

# ADHD: from childhood into adulthood

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## Abstract

This is an overview of some of the most recent and seminal research done on Attention Deficit Hyperactivity Disorders (ADHD). ADHD is currently one of the most common reasons for referral to child mental health services and still is under-recognised both in children (5.29%) and adults (2.5%). ADHD is a highly heritable disorder with a multifactorial pattern of inheritance. Parents, siblings and parents of a child with ADHD are 4-5 times more likely to have ADHD. Environmental factors also play a role in elucidating this disorder. Untreated ADHD leads to numerous co-morbidities, and longer term morbidity. Methylphenidate is suggested as the first line pharmacological treatment. ADHD is easy to treat, 80% of correctly diagnosed patients (children or adults) respond favourably to methylphenidate. All child and general adult psychiatrists should be aware of this disorder, comfortable with making the diagnosis and treating adults with ADHD. The purpose of the overview is to cover the epidemiology, aetiology, diagnostic criteria and different managements of ADHD.

## Keywords

ADHD, genetic, childhood, adult, methylphenidate

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## Introduction

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder. It is characterised by persistent symptoms of inattention, hyperactivity and impulsivity according to Diagnostic and Statistical Manual of Mental Disorders 4<sup>th</sup> edition (DSM IV)<sup>1</sup> or classed under the term hyperkinetic disorder in the International Classification of Diseases 10<sup>th</sup> edition (ICD10) with characteristics including early onset, disorganized, ill-regulated, and excessive activity, recklessness and impulsivity<sup>2</sup>. ADHD is markedly more prevalent in males than females<sup>3</sup>. However the ratio changes depending on the population studies, (the ratio ranges between 9:1 and 2.5:1). By definition, the onset of hyperkinetic disorder must be present in at least two out of three environments (home, school, clinic), this behaviour must be maladaptive and pervasive. The onset of hyperkinetic disorder is before the age of 7 years, but is frequently recognised in children less than 2 years old<sup>4</sup>. DSM V is proposing to keep ADHD as one of its disorders. The main proposed change is around broadening the age of onset "on and before age 12"<sup>5</sup>.

The aim of this paper is to bring together some of the seminal, recent studies on ADHD published and found on the main databases (these include; Embase, Medline, Web of knowledge, Ovid, Scopus). With the aim of providing the reader with a clear concise overview of this common disorder. The epidemiology, aetiology, diagnostic criteria and management for both children and adults suffering from ADHD will be elucidated below (Table 1).

## Epidemiology

The prevalence of ADHD varies from one study and country to another. In childhood, the prevalence of ADHD in the UK is estimated at 2.23 % age 5-15.<sup>6</sup> Whilst in the United States, the National Health Interview Survey (NHIS)(2006) estimated the prevalence of ADHD among children age 3-17 to be 7 %.<sup>7</sup> In adulthood, the worldwide prevalence of ADHD was found to be 5.29%<sup>8</sup> with minor differences between countries. Studies report that these values are actually underestimates of the true

prevalence of ADHD, stating that this disorder is under-identified and treated in only a minority of cases.<sup>9</sup> Cases are not being identified because young people are not brought forward to mental services (reason being; believing ADHD is not a disorder and/or the behaviours are self-limiting and/or the stigma attached to mental

health). In adults recall bias effects the accuracy of the actual prevalence of ADHD.<sup>6,7,8,9</sup> ADHD is more common in younger children, urban more than rural communities and low socio-economic status.<sup>9</sup>

**Symptoms Groups**

<u>Inattention</u>	<u>Hyperactivity</u>	<u>Impulsivity</u>
Does not attend	Fidgets	Talks excessively
Fails to finish tasks	Leaves seat in class	Blurts out answers
Cannot organize	Runs/climbs excessively	Cannot await turn
Avoids sustained effort	Cannot play/work quietly	Interrupts others
Loses things	Always “on the go”	Intrudes on others
Forgetful		Blurts out answers
Easily distracted		
Does not listen		

DSM-IV ADHD	ICD-10 HKD
<b>Symptoms</b>	
Either or both of the following: <ul style="list-style-type: none"> <li>• At least six of nine inattentive symptoms</li> <li>• At least six of nine hyperactive or impulsive symptoms</li> </ul>	All of the following: <ul style="list-style-type: none"> <li>• At least six of eight inattentive symptoms</li> <li>• At least three of five hyperactive symptoms</li> <li>• At least one of four impulsive symptoms</li> </ul>
<b>Pervasiveness</b>	
Criteria are met in one situation and impairment is present in another Criteria are met in more than one situation	

