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A Multiple Indicators Multiple Causes (Mimic) Model of Inattentive and Hyperactive Symptoms in a Representative Sample of British Children and Young People

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Abstract

Background: ADHD, when assessed using DSM IV criteria, is the most prevalent behavioral disorder (5%) in the United Kingdom (UK). Evidence is emerging that a percentage of children presenting with complex trauma-related symptoms may be misdiagnosed as having ADHD. However, the estimated prevalence is considerably lower (1.5%) when ICD-10 criteria are used to assess HKD. It is currently not known whether risk for misdiagnosis is an issue when the narrower ICD-10 criteria are used. This study aimed to systematically investigate these issues in order to investigate if: (1) significant associations between maltreatment exposures and ADHD symptom severity and HKD diagnosis were evident; (2) the percentage of trauma exposed HKD diagnosed cases whose parents reported an etiological link between trauma exposures and (a) symptom onset and (b) persistence of symptoms; (3) the percentage of trauma exposed HKD cases who were being treated with Methylphenidate or Dexamphetamine.

Methods: Data from the B-CAMHS epidemiological survey were analyzed (N=7997; male n=4111; female n=3886). A Multiple Indicators Multiple Causes (MIMIC) approach was utilized. The effects of physical abuse (PA), sexual abuse (SA) and domestic violence (DV) on the structure of a four-factor model consisting of teacher and parent "hyperactivity" and "inattentiveness" were investigated. Binary logistic regression analyses were estimated to examine links between maltreatment and HKD diagnoses. Population attributable fractions (PAFs) were calculated to estimate the percentage of cases where exposures to maltreatment were directly implicated.

Results: Significant associations between maltreatment exposures and the ADHD factors indicated that exposures significantly affected the manifestation of ADHD symptoms. Significant associations between HKD diagnoses and exposures to PA (OR=3.84, 95% CI=1.72-8.59**)** and DV (OR=3.46, 95% CI=1.98-6.05) were found. A total of 109 cases of HKD were diagnosed by the clinicians, of these a total of 26 cases (30%) were trauma exposed. Of these 26 cases, 45% of parents reported an etiological link between trauma exposure and current symptoms. Overall, 37.5% of physically abused and 15.8% of DV exposed HKD cases were taking stimulant based medication to treat their HKD symptoms.

Conclusions: The increased likelihood of a diagnosis of ADHD/HKD among maltreated children may reflect the emotional and behavioral sequel of maltreatment. Children presenting with ADHD/HKD symptomatology should be screened for maltreatment exposures before diagnosis is concerned.

Keywords: Trauma; Domestic violence; Child abuse; Medicalization; Epidemiology

Introduction

Attention-deficit/hyperactivity disorder (ADHD), as diagnosed using the American Psychiatric Association's (APA) diagnostic and statistical manual (DSM) criteria, is the most prevalent behavioral disorder among children and young people in the UK. The estimated UK prevalence is 5% according to DSM-IV criteria (NICE, 2006). The International Classification of Mental and Behavioral Disorders 10th revision (ICD-10) medical classification system developed by the World Health Organization (WHO) refers to ADHD as hyperkinetic disorder (HKD). The HKD diagnostic criteria, as outlined in the ICD-10, are narrower than the diagnostic criteria outlined for ADHD in both the DSM-IV and the recently published DSM-5. Accordingly, the prevalence of HKD in the UK is 1.5% when assessed using ICD-10 criteria [1]. A summary of the similarities and differences between these two diagnostic systems is illustrated in Table 1.

A recent UK study revealed a trend of increasing prescribing of ADHD drug treatment over the period 2003 to 2008 [2]. Furthermore, there is now an emerging concern that a percentage of children presenting with complex trauma-related symptoms may be misdiagnosed as having ADHD [3, 4]. Hadianfard reported that neglect, psychological and physical abuses are significantly higher in children affected by ADHD symptoms [5]. Additionally findings from the US established that childhood ADHD symptoms, particularly inattentiveness, predicted maltreatment [6]. Furthermore Lara et al. confirmed an association between ADHD symptoms in childhood and exposures to childhood adversities using data from 10 countries [7]. These studies tend to suggest that ADHD symptoms predict trauma exposures but findings that ADHD symptoms increase the risk

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of a child being abused are not consistently supported within the literature [8].

Other researchers argue however, that PTSD in children is often misdiagnosed as ADHD because ADHD symptoms are more external and easier to detect [3, 4]. Evidence from the field of developmental psychopathology has confirmed that the sequelae of child maltreatment significantly mirror the symptoms of ADHD/HKD [9, 10]. Recent UK research revealed that almost 6% and 12% of children under 11 years; 18.6% and 17.5% aged 11 to 17 years and 25.3% and 23.7% aged 18 to 24 years reported exposures to severe maltreatment and domestic violence (DV) respectively [11]. It is therefore possible that the increased likelihood of a diagnosis of ADHD among maltreated children may reflect the behavioural sequelae of maltreatment [12]. It is currently not clear whether similar risk for misdiagnosis exists when the narrower ICD-10 criteria are used.

