



Attention Deficit Hyperactivity Disorder

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Objectives

- Review ADHD and its diagnostic features
- Risk factors and causes
- Focus on pre-school, school age, and adolescent presentations
- Management of ADHD
 - Behavioural
 - Pharmacologic

What is ADHD?

Basic Definition

- Neurodevelopmental disorder
 - Structure
 - Function
 - Neurochemistry
- Impacts on
 - Inattention
 - Hyperactivity
 - Impulsivity



Neurobiology of ADHD

Prefrontal Cortex

- Executive Function
- Attention / Focus
- Impulse Control

Anterior Cingulate Cortex

- Emotional Regulation
- Mood Instability
- Dysregulated Behavior

Basal Ganglia

- Motivation & Motor Activity
- Hyperactivity
- Difficulty with Reward Processing

Limbic System

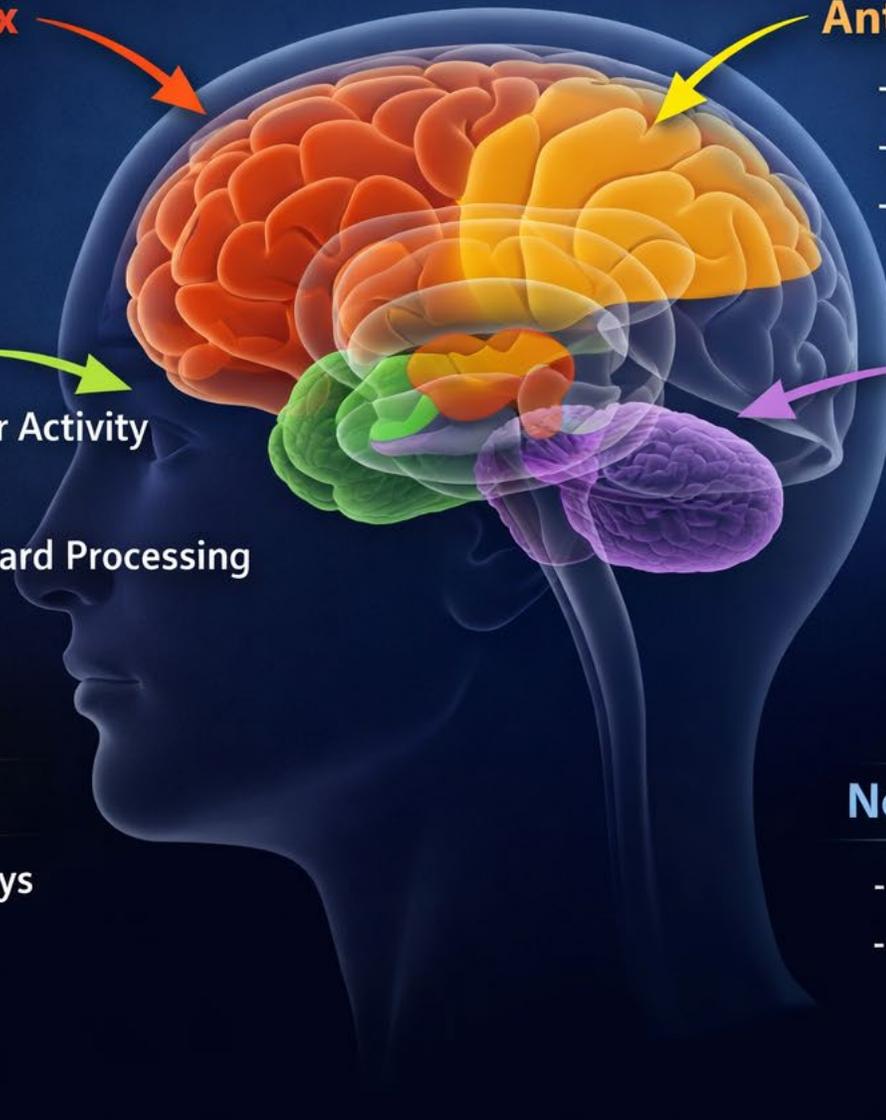
- Emotion & Memory
- Anxiety / Irritability
- Emotional Dysregulation