*Table 1: ADHD diagnostic criteria*

**Aetiology**

Genetic studies on ADHD indicate high heritability (this is a term used in twin studies to calculate the difference in concordance rates between monozygous and dizygous twins, the higher the hereditability rate the higher is the genetic contribution to a phenotype). In the case of ADHD the heritability is estimated as high as 76% and so is genetic linkage high, indicating that there is a high genetic contribution which gives rise to this disorder.<sup>4</sup> Genetic studies report that there is no one gene that codes for ADHD. Whole genome linkage studies suggest there are no common susceptibility genes but multiple genes of small effect size that interact with the environmental risk.<sup>10</sup>

Family studies show that the prevalence in children of adults suffering from ADHD is 57%. Parents and siblings of a child with ADHD are 4-5 times more likely to have ADHD than the general population.<sup>4</sup>

The neurobiology of ADHD suggests its association with cognitive processing deficit<sup>3</sup> and the pathophysiology is strongly linked to dopamine and norepinephrine neurotransmitter systems. Rutter in 2006 indicated that the main problem lies in “behavioural dysregulation, executive deficits in inhibitory control, working memory, and delay

aversion.”<sup>3</sup> The hypofrontality theory suggests that ADHD is associated with subnormal activation of the prefrontal systems responsible for higher-order motor control.

Paediatric neuroimaging studies showed reduced amygdala volumes and bilateral increase in hippocampus volumes.<sup>11</sup> Poor functioning in the striatum, frontal lobes, and posterior periventricular regions are indicated in attention problems.<sup>12</sup>

Biological based phenotypes that lie in the pathway from genes to behaviour may provide insight into this link, an example of these are endophenotypes. Endophenotypes are measurable components unseen by the unaided eye found along the pathway between disease and distal genotype. They may be neuroanatomical, cognitive, neurophysiological, biochemical or endocrinological in nature which represent simpler clues to genetic underpinnings than the disease syndrome itself. These endophenotypes serve to promote the view that a psychiatric disorder can be deconstructed; thus enabling more straightforward genetic analysis. These endophenotypes must be associated with a candidate gene or gene

region. Such endophenotypes have aided the clarification of aetiology of several neurodevelopmental disorders such as autism. Neuropsychological impairments, neuroimaging and electrophysiological paradigms for ADHD show potential to move molecular genetics research forward. The recognition of a specific ADHD ‘endophenotype’ would help identify individuals that are ‘at risk’ of developing ADHD and this could help reduce this high rate of disability associated with this disorder.<sup>13</sup>

Environmental factors also play a role in the development of ADHD. Obstetric complications<sup>14</sup> and extremely low birth weight (less than 1000g).<sup>15</sup> are linked to attentional difficulties. Exposure to lead, often through lead water pipes in old houses, and head trauma particularly implicating the frontal cortex famously in the case of Phineas Gage<sup>16</sup> can lead to cognitive effects mimicking ADHD. Similarly, it appears that some children benefit from hypoallergenic foods, which suggests that, although the mechanism is not clear, certain dietary elements can contribute to symptoms.<sup>17</sup> It is important to note that environmental risks need to be present during a critical period so as to have an effect on outcome.

Over the last decade there has been a vast increase in the knowledge on brain development and severe deprivation in infancy (in the form of neglect and/or abuse) which leads to attachment disruption having lasting developmental effects. It has been demonstrated that the establishment of synaptic connections between neurons and the programming of the neurochemical responses that have an effect on the development of the whole body are dependent on experience. The most sensitive period for brain growth and optimal plasticity, is over the first 3 years of life.<sup>18</sup> Through stress and misattunement of this relationship the child’s neurodevelopment is halted, this reduces the child’s ability to self-regulate affect and the child may present with symptoms which mimic ADHD symptomatology.<sup>19</sup>

### **The concept of ADHD**

The diagnosis of ADHD in children has been a controversial issue for many years, some arguing that it did not exist and whilst others reporting the contrary. The validity of a diagnosis of ADHD in pre-school children has also increased over the years; these present with the same symptom structure<sup>20</sup>, similar neuropsychological deficits, associated impairment, co-morbidity and developmental risk.<sup>20</sup>

The scepticism about adult ADHD is influenced by the absence of well validated and universally accepted diagnostic criteria. Also the retrospective diagnosis of adult ADHD is significantly biased by current level of functioning.<sup>21</sup>

### **Adult ADHD**

ADHD diagnosed in childhood tracks on through to adulthood, with 4-15% retain full diagnosis and 50-66% in partial remission.<sup>22</sup> A recent meta-analysis reported; the overall pooled prevalence rate for adult ADHD is 2.5%.<sup>23</sup> Many aspects play a role in the estimation of prevalence adult ADHD. Children do not outgrow the disorder but the diagnostic criteria. Meaning this actually is an underestimation of the true prevalence of the disorder.