As can be viewed in Table 1, ADHD/HKD is denoted by two behavioural symptom domains: inattention and hyperactivity-impulsivity. DSM criteria for ADHD specify two dimensions of inattention and hyperactivity symptoms that are used to describe three nominal subtypes: predominantly hyperactive-impulsive type, predominantly inattentive type, and combined type. These subtypes do not exist within the ICD classification system where 6 inattentive and 4 hyperactive-impulsive symptoms must be present and directly observed by the clinician. This syndrome therefore, at least according to DSM criteria, encompasses a heterogeneous group of youth [13] and may reflect diverse inputs to the symptom domains [14]. Confirmatory factor analyses offer support for a two-factor structure of ADHD [15, 16], encompassing inattention and hyperactivity dimensions. Furthermore, although there is evidence for distinct behavioural sub-phenotypes in ADHD, the effects of specific maltreatment exposures on their expression have been little investigated. Endo et al. (2006) found that maltreatment exposures are etiologically related to ADHD using a sample of psychiatric inpatients. Specifically it was found that only a small proportion of the children diagnosed with ADHD showed ADHD-type symptoms before their documented abuse, suggesting abuse may be aetiologically related to ADHD.

Currently little is known about the role of maltreatment exposures on the heterogeneity of ADHD symptoms but evidence supports a symptom overlap between PTSD and ADHD symptoms in children. Overlaps between dissociation and inattentive symptoms [17] and hyperarousal and hyperactivity symptoms [3] have been identified. Specifically, Endo et al. [18] reported 71% comorbidity between dissociative disorder and ADHD in their psychiatric inpatient sample. Weinstein et al. [4] reported that the high rate of symptom overlap between ADHD and PTSD and the high risk for these disorders to manifest in sexually abused children pose the risk for mis-medication and other inappropriate treatment interventions. They highlighted that this was an area that requires crucial attention and argued for the inclusion of trauma history in ADHD assessment.

Thus, the aims of our study were to: (1) investigate the associations between maltreatment exposures and both ADHD symptoms and factors, as measured using the Strengths and Difficulties Questionnaire [19] indicators, using a large representative population based UK sample of children and young people; (2) to investigate what percentage of trauma exposed HKD diagnosed (using ICD-10 diagnostic criteria) children were reported by their parents or caregiver to have (a) displayed dramatic behavior changes following their trauma exposure and (b) to still be impacted upon by this trauma exposure; (3) to delineate the PTSD symptom profiles of HKD trauma exposed children and compare these to PTSD diagnosed children and young people; (4) to estimate the percentage of cases involving possible HKD misdiagnosis in a representative British sample and (5) to investigate the rates of trauma

Indicators of ADHD & HKD (similar across DSM-IV & DSM-5 and ICD-10)	
9 Inattentive Symptoms	9 Hyperactive-Impulsive Symptoms
Often fails to give close attention to details or makes careless mistakes in schoolwork, work, or during other activities	Often fidgets with or taps hands or squirms in seat
Often has difficulty sustaining attention in tasks or play activities	Often leaves seat in situations when remaining seated is expected
Often does not seem to listen when spoken to directly	Often runs about or climbs in situations where it is inappropriate
Often does not follow through on instructions and fails to finish school work, chores, or duties	Often unable to play or engage in leisure activities quietly
Often has difficulty organizing tasks and activities	Is often "on the go" acting as if "driven by a motor"
Often avoids or is reluctant to engage in tasks that require sustained mental effort	Often talks excessively
Often loses things necessary for tasks or activities	Often blurts out answers before questions have been completed
Is often easily distracted by extraneous stimuli	Often has difficulty awaiting turn
Is often forgetful in daily activities	Often interrupts or intrudes on others
CLASSIFICATION SYSTEMS	
DSM Criteria	ICD-10 Criteria
According to DSM there are 3 subtypes	Subtypes are not delineated
Hyperactive Presentation: Must display at least 6 of 9 hyperactive impulsive symptoms	
Inattentive Presentation: Must display at least 6 of 9 inattentive symptoms	
Combined Presentation: Must display at least 6 of 9 inattentive and hyperactive impulsive symptoms	HKD: At least six inattention, three hyperactivity and one impulsivity symptom be present in two or more settings
Onset must be by age 7 years (DSM-IV) and 12 years (DSM-5), present for at least 6 months to a degree that is judged to be inconsistent with an individual's developmental level	Onset must be by age 6, of long duration and inconsistent with an individual's developmental level
Several inattentive or hyperactive-impulsive symptoms are present in two or more settings	Symptoms are present in two or more setting Clinician directly observes the symptoms rather than relying only on parent and teacher reports
Symptoms do not occur exclusively during the course of a psychotic disorder and are not better accounted for by another disorder	Mania, a depressive or anxiety disorder rules out a diagnosis of HKD

Table 1: Comparison of DSM and ICD diagnostic Criteria for ADHD/HKD.

exposed HKD diagnosed children taking medication to treat their symptoms.

Methods

Survey Data from both waves of the British Child and Adolescent Mental Health Survey (B-CAMHS) were analyzed during the course of this study. Data were collected from distinct samples in 1999 (N=10438; male n=5213; female n=5225) and 2004 (N=7997; male n=4111; female n=3886). The sample of children for each of the surveys was derived from the Child Benefit Records. Stratified sampling frames were utilised with random sampling of children aged 4 to 17 years from within each sector. Initially, parents were administered The Development and Well Being Assessment [20] interview by lay interviewers. Subsequently, permission was sought to obtain data for children aged 11 to17 years for a face-to-face interview with the lay interviewer. Only parent and teacher reports were obtained for each child aged 5 to 10 years. Once data was obtained from the parent, permission was then sought to obtain data from the child's teacher (1999: N=8338; 2004: N=6003). Subsequently diagnoses were assigned according to ICD-10 criteria (WHO, 1993). Goodman et al. [20] reported that the DAWBA successfully distinguished between clinical and community based samples. The survey was conducted in full accordance with the latest version of the Declaration of Helsinki and the study design received full ethical approval. Informed consent of the survey participants was obtained after the nature of the procedures had been fully outlined.