Dopamine

- Reward Pathways
- Motivation

Norepinephrine

- Arousal / Alertness
- Focus / Concentration



Neurobiology of ADHD – Key Circuits & Neurotransmitters

Brain Region / Circuit	Core Function	ADHD-Related Impact
• Prefrontal Cortex	Executive control, sustained attention,	Inattention, disorganization, poor self-regulation
• Anterior Cingulate Cortex	Error monitoring, emotional control,	Emotional reactivity, difficulty shifting attention
• Basal Ganglia (Striatum)	Reward processing, motivation, motor	Impulsivity, hyperactivity, altered reward sensitivity
• Limbic System (Amygdala/Hippocampus)	Emotion, stress response, memory integration	Mood lability, irritability, emotional dysregulation
• Dopamine Pathways	Reward, reinforcement learning, motivation	Reduced reward anticipation, need for immediate feedback
• Norepinephrine Systems	Arousal, alertness, attention modulation	Variable focus, impaired concentration, inconsistent performance

Take-Home Message: ADHD reflects dysregulation of fronto-striatal and fronto-limbic networks, modulated by dopamine and norepinephrine systems.

ADHD

Diagnosis

- Observable symptoms
 - Outside of the range of developmental norms
 - Different presentations of ADHD symptoms clusters
 - Fulfill “diagnostic criteria” - DSM-5, ICD-10
- Must impact function multiple domains
- Multiple sources - individual report, parents, schoolteachers, etc...
 - Additional help - questionnaires

Is ADHD ‘one diagnosis’?

No! ... and Yes!

- Where is the “defect” in the brain?
 - Past science: a disorder of executive function
 - New science: the past science is not untrue, but it doesn’t capture the full heterogeneity of its likely causes
 - e.g. organization vs impulsivity
- Overlaps genetically with many other psychiatric and medical conditions e.g. bipolar disorder, autism, depression, rheumatoid arthritis, obesity, and others
 - Where does one condition begin and another one end?

Science of ADHD

What do we know? Causes and Risk Factors

Genetics of ADHD

- Highly Heritable - 70-80%
- 3/4 of phenotypic presentation can be explained by genetics
 - 7,000 genetic variants have been identified
 - Categorical → dimensional, variable
 - No single “ADHD gene”
- Environmental risk factors - 20-30%

Environment

Risk Factors

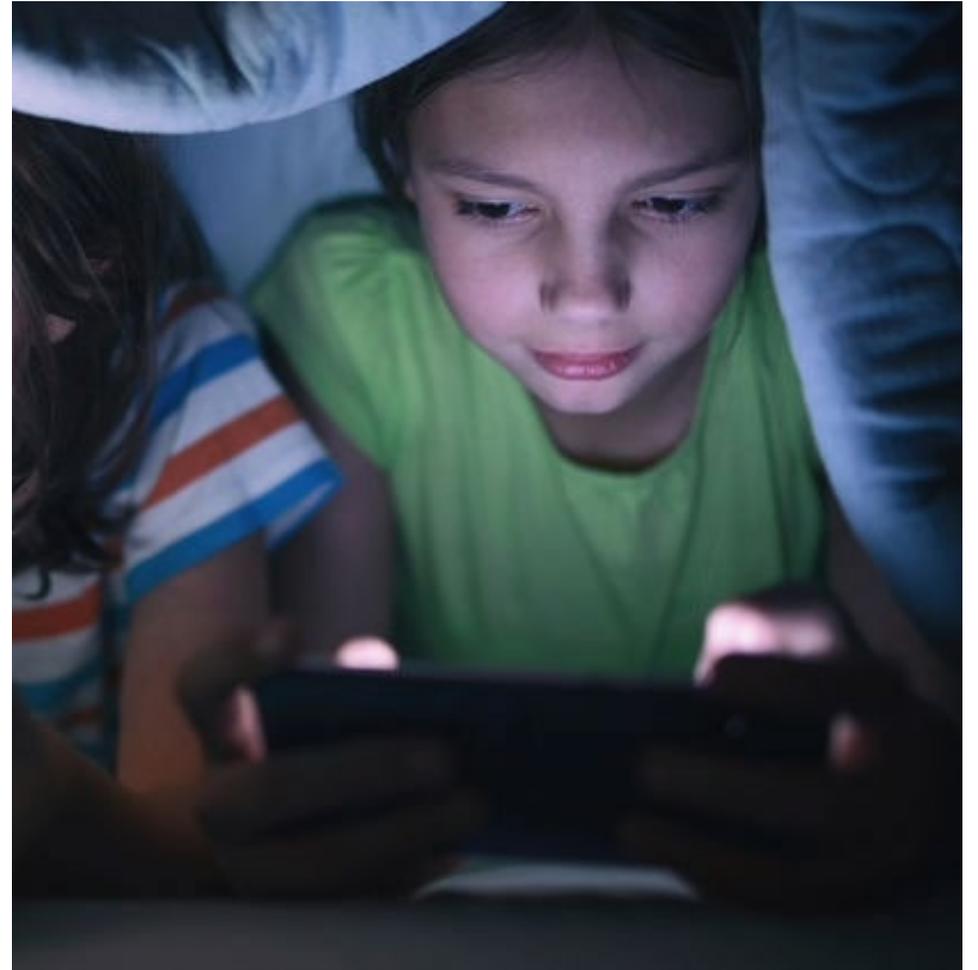
- Heavy metal and chemicals: lead exposure, organophosphates, phthalates, manganese
- Prenatal substances (smoking, alcohol, caffeine) show mixed findings and genetic confounding
- **Nutritional links: low folate, maternal obesity, low omega-3 (iron/zinc inconsistent)**
- **Psychosocial adversity: prenatal stress, trauma, institutional care increases risk**
- Overall: effects are modest, complex, and require better prospective cohort data