### **Why should adult mental health services be interested in ADHD?**

ADHD is a common behavioural disorder that is associated with significant adult psychopathology, social and academic impairments. In many cases ADHD symptoms persist into adult life and cause significant clinical impairments.<sup>22</sup>

### **Clinical presentation in adults**

When looking to diagnose adults with ADHD, it is important to keep in mind that hyperactivity is a less prominent symptom when compared to inattention and impulsivity. Adults are more often disabled by their poor concentration (having ceaseless mental activity or a distracted mind) affecting their daily function, this in turn may result in low self-esteem, variable performance at work and low mood.<sup>24</sup>

Adults with ADHD prefer occupations that are exciting and busy and have an element of risk (e.g. stock broking, entrepreneurial ventures), undergo frequent changes in employment, have poor planning abilities (e.g. organizing finances, handling course work), messiness, dangerous driving, unstable relationships, and engagement in leisure activities that are highly absorbing or stimulating (e.g. downhill skiing, high-contact sports). Adults usually have difficulty organizing their homes (e.g., cooking regular meals, cleaning) and managing their children (e.g. packing their lunches, getting to appointments on time).<sup>25</sup>

### **Psychiatric comorbidity**

Comorbidity is not uncommon in adults with ADHD. Studies report high rates of antisocial personality disorders with poorer prognosis<sup>3</sup>, (rates vary from 12% to 23%). Other comorbidities include: high rate of substance abuse<sup>3</sup>, depression, anxiety and bipolar disorder<sup>26</sup>, Oppositional Defiant Disorder, Conduct disorder and aggression probably as a result of affective disorders (Figure 1).

### **Management**

The first step in management is making an accurate diagnosis, using a multimodel assessment

approach (this includes an indepth clinical psychiatry interview, a cognitive assessment by psychologist, school observation, ADHD nurse specialist assessment, clinical review of young person and physical examination, blood investigations, collateral history from parent or partner and questionnaires such as the Conner's questionnaire are useful adjuncts.<sup>26</sup> This multimodal assessment is brought together in a formulation meeting where a diagnosis decision takes place for both young people and adults. Management of ADHD must be delivered by a specialist in ADHD. In children, this involves passing on the appropriate information and advice to parents and child, informing the family doctor, school education and educational psychologist. In adults, the same approach should be adapted depending on the person circumstances and services/work/ education involved with the specific individual.<sup>27</sup>

A combination of interventions plays a role in managing adults with ADHD these include; pharmacological, neuropsychological and environmental interventions.<sup>12</sup> Methylphenidate is suggested as the first line pharmacological treatments.<sup>26, 12</sup> Other common treatments include atomoxetine, and amphetamines.<sup>26, 12</sup> However, other pharmacological treatments are used, but with less evidence: these include alpha-2 agonists (clonidine, bupropion, modafinil) and antidepressant with noradrenergic effects (imipramine and venlafaxine).<sup>26</sup>

Parent training should be the first choice treatment for pre-school children presenting symptoms of ADHD. Medication is only introduced for those, where parent training has failed. The adverse events rate for methylphenidate in this age group is high 30% compared to <1% in older children.<sup>28</sup>