Analytic plan

In order to systematically address both the broad and specific aims of this study a number of distinct analyses were conducted. First, prevalence rates for trauma exposures were estimated using data from the PTSD sections of the parent and youth components of the 2004 DAWBA (ICD-10 criteria) in SPSS version 22 [21]. Trauma exposures were queried as follows: Has anything like this happened to him/her/you? (1) A serious and frightening accident, e.g. being run over by a car or train crash etc. (2) A bad fire, e.g. trapped in a burning building; (3) Other disasters, e.g. kidnapping, earthquake, war; (4) A severe attack or threat, e.g. by a mugger or gang; (5) Severe physical abuse that s/he still remembers; (6) Sexual abuse; (7) Rape; (8) Witnessed severe domestic violence, e.g. saw mother badly beaten up at home; (9) Saw family member or friend severely attacked or threatened, e.g. by a mugger or a gang; (10) Witnessed a sudden death, a suicide, an overdose, a serious accident, a heart attack etc; (11) Some other severe trauma. Parent and youth endorsements were combined to create the sexual abuse (SA), physical abuse (PA) and domestic violence (DV) variables. In order to control for all other types of trauma the other queried traumatic exposures were combined to create a variable labeled Other Trauma (OT).

Second, chi-square tests of independence were conducted in SPSS version 22 [21] to examine links between maltreatment and the SDQ [19] indicators. Dose response patterns were examined by recoding the maltreatment and 'other traumas' into 3 new variables (any 1 type, any two types and 3/>3 types). The associated Odds Ratios (ORs) and 95% Confidence Intervals (CIs) were also estimated. These analyses were performed on data from the 2004 dataset only because the 1999 child trauma exposure data was incomplete. The 'hyper' dimension of the SDQ [19] was utilized to broadly screen for ADHD symptoms. The SDQ [19] is a validated psychopathological screener and was selected because of its brevity. Goodman's [19] initial validation demonstrated that the instrument was highly comparable to the Rutter screener [22]. According to Muris, Meesters and van den Berg [23] the instrument has good concurrent validity, good test-retest validity and internal consistency. Research has reported fairly good psychometric properties for the hyper dimension (Cronbach α range=0.63-0.78) [24]. The SDQ [19] items used within the current research are displayed in Table 3. Each question was scored 0-2 based on answering either "not at all", "somewhat true" or "certainly true".

Third, multiple indicators and multiple causes (MIMIC) modeling was used to examine the role of maltreatment exposures on the heterogeneity of ADHD symptoms. The SDQ hyper subscale usually measures a single dimension of ADHD vulnerability. Giannakopoulous et al. [25] suggested that modeling the items to load on distinct factors may offer a more optimal fit for the data. Exploratory factor analysis (EFA) was conducted to test this, using the weighted least squared means and variance adjusted (WLSMV) estimator [26] in Mplus version 7 [27] using the 1999 data. Analysis was based on the polychoric correlation matrix of latent continuous response variables. Several fit statistics were referred to when deciding on the optimal solution. The robust WLSMV chi-square offers a good model fit if the value is not significant ($p>0.05$) [26]. The Root Mean Square Error of Approximation (RMSEA) proves a good model fit if the value is ≤0.05 [28, 29]. For the Comparative Fit Index [29, 30] and the Tucker-Lewis Fit Index [31] values of between 0.90 and 0.95 are acceptable and values ≥0.95 offer a good model fit. Item loadings were considered a good fit if they were >0.40 [32]. In order to confirm the results from the EFAs, confirmatory factor analyses (CFAs) using the WLSMV estimator were conducted on the 2004 data. The best fitting model was selected for estimating the MIMIC model. The goodness of fit indicators were used to make judgments about the CFA models.

Mimic model

The covariates (described in a later section), child maltreatment and other trauma variables were entered into a model to predict the four latent factors of hyperactivity and inattention. The correlations between the teacher and parent factor were estimated within the model. The model was estimated in Mplus version 7 [27] using WLSMV estimator. The goodness of fit indicators were referred to in order to assess the model's fit for the data.

Fourth, subpopulation analysis was conducted on the subgroup of children and young people who qualified for a diagnosis of HKD. The DAWBA [20] contained a component to assess for HKD. Examples of screening questions: Hyperactivity: (1) "Does she/he often fidget?"; (2) "Is it hard for him/her to stay sitting down for long?"; Impulsivity: (1) "Does she/he often blurt out an answer before she/he has heard the question properly?"; (2) "Is it hard for him/her to wait his/her turn?"; Inattentiveness: (1) "Does she/he often make careless mistakes or fail to pay attention to what she/he is supposed to be doing?"; (2) "Is it hard for him/her to wait his/her turn". Clinicians used the ICD-10 diagnostic criteria outlined in Table 1 to assess for HKD. During our subpopulation analysis we estimated frequencies (for HKD diagnosed children) of post-trauma symptomatology (symptoms detailed in Figure 3) using the ICD-10 PTSD diagnostic criteria as utilized in the DAWBA [20].

Fifth, the rates of post trauma symptomatology in HKD cases were then delineated and compared with rates of post-trauma symptomatology in PTSD cases.