Environment

Risk Factors

- Electronic device/media use
- Large meta-analyses show that higher screen time is associated with more ADHD-like symptoms, especially:
 - Inattention
 - Impulsivity
 - Poorer executive functioning



Environment

Screen Time Continued

- Small but reliable association
- Bidirectional association
- Current consensus?
 - NOT thought to cause ADHD
 - But more needs to be studied...
 - Sleep and psychosocial factors play mediating roles

Screen Time

Shou, Q., Yamashita, M. & Mizuno, Y. Association of screen time with attention-deficit/hyperactivity disorder symptoms and their development: the mediating role of brain structure. *Transl Psychiatry* 15, 447 (2025)

“Regarding the relationship between screen time and mental health, studies have found that increased screen time is associated with increased attention-deficit/hyperactivity disorder (ADHD) symptom severity and a higher risk of meeting diagnostic criteria for ADHD, a neurodevelopmental disorder characterized by age-inappropriate inattention and/or hyperactivity/impulsivity. However, several studies have also reported that the association between screen time and ADHD tends to be weak, with small effect sizes that are not considered clinically significant or harmful.”

ADHD Causes - Summary

The causes may be complex, but the expression of the causes is uniform.

Evolving science may allow us to target underlying causes for improved outcomes in treatment.



ADHD

Across Childhood and Adolescence

- Incidence reported: 7 - 9%
- More common in males
 - Females less likely to be diagnosed
 - 4 year delay
 - Different presentation? Or different understanding?
 - Anja vs. Eddie

Childhood ADHD

Pre-school Age (2-6 years)

- Can show early signs of ADHD
- If diagnosed - 80% retain diagnoses into later childhood
- Already show signs of
 - Peer rejection
 - Increased accidents and injuries
 - Academic underachievement



Childhood ADHD

School Age

- Often classic “textbook” presentations of ADHD
 - Hyperactive, impulsive, distractible
 - Not listening, hyper, rambunctious
 - Easily distracted, hard to focus
- May impact self esteem, peer relationships, family function

Adolescent ADHD

When things begin to change...

- Presentation may be more confounded
- ADHD is associated with higher rates of:
 - Substance use
 - Legal involvement
 - School drop out
 - Teenage pregnancy & birth
 - Depression/suicide
 - MVAs
 - Traumas/injuries

Adolescent Females with ADHD

- *Misdiagnosed*
- *Polypharmacy*
- *Higher rates of healthcare utilization*
- *BPD/Addiction/Trauma*
- *Become a teenage mother (15% vs 3%)*
 - *Increased rates of complications*
 - *Preterm birth*
 - *Comorbidities (PPD, PPA)*
 - *Social assistance*
 - *Single parent*
 - *Depressive symptoms with hormonal contraception*

Adolescent ADHD

- Less likely to be open to treatment
- Families/caregivers engage in treatment
 - Teenager does not!
- General trend, both medication and non-med intervention



ADHD

Comorbidity

- ODD: 40–60%
- Conduct Disorder: 25–35% (ASPD in adults)
 - Aggressive behaviours
- Anxiety/Depression: 25–40%
- Substance Use Disorder: 20–25%
- Learning Disorders: 20–40%