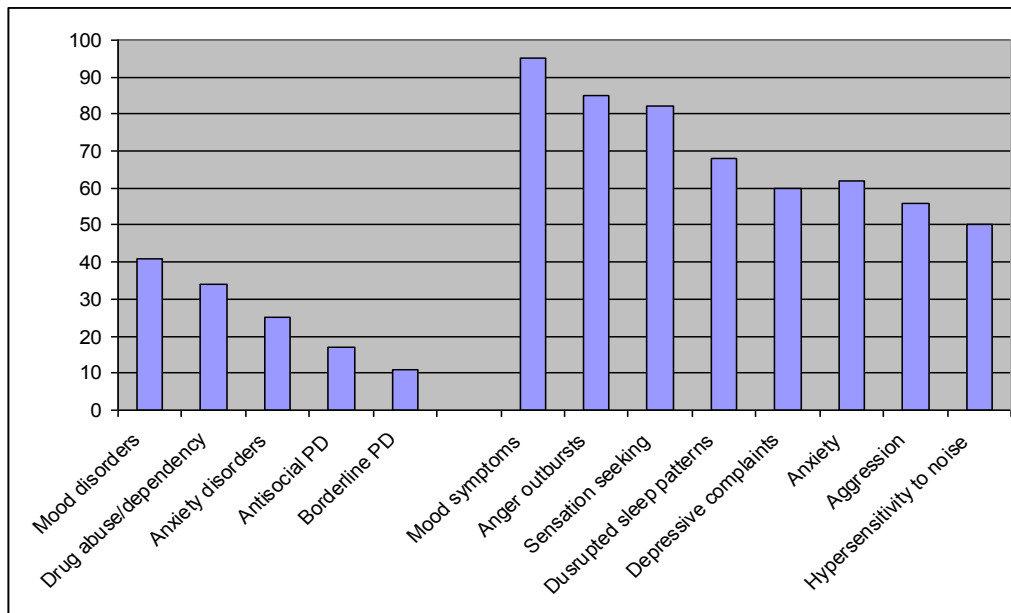


Figure 1: **Co-morbidity in Dutch series of 141 adult ADHD cases**<sup>35</sup>  
78% of ADHD cases had one co-morbidity

### Pharmacological treatment

Therapeutic effects of medication include improvements in ADHD symptoms, peer and family relationships, improved learning, self-esteem and social skills will be observed soon after started medication.

Clinical monitoring involves:

- Pre-treatment: plotting height and weight on a growth chart (children only), assessing motor coordination (children only) and a cardiovascular examination (children and adults).
- During treatment: measurement of weight (children and adults), height (children), blood pressure and pulse (children and adults)<sup>27</sup>, as well as monitoring side effects of the medication (children and adults).

ADHD is easy to treat with 80% of correctly diagnosed patients responding to treatment.

### **Stimulants (e.g. methylphenidate hydrochloride such as Ritalin)**

The use of psychomotor stimulants to treat the symptoms of ADHD goes back to 1937 when Bradley noticed a significant change in behaviour and improvement in school performance.<sup>29</sup>

Methylphenidate is a central nervous system stimulant, it blocks the presynaptic membrane dopamine transporter and thereby inhibits the reuptake of dopamine and noradrenaline into the presynaptic neuron.<sup>26</sup>

There are two forms of Methylphenidate: immediate release and extended release. The extended-release form of methylphenidate was initially developed to address the issues of multiple dosing and compliance issues in children and adolescents. The extended release form such as (Metadate CD) comprise of both an immediate release component (30% of the dose) and extended release component (70% of the dose) or such as (Concerta) uses osmotic pressure to deliver methylphenidate hydrochloride at a controlled rate.

Immediate release methylphenidate has some advantages in targeted situations such as important meetings/events or exams. While the advantages for the extended-release methylphenidate for adults are similar to those in children: improvement of compliance and avoiding taking medication during education/employment hours. There is a potential for drug misuse or diversion, though research reports this is rare.<sup>26</sup>

### *Non-stimulants*

Atomoxetine increases nor adrenaline and also dopamine in the prefrontal cortex. It blocks noradrenaline reuptake pumps. Atomoxetine appears to be an efficacious treatment of adult ADHD. Its lack of abuse potential may be an advantage. The effect size reported is smaller than that of the stimulants<sup>30</sup>.

### **Psychological treatment**

This includes making use of some of the following: cognitive-behavioural therapy, family therapy, social skills training.<sup>24</sup> When using CBT and/or social skills training for the child or young person in conjunction with a parent training/education programme, particular emphasis should be given to targeting a range of areas, including social skills with peers, problem solving, self-control, listening skills and dealing with and expressing feelings. Active learning strategies should be used, and rewards given for achieving key elements of learning. For older adolescents with ADHD individual psychological interventions (such as CBT or social skills training) are advised as they are more effective and acceptable than group parent-training/education programmes or group CBT and/or social skills training.<sup>26</sup>

The current evidence for pre-school children demonstrates that there is good efficacy in reducing ADHD symptoms by parenting training. The three interventions with most evidence are: New forest parent training programme, the triple P-positive parenting programme<sup>31</sup>, and the incredible years training programme.<sup>32</sup> The latter programme has the most research evidence for being effective. It is a form of group parent/child training, which involves focusing on child-directed play, effective praise, handling separations,

routines, limit setting and using positive discipline with distending/redirecting unwanted behaviour.<sup>32</sup>

### **Conclusions/key points**

ADHD is a common disorder which is probably under-recognised in mental health settings and the community. Prevalence estimated at 5.29% for children<sup>9</sup> and 2.5% for adults with high heritability.<sup>33</sup>

ADHD is best viewed as a gene-environment interaction. Currently there are two predominant theoretical models used to explain ADHD: first executive dysfunction underpinned by deficient inhibitory control mechanisms and second, delay aversion, underpinned by behaving impulsively in order to avoid delay.