Sixth, a series of binary logistic regression models were estimated in Mplus version 7 [27] using the maximum likelihood robust (MLR) estimator to examine the associations between the risk variables and HKD Diagnosis. PAFs were calculated to estimate the percentage of HKD cases where maltreatment exposures were directly implicated. The following formula: P (OR–1)/1+P (OR–1) was used, where P was

the proportion of the maltreatment subtype endorsed in the population and OR was equal to the odds ratio for HKD diagnosis.

Finally, rates of trauma exposed children taking ADHD/HKD medication were estimated. The use of Methylphenidate and Dexamphetamine were queried in the BAMHS.

Covariates

Covariates included gender and age. Ethnicity was dummy coded into Asian (n=549), Black (n=222), Chinese (n=17), Mixed (n=236) and Other Ethnicity (n=76), with White (n=6873) selected as the reference class. Maternal level of education was dummy coded into degree level qualification (n=1107; 13.9%), HND, teaching or nursing qualification (n=969; 12.1%), A-Levels (n=889; 11.1%); GCSE level (n=3156 parents; 39.6%), and some other form of qualification (n=232; 2.9%), with no qualifications used as the reference category (n=1412; 17.7%). Previous Parent Mental Health (PMH) was queried using an item from the stressful life events section, "Since child was born, has the parent (or partner) had a serious mental illness?"

Results

The rates of British children and young people exposed to the trauma categories are delineated in Table 2. These rates reveal that 9.1% of the populations were exposed to at least one trauma type. The highest rates for the maltreatment exposures were reported for DV. Based on the ICD-10 criteria which were used in the BCAMHS, 3.5% of the trauma exposed population qualified for a diagnosis of HKD while 0.6% qualified for a diagnosis of PTSD. Children of lone parents displayed increased rates of HKD diagnoses (9.2%) by comparison to the general population and they also demonstrated higher rates of exposure to PMH, PA, SA and DV.

The overall prevalence of hyperactive and inattentive-impulsive symptoms, as measured by both parent and teacher reports on the SDQ 'hyper' subscale indicators are illustrated in Figure 1. Across raters, endorsements were consistently higher for boys than girls and they consistently decreased as a function of age. Teacher endorsements of pupil restlessness and distractibility were noticeably lower than parent ratings.

Chi-square tests of independence were conducted to investigate if the 9.1% of children and young people who were exposed to the various trauma subtypes were more likely than those who were not trauma exposed to be rated as displaying ADHD symptoms by both their parents and teachers. The results, displayed in Table 3, reveal significant patterns of association between PA, SA, DV and PMH exposures and the individual 'hyper' SDQ symptom indicators. Perusal of Table 3 reveals that the significant positive patterns of association were, for the most part, consistent across parent and teacher reports. Notably, exposures to sexual abuse were not significantly associated with 3 of the indicators, and where significant associations were found these were not consistent across raters. Moreover, further analysis revealed an incremental increase in risk for symptom expression associated with co-occurring traumatic exposures.

The estimated MIMIC model is illustrated in Figure 2. It displayed a very good fit to the data (RMSEA=0.021; CFI=0.994; TLI=0.990). Additionally all of the indicators loaded strongly onto the estimated factors, with loadings varying in strength from 0.666 to 0.950. The within-rater correlations were stronger for both factors than the between-rater correlations. Additionally, scores on the inattentiveness

Population	P MH	PA	SA	DV	OT
General	627	103	70	369	393
(N=7997)	7.70%	1.3%	0.80%	4.60%	4.80%
Lone Parent (N=446)	84	24	11	87	38
	19.10%	5.50%	2.60%	19.60%	8.50%
	Any 1*	Any 2*	3/>*		
General	737 (9.1%)	78 (1.0%)	14 (0.2%)		
Lone Parent	103 (23.1%)	21 (4.9%)	5 (1.1%)		
Note: * = trauma subtype/s					

Table 2: Rates of reported trauma exposures in the UK sample of children and young people in the general population and in children of lone parents.

factors were more strongly correlated across raters than scores on the hyperactivity dimension.

The standardized beta coefficients for the parent factors are displayed in Table 4. A significant negative association was observed for age and sex with both factors demonstrating that as age increased, factor scores decreased. Furthermore, males dominated both latent factors. The hyperactive latent factor was not associated with any ethnicity. However, the inattentive latent factor was negatively associated with being Asian (β=-0.061) and Black (β=-0.036). A dose response relationship was observed for level of education (apart from other education). As the parent education level increased, the hyperactivity (Degree β=-0.2 vs GCSE β=-0.077) and inattentive (Degree: β=-0.185 vs. GCSE β=-0.053) scores decreased. PMH was associated with both factors however the relationship was stronger for the hyperactive factor (Hyperactive β=0.053; Inattentive β=0.043). Each maltreatment variable was associated with each latent factor however the strongest relationship was observed for DV. A particularly strong relationship was observed between DV and the Inattentive latent factor (Hyperactive β=0.062; Inattentive β=0.089).

The standardized beta coefficients for the teacher factors are displayed in Table 5. A negative association was observed between age, sex and both factors. No association was observed between ethnicity and the hyperactive latent factor. However, being Chinese (β=-0.58) was associated with lower scores on the inattentive latent factor. Mixed ethnicity (β=0.036) was linked with increases on the inattentive latent factor. A dose response relationship was also observed with increases in parent educational attainment resulting in lower scores for Hyperactive (Degree β=-0.154 vs. GCSE β=-0.095) and Inattentive (Degree β=-0.216 vs. GCSE β=-0.119) latent factors. PMH was associated only with the inattentive latent factor (β=0.027). In terms of maltreatment, only SA was not associated with either of the factors. Similar to the parent sample, the strongest association for each latent factor was with DV (Hyperactive β=0.093; Inattentive β=0.105).