ADHD Treatment

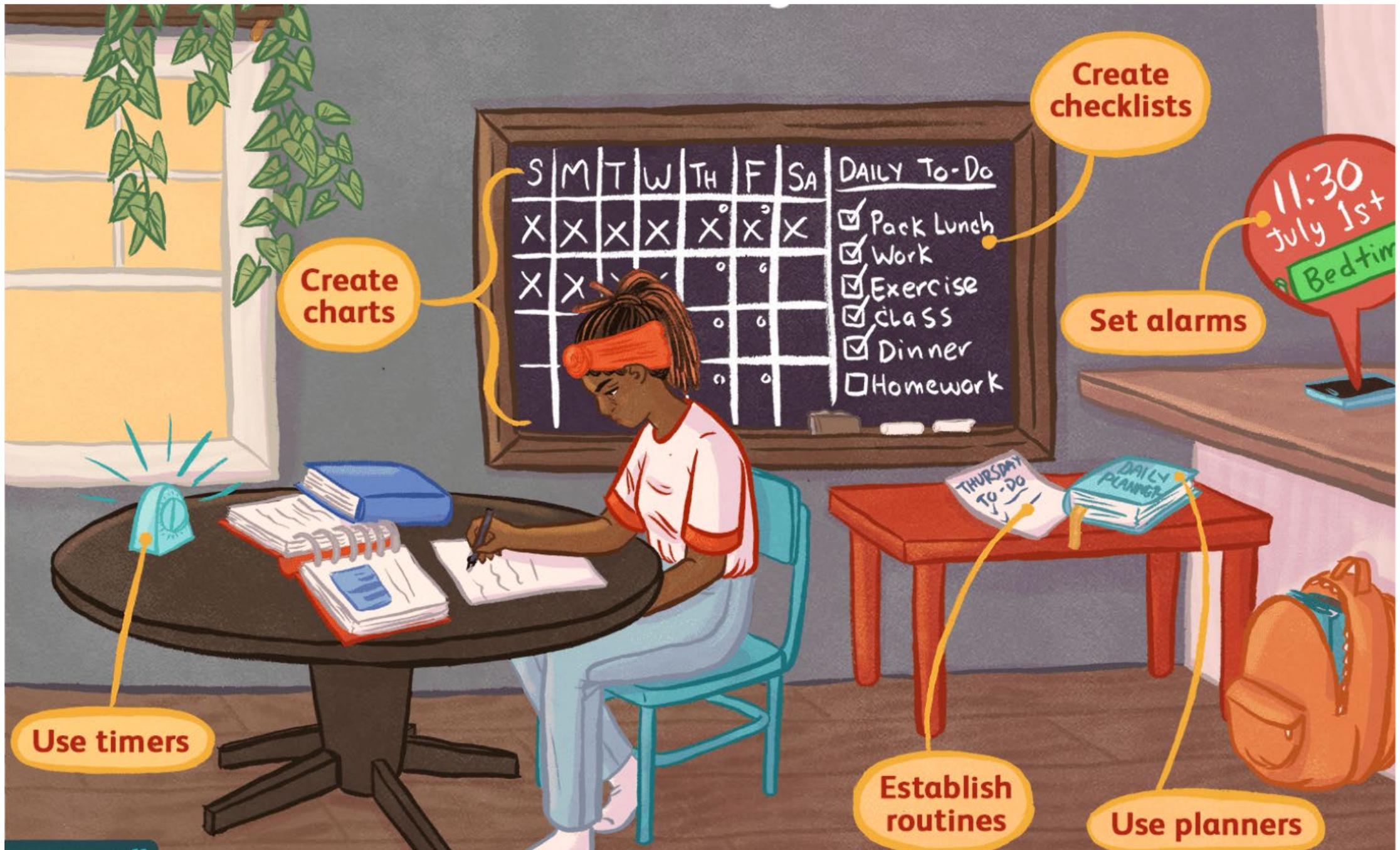
Non-Pharmacological and Pharmacologic

- 8-13 years of reduced life expectancy without treatment
- Pharmacologic >>> Non-Pharmacologic
 - Both *should* be offered
 - Some guidelines suggest non pharmacologic only if meds fail/limited response
- “*PILLS AND SKILLS*”

Non-Pharmacologic Interventions

Evidence base

- Broadly, *Cognitive Behavioural Therapy* most efficacious
 - Includes thinking patterns, behavioural skills, strategies arounds routine management
 - Pure CBT works best if comorbid internalizing symptoms (anxiety, depression)
 - Sleep hygiene included in this category
 - Recent data - sleep hygiene vs sleep quality in ADHD