Comorbidity is prevalent in 30-70% of children and adults diagnosed with ADHD, this should be carefully considered when assessing people with ADHD.

A multidisciplinary multimodal approach with specialists carrying out their individual assessments then bringing them all together in a formulation meeting, followed by clear reporting to child/adult care givers is key to accurate diagnosis of both children and adults.

The management of ADHD should focus on pharmacological, psychological and environmental interventions, with methylphenidate being first line in adults but used only after parental training in pre-school children<sup>26</sup>. ADHD is a disorder that is easy to treat with 80% of correctly diagnosed patients (children or adults) responding to treatment.<sup>34</sup>

Awareness of ADHD is improving in the speciality of child and adolescent psychiatry but remains poor in general adult psychiatry. The authors suggest psychiatrists and clinicians access more training courses to help them be comfortable with making the diagnosis and treating ADHD.

### **References**

1. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th edition. Washington DC: American Psychiatric Publishing, 1994.
2. World Health Organization. International Classification of Diseases 10<sup>th</sup> edition (ICD10). 1994.
3. Rutter M, Kim-Cohen J, and Maughan B. Continuities and discontinuities in psychopathology between childhood and adult life. *Journal of Child Psychology and Psychiatry*; 2006; 47(3/4):276-295.
4. Taylor E, Sergeant J, Doepfner M, Gunning B, Overmeyer S, .Mobius H.J, Eisert H. G. "Clinical guidelines for hyperkinetic disorder." *European Child & Adolescent Psychiatry*. 1998,7(4): 184-200.
5. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders: Proposed Draft Revisions to DSM Disorders and Criteria (DSM 5). 2010.