A total of 109 cases (1.4%) of HKD were diagnosed by the clinicians using the ICD-10 diagnostic criteria. A total of 26 HKD cases were identified by the current study as being trauma exposed. This represents over a quarter of all those children diagnosed with HKD (30.0%). Overall, 7.0% of cases reported exposures to PA, 18.0% reported exposures to DV, 0.8% reported exposures to SA and 9.3% reported exposures to other types of trauma. 23.7% of HKD cases reported exposures to one trauma subtype, 4.3% of cases reported exposures to two trauma subtypes, while 1.0% reported exposures to three subtypes.

Parents of the 30.0% of HKD cases, who were trauma exposed, were then queried in relation to the impact of the trauma exposure on their children's behavior. 72.1% reported that their child's behavior changed dramatically after the exposures and 45.3% reported that it was still impacting on their child's behavior or concentration. Therefore,

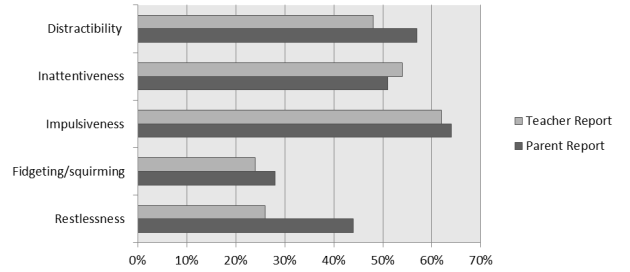

Figure 1: Rates of endorsement for the hyperactive and inattentive SDQ indicators across parent and teacher reports.

according to these parent reports, trauma exposures are etiologically linked to symptoms in at least 45.0% of trauma exposed HKD cases.

Parents of the 45.0% of HKD cases who stated that trauma exposures were still affecting their child's behavior were then queried in relation to their child's enduring post trauma symptomatology. Figure 3 illustrates a comparison of parent reporting of rates of post trauma symptomatology in PTSD and HKD diagnosed children and young people.

Binary logistic regression analyses confirmed significant associations between HKD diagnoses and exposures to both PA (OR=3.84, 95% CI=1.72-8.59) and DV (OR=3.46 95% CI=1.98-6.05), while controlling for all other covariates. 7.0% of those with a HKD diagnoses had reported exposures to PA compared with 1.3% in the general population. 18.0% of those with a diagnosis of HKD reported exposures to DV compared with 4.6% in the general population. Additionally a dose response relationship between trauma exposures and HKD diagnoses was revealed (any 1: OR=2.59, 95% CI=1.67-4.03; any 2: OR=5.70, 95% CI=2.79-11.65; 3 or more OR=6.18, 95% CI=1.41-27.09). The PAF calculations revealed that 3.55% of HKD cases were associated with PA exposures and 10.17% were associated with DV exposures.

Finally, 37.3% of all HKD cases were taking prescribed stimulant based medication to treat their symptoms. 37.5% of physically abused children with a HKD diagnoses were taking stimulant based medication while 15.8% of those exposed to domestic violence were taking medication. Of the 11 HKD diagnosed cases who also went through the screening for PTSD (Figure 3), four (36.4%) were reported to be taking medication for ADHD at the time of the study. There was no data on medication use available for the remaining 7.

Discussion

This study aimed to further investigate the validity of an emerging concern that children presenting with complex trauma-related symptoms may be misdiagnosed as having ADHD/HKD. The descriptive results from the chi-square tests of independence suggest that exposures to PA and DV were significantly linked with symptoms from both the hyperactive and inattentive domains of ADHD, while SA exposures seem to be significantly linked with symptoms from the hyperactive domain. As outlined earlier, the possibility that dissociative symptoms resulting from traumatic exposures could be mistaken for the inattentiveness symptoms of ADHD has been raised [3, 17]. Additionally, the possibility that hyper arousal symptoms could be mistaken for hyperactivity symptoms has also been highlighted [17]. An alternative interpretation of these results therefore is that the children who were exposed to PA and DV were more likely to display dissociative and hyper arousal symptoms, which mirror the inattentive and hyperactive symptoms associated with ADHD, while SA exposures appear to be significantly linked with symptoms of hyper arousal.

During the next stage of our analyses we examined the specificity of the impact of maltreatment exposures on the expression of the ADHD dimensions. The results from the factor analyses offered support for a two factor structure which estimated two correlated ADHD dimensions, namely inattentiveness and hyperactivity. A MIMIC model, encompassing teacher and parent indicators of ADHD, was then created to investigate whether and how age, sex, maternal education, ethnicity, maltreatment exposures, parent mental health and trauma exposures affected the predicted factor structure. This model was a very good approximation to the data. Using a CFA approach to assess inter-rater agreement was beneficial because the estimates of the correlations were corrected for the effects of measurement error. The association between the parent and teacher rating are shown by the correlations between the latent factors (Figure 2). The within-rater correlations were all statistically significant and were stronger for teacher ratings (r=0.85) than parent ratings (r=0.67). The between-rater correlations were all significant and varied in strength across the factors (Hyperactivity: r=0.41; Inattentivess: r=0.59; Parent Inattentiveness and Teacher Hyperactivity: r=0.49; Teacher Inattentiveness and Parent Hyperactivity: r=0.36). Stone et al. [24], using data from 8 studies, reported an average weighted parent and teacher inter-rater agreement correlation of 0.47 (range=0.44-0.61) on the SDQ hyperactivity-inattention dimension. Although inter-rater reliability was modest in this study, this is a well-documented phenomenon in psychological assessment [24]. Generally, parents were more likely to endorse symptoms in their children than teachers. Teacher endorsement rates of pupil restlessness (26.4%) and distractibility (47.7%) were noticeably lower than parent ratings (44% and 57.1%, respectively).