Non-Pharmacologic Interventions

Evidence base

- Exercise - helpful for everyone's cognitive function, no specific effects in ADHD noted
- Parent management training - inconclusive for ADHD treatment
 - Overall helps with improved general parenting skill
 - Efficacy for ODD/conduct
- Cognitive training, neurofeedback, neurostimulation* - weak evidence base showing no improvements*
 - *one trial on external trigeminal nerve stimulation (FDA approved)

Non-Pharmacologic Interventions

Nutrition

Supported by evidence (limited/adjunctive):

- Balanced, nutrient-rich diets correlate with *fewer* ADHD symptoms
- Some individuals may benefit from omega-3 supplements or specific micronutrient supplementation if deficient

Not sufficiently supported by strong evidence:

- Diets as standalone ADHD “cures” or universal treatments (e.g., elimination diets)
- Specific foods reliably worsening or improving symptoms across all individuals

Pharmacological Management

Basics

- Principle in pediatric prescribing:
 - *Start LOW and go SLOW*
- Treatment choice
 - Guidelines (CADDRA, NICE, AACAP/AAP)
 - Follow up ability
 - Side effect monitoring (increased risk with decreasing age)
 - Co-morbidity
 - Abuse potential
 - Objective feedback eg. Rating scales

Pharmacological Management

Medication

- Guidelines consensus*: First line treatment is MEDICATION
 - STIMULANTS and NON-Stimulants

*excludes pre-school age

CADDRA GUIDE TO ADHD PHARMACOLOGICAL TREATMENTS IN CANADA - NOVEMBER 2022

	Medications & Illustrations	Delivery	Duration of action ¹	Starting dose ²	Release mode Immediate/Delayed (%)	Dose titration per product monograph ³
AMPHETAMINE-BASED PSYCHOSTIMULANTS						
First Line	Adderall XR* Capsules 5, 10, 15, 20, 25, 30 mg 	Granules can be sprinkled	~12 h	5-10 mg q.d. a.m.	50/50	▲5-10 mg at weekly intervals Max. dose/day: Children = 30 mg Adolescents & Adults = 20-30 mg
First Line	Vyvanse* Capsules 10, 20, 30, 40, 50, 60, 70 ⁴ mg Chewable Tablets 10, 20, 30, 40, 50, 60 mg 	Capsule content can be diluted in liquid or sprinkled Chewable tablets should be chewed thoroughly	~13-14 h	20-30 mg q.d. a.m.	Not Applicable (Prodrug)	▲10-20 mg by clinical discretion at weekly intervals Max. dose/day: All ages = 60 mg
Second Line	Dexedrine* Tablets 5 mg Spansules 10, 15 mg 	Scored Tablet Beaded Formulation	~4 h ~6-8 h	Tablets = 2.5 to 5 mg b.i.d. Spansules = 10 mg q.d. a.m.	100/0 50/50	▲5 mg at weekly intervals Max. dose/day: (q.d. or b.i.d.) Children & Adolescents = 20-30 mg Adults = 50 mg
METHYLPHENIDATE-BASED PSYCHOSTIMULANTS						
First Line	Biphentin* Capsules 10, 15, 20, 30, 40, 50, 60, 80 mg 	Granules can be sprinkled	~10-12 h	10-20 mg q.d. a.m.	40/60	▲10 mg at weekly intervals Max. dose/day: Children & Adolescents = 60 mg Adults = 80 mg
First Line	Concerta* Extended Release Tablets 18, 27, 36, 54 mg 	Osmotic-Controlled Release Oral Delivery System (OROS) ⁵	~12 h	18 mg q.d. a.m.	22/78	▲18 mg at weekly intervals. Max. dose/day: Children & Adolescents = 54 mg Adults = 72 mg
First Line	Foquest* Capsules 25, 35, 45, 55, 70, 85, 100 mg 	Granules can be sprinkled	~13-16 h	25 mg q.d. a.m.	20/80	▲10-15 mg in intervals of no less than 5 days Max. dose/day: Children & Adolescents = 70 mg Adults = 100 mg
Second Line	Methylphenidate short-acting Ritalin* SR Tablets 5 mg (generic) 10, 20 mg (Ritalin*) Tablets 20 mg 	Scored Tablet Wax Matrix Preparation	~3-4 h ~8 h	5 mg b.i.d. to t.i.d. Adult: 20 mg q.d.	100/0 100/0	▲5-10 mg at weekly intervals Max. dose/day: All ages = 60 mg
NON-PSYCHOSTIMULANT - SELECTIVE NOREPINEPHRINE REUPTAKE INHIBITOR						
Second Line	Strattera* (Atomoxetine) Capsules 10, 18, 25, 40, 60, 80, 100 mg 	Capsule needs to be swallowed whole to reduce GI side effects	Up to 24 h	Children & Adolescents: 0.5 mg/kg/day Adults = 40 mg q.d. for 7-14 days	Not Applicable	Maintain dose for a minimum of 7-14 days before adjusting: Children = 0.8 then 1.2 mg/kg/day 70 kg or Adults = 60 then 80 mg/day Max. dose/day: 1.4 mg/kg/day or 100 mg
NON-PSYCHOSTIMULANT - SELECTIVE ALPHA-2A ADRENERGIC RECEPTOR AGONIST						
Second Line	Intuniv XR* (Guanfacine XR) Extended Release Tablets 1, 2, 3, 4 mg 	Pills need to be swallowed whole to keep delivery mechanism intact	Up to 24 h	1 mg q.d. (morning or evening)	Not Applicable	Maintain dose for a minimum of 7 days before adjusting by no more than 1 mg increment weekly. Max. dose/day: Monotherapy: 6-12 years = 4 mg, 13-17 years = 7 mg As adjunctive therapy to psychostimulants: 6-17 years = 4 mg