- [cited Oct 2012]. Available from: <http://www.dsm5.org/Pages/Default.aspx>
6. Ford T, Goodman R, and Meltzer H. The British Child and Adolescent Mental Health Survey 1999: The Prevalence of DSM-IV Disorders. *J. Am. Acad. Child Adolesc. Psychiatry* 2003; 42(10):1203-1211.
  7. Bloom B., and Cohen RA. National Center for Health Statistics. Vital and Health Statistics. U.S Department of Health and Human Services. Vol. 10. Washington DC: U.S. Government Printing Office, 2007.
  8. Polanczyk G, de Lima MS, Less-Horta B, Biederman J, Rohde LA. The Worldwide Prevalence of ADHD: A Systematic Review and Meta-regression Analysis. *Am J Psychiatry* 2007;164:942-948.
  9. Angold A, Erkanli A, Egger A, Costello H, and Jane E. "Stimulant Treatment for Children: A Community Perspective." *Journal of the American Academy of Child & Adolescent Psychiatry* 2000; 39(8): 975-984.
  10. Stergiakouli E, and Thapar A. Fitting the pieces together: current research on the genetic basis of attention-deficit/hyperactivity disorder. *Neuropsychiatric Disease and Treatment* 2010;6:551-60
  11. Perlov E, Philipsen A, van Elst LT, Ebert D, Henning J, Maier S, Bubl E, Hesslinger B. Hippocampus and amygdala morphology in adults with attention-deficit hyperactivity disorder. *J Psychiatry Neurosci* 2008;33(6):509-15.
  12. Janakiraman R, and Benning T. Attention-deficit hyperactivity disorder in adults. *Advances in psychiatric treatment* 2010;16:96-104.
  13. Doyle AE, Willcutt EG, Seidman LJ, Biederman J, Chouinard VA, Silva J, et al. Attention-deficit/hyperactivity disorder endophenotypes. *Biological Psychiatry*. [Proceedings Paper]. 2005 Jun;57(11):1324-35
  14. Biederman J, and Faraone, SV. Attention-deficit hyperactivity disorder. *The Lancet* 2005;366(9481):237-248.
  15. Hille ETM, Ouden ALD, Saigal S, Wolke D, Lambert M, Whitaker A, et al Behavioural problems in children who weigh 1000 g or less at birth in four countries. *The Lancet* 2001;357:1641-43.
  16. Damasio H, Grabowski T, Frank R, Galaburda A, Damasio A. The return of Phineas Gage: clues about the brain from a famous patient. *Science* 1994;264:1102-5.
  17. Pelsser L, Frankena K, Toorman J, Savelkoul H, Dubois A, Pereira R, et al. Effects of a restriction elimination diet on the behaviour of children with attention-deficit hyperactivity disorder (INCA study): a randomised controlled trial. *Lancet* 2011;377:494-503.
  18. Balbernie R. Circuits and circumstances: the neurobiological consequences of early relationship experiences and how they shape later behaviour. *Journal of child psychotherapy* vol.27 no3 2001 237-255
  19. Schore AN. Attachment, affect Regulation and the Developing Right Brain: Linking Developmental neuroscience to Pediatrics. *Pediatrics in review* Vol26 No.6 June 2005
  20. Gadow K, & Nolan E. Differences between preschool children with ODD, ADHD, and ODD & ADHD symptoms. *Journal of Child Psychology and Psychiatry*, 2002, 43, 191–201
  21. McGough JJ, Barkley RA. Diagnostic Controversies in Adult Attention Deficit Hyperactivity Disorder. *Am J Psychiatry* 2004;161:1948-1956.
  22. Faraone S. V., Biederman J, and Mick E. The age-dependent decline of attention deficit hyperactivity disorder: a meta-analysis of follow-up studies. *Psychological Medicine* 2006;36(2):159-165.
  23. Simon V, Czobor P, Balint S, Meszaros A, and Bitter I. Prevalence and correlates of adult attention-deficit hyperactivity disorder: meta-analysis. *The British Journal of Psychiatry* 2009;194:204-211.
  24. Barkley RA. International consensus statement on ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry*. [Letter]. 2002 Dec;41(12):1389
  25. Weiss M, Murray C. Assessment and management of attention-deficit hyperactivity disorder in adults. *Can Med Assoc J*. [Review]. 2003 Mar;168(6):715-22.
  26. National Institute for Health & Clinical Excellence. Attention Deficit Hyperactivity Disorder: Diagnosis and management of ADHD in children, young people and adults, National Clinical Practice Guideline Number 72. London: The British Psychological Society and the Royal College of Psychiatrists, 2009.
  27. Hill P, Taylor E. An auditable protocol for treating attention deficit/hyperactivity disorder. *Arch Dis Child*. 2001 May;84(5):404-9.
  28. Wigal T, Greenhill L, Chuang S, McGough J, Vitiello B, Skrobala A, et al Safety and tolerability of methylphenidate in preschool children with ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry*, 2006,45, 1294–1303.
  29. Bradley C. The behavior of children receiving Benzedrine. *Am J Psychiatry* 1937;94:577-585.
  30. Michelson D, Buitelaar J, Danckaerts M, Gillberg C, Spencer TJ, Zuddas A, et al. Atomoxetine in the long-term prevention of relapse in ADHD. *Eur Neuropsychopharmacol*. [Meeting Abstract]. 2003 Sep;13:S455-S6.
  31. Sanders MR, Markie-Dadds C. & Turner KMT. (1998b) Practitioner's Manual for Standard Triple P. Families International Publishing, Brisbane, Qld, Australia.
  32. Webster-Stratton C. & Hancock L. Parent training for young children with conduct problems. Content, methods and therapeutic process. In: *Handbook of Parent Training* (ed. C. E. Schaefer), 1998, pp. 98–152. Wiley, New York, NY, USA
  33. Faraone SV, Biederman J, Spencer T, Wilens T, Seidman LJ, Mick E, Doyle AE. (2000). "Attention-deficit/hyperactivity disorder in adults: An overview." *Biological Psychiatry* 48(1): 9-20.
  34. Faraone SV, Spencer T, Aleardi M, Pagano C, Biederman J. Meta-analysis of the efficacy of methylphenidate for treating adult attention-deficit/hyperactivity disorder. *J Clin Psychopharmacol*. [Article]. 2004 Feb;24(1):24-9.
  35. Kooij JJ, Boonstra A, Swinkels SHN, Bekker EM, DeNoord I. Reliability, Validity, and Utility of Instruments for Self-Report and Informant Report Concerning Symptoms of ADHD in Adult Patients *Journal of attention disorder*. 2008,11 (4) 445-458.