The significant associations between the covariates and the factors indicated that the covariates significantly affected the manifestation of the ADHD symptoms across parent and teacher factors. Our findings are consistent with previous studies where associations between maltreatment and symptoms of hyperactivity and inattentiveness have been identified [33, 12]. Furthermore, our findings confirm a stronger association with PA and inattentiveness across both parent and teacher reports [6]. However our findings suggest an association between SA and hyperactivity symptoms which was not established by Ouyang et al [6]. Weinstein et al. have strongly argued that SA is linked with ADHD symptoms [4]. Our findings further contribute to the existing epidemiological literature [6, 7] on ADHD in two important ways, by highlighting that: (1) DV exposures also impact on both dimensions but they have a very strong impact on inattentive symptoms and (2) SA exposures have a stronger impact on hyperactive symptoms than on inattentive symptoms. These findings add support to the concern of other researchers who have highlighted the risk for misdiagnosis of ADHD in maltreated children [3, 4]. However, our findings suggest that sexually abused children are less likely to be misdiagnosed when ICD-10 criteria are used because 6 inattentive criteria need to be observed by the clinician for a diagnosis of HKD to be assigned. Our findings certainly suggest that exposures to maltreatment are associated with more severe manifestations of inattentive and hyperactive symptoms and highlight the specificity of the maltreatment subtype effects on the factor scores.

Specifically, our findings revealed that those who were exposed to PA were almost 3 times more likely than those with no such exposures

	Parent Report		Teacher Report	
	χ2	OR (95% CI)	χ2	OR (95% CI)
Restless				
PA	6.14*	1.64 (1.10-2.43)	8.73**	2.07 (1.26-3.78)
SA	2.69	1.50 (0.92-2.45)	2.15	1.61 (0.85-3.05)
DV	24.33***	1.70 (1.37-2.10)	30.18***	2.05 (1.58-2.66)
OT	6.56*	1.31 (1.07-1.61)	9.96**	1.48 (1.16-1.90)
PMH	18.45***	1.43 (1.22-1.69)	4.89*	1.26 (1.03-1.55)
Constantly Fidgeting				
PA	15.65***	2.18 (1.47-3.23)	10.37**	2.20 (1.35-3.60)
SA	3.57	1.62 (0.98-2.67)	4.26*	1.95 (1.02-3.70)
DV	20.44***	1.65 (1.32-2.05)	31.72***	2.10 (1.62-2.74)
OT	2.11	1.18 (0.94-1.47)	5.64*	1.37 (1.06-1.77)
PMH	26.49***	1.57 (1.32-1.86)	4.84*	1.27 (1.03-1.58)
Thinks Before Acting				
PA	11.52**	2.89 (1.40-3.74)	11.36**	2.81 (1.50-5.25)
SA	5.65*	2.02 (1.12-3.66)	1.03	1.42 (0.72-2.79)
DV	23.84***	1.83 (1.43-2.34)	22.45***	2.04 (1.51-2.76)
OT	2.44	1.19 (0.97-1.49)	0.75	1.11 (0.87-1.42)
PMH	3.79	1.19 (0.99-1.42)	15.20***	1.51 (1.23-1.86)
Sees Tasks Through to the End				
PA	11.01**	2.00 (1.32-3.04)	6.84**	1.99 (1.18-3.37)
SA	0.22	1.23 (0.69-1.84)	0.07	1.09 (0.58-2.05)
DV	15.97***	1.55 (1.25-1.92)	48.66***	2.77 (2.06-3.73)
OT	3.78	1.23 (0.99-1.51)	4.34*	1.28 (1.01-1.63)
PMH	9.24**	1.29 (1.10-1.53)	19.10***	1.55 (1.27-1.89)
Easily Distracted				
PA	12.82	2.22 (1.42-3.47)	8.14**	2.07 (1.24-3.44)
SA	0.97	1.29 (0.78-2.14)	0.86	1.34 (0.72-2.51)
DV	30.87***	1.91 (1.51-2.40)	26.71***	1.99 (1.53-2.59)
OT	11.92**	1.46 (1.18-1.81)	4.26*	1.28 (1.01-1.62)
PMH	16.31**	1.42 (1.20-1.69)	12.02**	1.40 (1.16-1.70)

Note: *N* = actual number; % = weighted percentage; *p<0.05;**p<0.01;***p<0.001; OR = odds ratio; CI = confidence interval; OT = other trauma

Table 3: Results of the chi-square tests of independence showing associations between trauma subtypes and the 'hyper' SDQ indicators (N=7997).