Illustrations do not reflect actual size of pills/capsules. Longer-acting stimulants tend to have lower abuse potential than shorter-acting formulations. Non-stimulant formulations have no abuse potential.

¹Pharmacokinetic and pharmacodynamic responses vary from individual to individual. The clinician must use clinical judgment as to the duration of efficacy and not solely rely on reported values for PK-PD and duration of effect. ²Starting doses in table are taken from product monographs. CADDRA recommends usually starting with the lowest dose available. ³For specific details on how to start, adjust and switch ADHD medications, clinicians should refer to the Canadian ADHD Practice Guidelines (www.caddra.ca). ⁴Vyvanse 70 mg is an off-label dosage for ADHD treatment in Canada. Original version of this sheet developed by Dr. Annick Vincent in collaboration with Direction des communications et de la philanthropie, Laval University. Access provincial and federal formulary information at tinyurl.com/uf3mrxl



Treatment of ADHD

Stimulant	Non-stimulant Atomoxetine	Alpha-2 Adrenergic Agonist
Mechanism: Dopamine/Norepinephrine transmission in PFC & BG	Mechanism: Selective norepinephrine reuptake inhibitor	Mechanism: Central alpha-2 adrenergic agonist
Onset of Action: Within hours	Onset of Action: 4–6 weeks	Onset of Action: Immediate and delayed
Adverse Effects: <ul style="list-style-type: none"> • Sleep disturbance • Appetite suppression • Paradoxical worsening (irritability/anxiety) • Mood changes • Headaches • Rebound symptoms as dose wears off • Over-focussing on details Tics/mannerisms 	Adverse Effects: <ul style="list-style-type: none"> • Sleep disturbance • Appetite disturbance • Paradoxical worsening • Mood changes • Headaches • Dyspepsia 	Adverse Effects: Sedation <ul style="list-style-type: none"> • Hypotension, dizziness • Dry mouth • Rebound withdrawal effects • Irritability • Hypertension (if abruptly stopped)
Clinical role: First-line choice	Black Box Warning: Hepatitis, Aggression, Suicidality	Clinical role: Helpful when tics, sleep problems, or hyperarousal are prominent
	Clinical role: Useful when comorbid depression/anxiety or stimulant intolerance	Clinical role: Helpful when tics, sleep problems, or hyperarousal are prominent

Major Considerations in Treatment Selection

- ✓ Follow-up feasibility
- ✓ Side-effect monitoring

- ✓ Abuse/diversion potential
- ✓ Objective feedback (rating scales, school reports)

Stimulants

Considerations and side effects con't

- Differences between methylphenidate and amphetamine group
- Action of onset
- Sleep?
- Growth
- **CARDIOVASCULAR** workup

Atomoxetine

Considerations

- Action of onset
- Efficacy
- Black box warning (FDA) - Suicidal ideation
 - **0.4% (5/1357)** of atomoxetine-treated youth
 - **0% (0/851)** of placebo-treated youth
- Cardiac Side Effects
- Liver (Jaundice, dark urine, abdominal pain → stop medication)
- Bipolar Disorder

Alpha agonists

Guanfacine XR (Intuniv XR) and Clonidine

- Efficacy
- Dosing (clonidine)
- Clonidine - consider in PTSD
- Hyperactive/impulsive presentation

QUESTIONS?

kinark.on.ca

BETTER OUTCOMES. TOGETHER.