levin HS (2013). Response inhibition in children with and without ADHD after traumatic brain injury. *Journal of Neuropsychology* 7, 1, 1-11.

Oxford Centre for Evidence Based Medicine levels of Evidence Working Group (Online) (2011). The 2011 Levels of Evidence. http://www.cebm.net/index.aspx?o=5653 (accessed 25 August 2016).

Quay HC, Peterson DR (1987). *Manual for the revised problem behavior checklist.* University of Miami, Coral Gables.

Reynolds CR, Richmond BO (1978). What I think and feel: A revised measure of children's manifest anxiety. *Journal of Abnormal Child Psychology* 6, 2, 271-280.

Rockhill CM, Fann JR, Fan MY, Hollingworth W, Katon WJ (2010). Healthcare costs associated with mild traumatic brain injury and psychological distress in children and adolescents. *Brain Injury* 24, 9, 1051-1060.

Rosema S, Muscara F, Anderson V, Godfrey C, Eren S, Catroppa C (2014). Agreement on and predictors of long-term psychosocial development 16 years post-childhood traumatic brain injury. *Journal of Neurotrauma* 31, 10, 899-905.

Schwartz L, Taylor HG, Drotar D, Yeates KO, Wade SL, Stancin T (2003). Long-term behavior problems following pediatric traumatic brain injury: Prevalence, predictors, and correlates. *Journal of Pediatric Psychology* 28, 4, 251-263.

Simblett SK, Badham R, Greening K, Adlam A, Ring H, Bateman A (2012). Validating independent ratings of executive functioning following acquired brain injury using Rasch analysis. *Neuropsychological Rehabilitation* 22, 6, 874-889.

Simblett SK, Bateman A (2011). Dimensions of the Dysexecutive Questionnaire (DEX) examined using Rasch analysis. *Neuropsychological Rehabilitation* 21, 1, 1-25.

Simblett SK, Gracey F, Ring H, Bateman A (2015). Measuring coping style following acquired brain injury: A modification of the Coping Inventory for Stressful Situations Using Rasch analysis. *British Journal of Clinical Psychology* 54, 3, 249-265.

Sinopoli KJ, Schachar R, Dennis M (2011). Traumatic brain injury and secondary attention-deficit/hyperactivity disorder in children and adolescents: the effect of reward on inhibitory control. *Journal of Clinical and Experimental Neuropsychology* 33, 7, 805-819.

Slomine BS, Salorio CF, Grados MA, Vasa RA, Christensen JR, Gerring JP (2005). Differences in attention, executive functioning, and memory in children with and without ADHD after severe traumatic brain injury. *Journal of the International Neuropsychological Society* 11, 5, 645-653.

Soo C, Tate R, Brookes N (2014). Psychosocial adjustment following acquired brain injury in childhood and adolescence: Executive, behavioural and emotional contributions. *Brain Injury* 28, 7, 906-914.

Wassenberg R, Max JE, Koele SL, Firme K (2004a). Classifying psychiatric disorders after traumatic brain injury and orthopaedic injury in children: adequacy of K-SADS versus CBCL. *Brain Injury* 18, 4, 377-390.

Wassenberg R, Max JE, Lindgren SD, Schatz A (2004b). Sustained attention in children and adolescents after traumatic brain injury: Relation to severity of injury, adaptive functioning, ADHD and social background. *Brain Injury* 18, 8, 751-764.

Welner Z, Reich W. Herjanic B, Jung KG, Amado H (1987). Reliability, validity, and parent-child agreement studies of the Diagnostic Interview for Children and Adolescents (DICA). *Journal of the American Academy of Child and Adolescent Psychiatry* 26, 5, 649-653.

White HR, Labouvie EW (1989). Towards the assessment of adolescent problem drinking. *Journal of studies on alcohol* 50, 1, 30-37.

World Health Organization (2006). *Neurological disorders: public health challenges.* World Health Organization Press, Geneva.