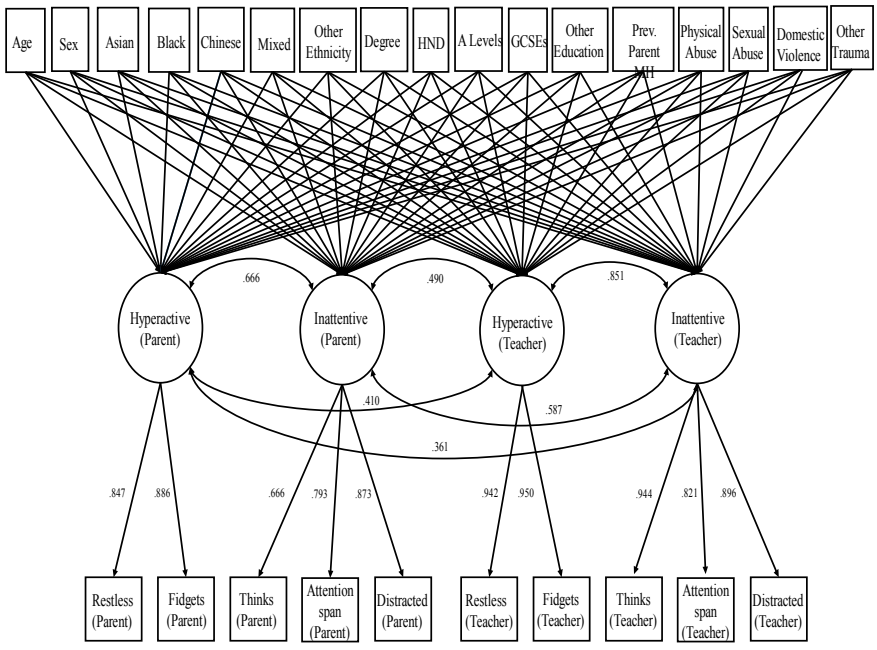

Figure 2: MIMIC model depicting the 'hyper' subscale of the SDQ with Hyperactive and Inattentive teacher and parent latent factors regressed onto a range of predictors.

	Hyperactive			Inattentive		
	β	SE	P	β	SE	P
Age	-0.22	0.004	0	-0.046	0.003	0.001
Sex	-0.18	0.025	0	-0.22	0.018	0
Asian	0	0.054	0.759	-0.061	0.036	0
Black	-0.02	0.324	0.796	-0.036	0.058	0.007
Chinese	0.01	0.08	0.264	-0.021	0.198	0.136
Mixed	0.02	0.074	0.106	0.007	0.057	0.628
Other Ethnicity	0	0.137	0.919	-0.018	0.099	0.181
Degree	-0.2	0.045	0	-0.185	0.031	0
HND	-0.12	0.045	0	-0.102	0.032	0
A Level	-0.1	0.044	0	-0.059	0.032	0
GCSE	-0.08	0.033	0	-0.053	0.024	0.002
Other Education	-0.02	0.015	0.266	-0.011	0.013	0.481
PMH	0.05	0.044	0	0.043	0.031	0
PA	0.05	0.101	0	0.053	0.077	0
SA	0.05	0.122	0.001	0.031	0.084	0.012
DV	0.06	0.057	0	0.089	0.039	0
OT	0.044	0.057	0.001	0.036	0.043	0.007
Note: β = standardized beta co-efficient; SE = standard error						

Table 4: MIMIC results showing predictors of the parent 'hyperactive' and 'inattentive' factors.

	Hyperactive			Inattentive		
	β	SE	P	β	SE	P
Age	-0.109	0.005	0	-0.086	0.004	0
Sex	-0.316	0.034	0	-0.279	0.029	0
Asian	-0.01	0.076	0.533	-0.013	0.066	0.357
Black	0.019	0.117	0.299	0.029	0.101	0.063
Chinese	-0.002	2453	1	-0.058	0.345	0.001
Mixed	0.014	0.104	0.454	0.036	0.085	0.015
Other Ethnicity	-0.004	0.198	0.842	-0.009	0.166	0.577
Degree	-0.154	0.058	0	-0.216	0.05	0
HND	-0.091	0.06	0	-0.134	0.051	0
A Level	-0.079	0.059	0	-0.117	0.051	0
GCSE	-0.095	0.045	0	-0.119	0.04	0
Other Education	0.002	0.028	0.945	-0.002	0.023	0.924
PMH	0.001	0.061	0.93	0.027	0.052	0.047
PA	0.037	0.142	0.017	0.053	0.129	0.019
SA	0.024	0.17	0.157	0.009	0.148	0.527
DV	0.093	0.075	0	0.105	0.068	0
OT	0.041	0.072	0.006	0.022	0.067	0.115
Note: β = standardized beta co-efficient; SE = standard error						

Table 5: MIMIC results showing predictors of teacher 'hyperactive' and 'inattentive' factors.

to have a diagnosis of HKD. 7% of those with a HKD diagnoses had reported exposures to PA. PAF calculations revealed that 3.55% of HKD cases were associated with PA exposures and therefore may represent cases who are presenting with post trauma symptomatology. PA has not been conclusively identified as risk factor for ADHD although Hadianfard [5] reported that PA exposures are significantly higher in children affected by ADHD symptoms. Moreover, the findings of Endo et al. [18] suggest that exposures are etiologically related to ADHD. Additionally, exposure to DV significantly predicted a diagnosis of HKD and PAF calculations revealed that 10.17% of HKD cases are related to DV exposures. 18% of children and young people diagnosed with HKD were reported to have been exposed to DV. These findings deserve attention as Endo et al. [18] revealed a very high level of comoridity between ADHD and dissociative disorder in their psychiatric inpatient sample and they also found that maltreatment was etiologically linked to ADHD. Weinstein et al. [4] highlighted that the high rate of symptom overlap between ADHD and PTSD and the high risk for these disorders to manifest in abused children pose the risk for mis-medication and other inappropriate treatment interventions.

Importantly our results revealed that 72.1% of parents of trauma exposed HKD cases reported that their child's behavior changed dramatically after trauma exposures and 45.3% reported that it was still impacting on their child's behavior or concentration. Therefore, according to these parent reports, trauma exposures are etiologically linked to symptoms in at least 45.0% of trauma exposed HKD cases. Furthermore, Figure 3 highlights the need for further investigation of these issues as rates of dissociative symptoms (blocked memories) were higher in the HKD diagnosed trauma sample than the PTSD diagnosed trauma sample. Further focused investigations of these issues are urgently required because we found that 37.5% of physically abused

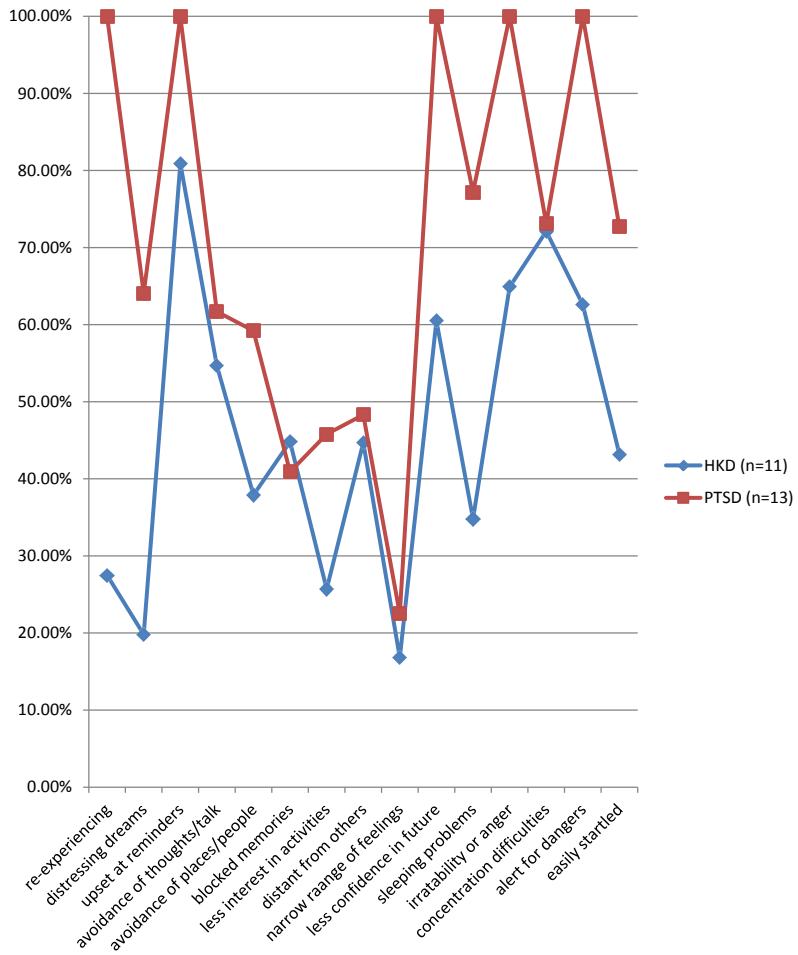

Figure 3: Comparison of trauma exposed HKD cases (whose caregiver stated that trauma still impacting on behaviour and concentration) and PTSD cases on ICD-10 post trauma symptomatology.

children and 15.8% of those exposed to domestic violence with a HKD diagnoses were taking stimulant based medication (Methylphenidate or Dexamphetamine).

Limitations

Findings of the current study must necessarily be considered in light of a number of limitations. First, this study is cross-sectional and therefore no causal inferences about the relationships between the maltreatment exposures and ADHD/HKD symptoms can be made. Notably, however, parent reports of the etiological links between trauma exposure and psychopathology certainly add credence to the evidence supporting our hypothesis. Second, we had to rely on parent reports of maltreatment for children under 11 years of age. This created a risk for under-reporting of maltreatment. Indeed, there is an obvious discrepancy between the rates of maltreatment exposures reported in the BCAMHS compared with those reported by Radford et al. [11]. Importantly, Radford et al. highlighted that a substantial percentage of these maltreated children did not disclose their experiences of abuse to anyone. Specifically these findings elucidated that 22.9% of PA cases, 34% of SA cases perpetrated by an adult, and 82.7% of SA cases perpetrated by a peer went undisclosed. These findings suggest under-reporting of maltreatment by both parents and youth in the BCAMHS. This suggests an underestimation of the strength of the relationship between maltreatment exposures and ADHD/HKD symptoms in this study. These limitations notwithstanding, the current study contributes significantly to the literature aiming to explain the heterogeneity of ADHD symptomatology and certainly highlights the need to consider how maltreatment exposures may lead to dissociative and hyper arousal symptoms which may mirror the behavioral indicators of ADHD. Specifically our findings highlight that exposures to PA and DV are particularly implicated in the inattentive subtype, while SA is more strongly implicated in the manifestation of hyperactive (hyper arousal) symptomatology [34-40].

Conclusion

These findings highlight the need to routinely inquire about trauma history, and to investigate the presence of dissociative and hyper arousal symptoms when assessing for ADHD/HKD.

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