Effects of E-cigarettes on the Nervous System

Focus on Children and Youth

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เอกสารประกอบการอบรมเชิงปฏิบัติการเครือข่ายสายสามัญเพื่อสังคมปลอดบุหรี่

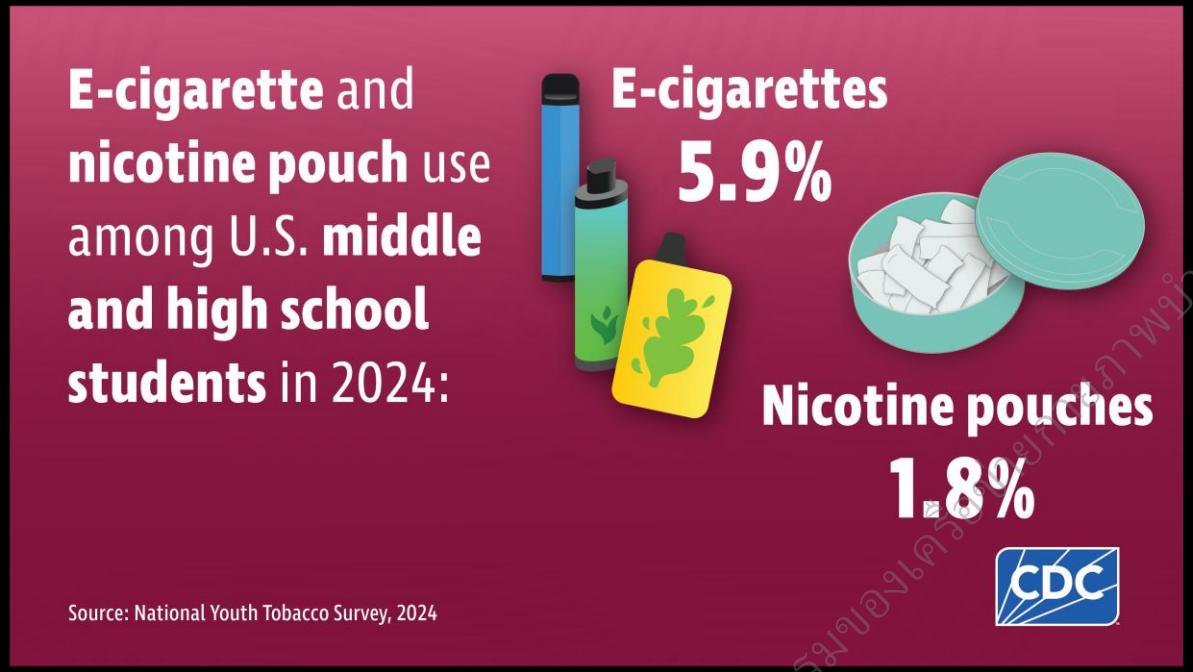
E-Cigarettes (Vapes)

- There are no safe tobacco products, including e-cigarettes.
- E-cigarettes should not be used by youth, young adults, or women who are pregnant.
- Adults who have never smoked or used other tobacco products, including e-cigarettes, should not start.

เอกสารประกอบการอบรมเชิงปฏิบัติการ...

E-Cigarettes (Vapes). (2025, January 31). Smoking and Tobacco Use. https://www.cdc.gov/tobacco/e-cigarettes/index.html

Youth E-cigarette Use: Prevalence and Context



- In 2024, about 5.9% of U.S. middle and high school students (1.63 million youth) were current e-cigarette users, making e-cigarettes the most commonly used tobacco product among teens.
- Most youth who vape use flavored products and many report frequent or daily use.

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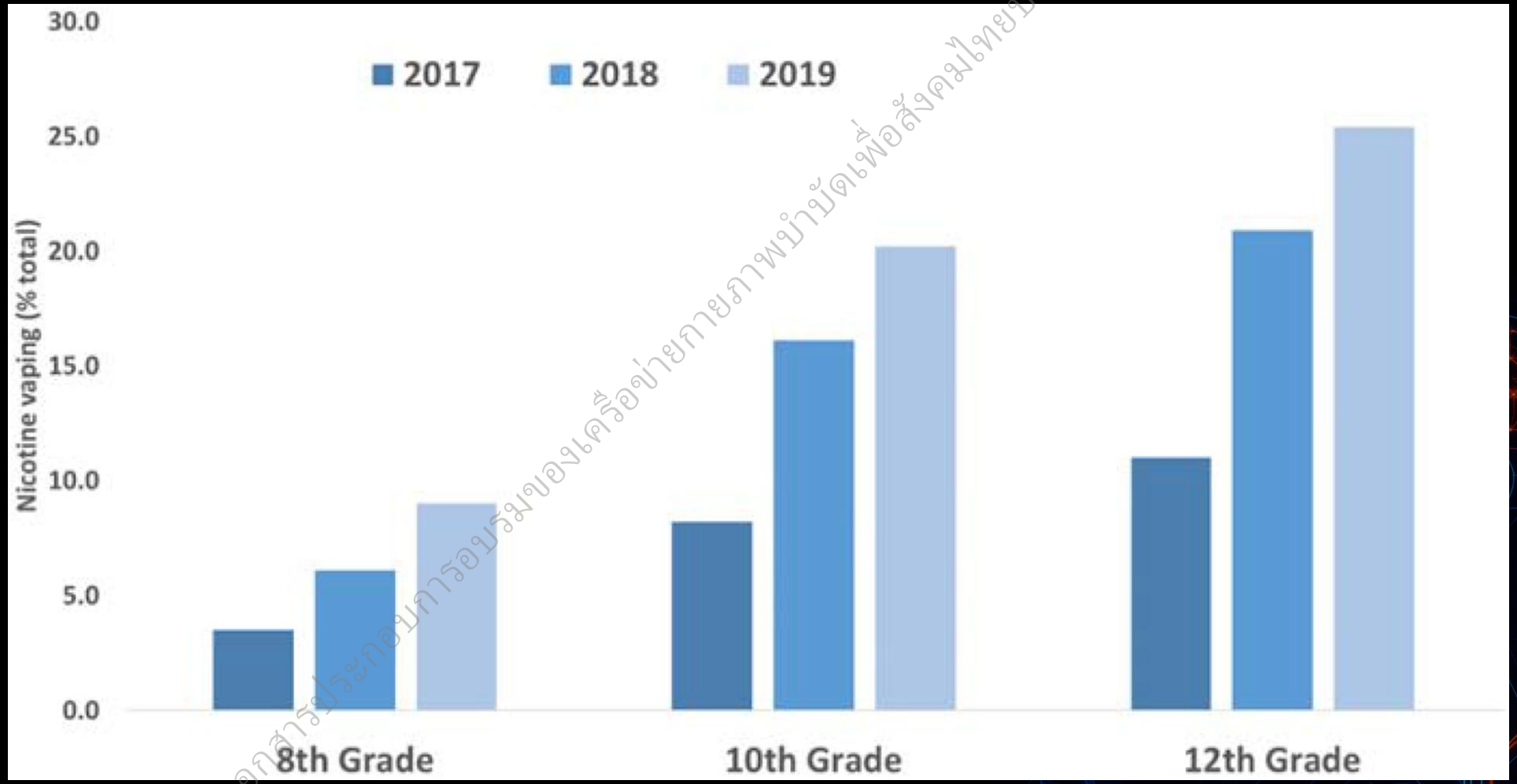
E-Cigarette use among youth. (2024, October 17). Smoking and Tobacco Use. https://www.cdc.gov/tobacco/e-cigarettes/youth.html

High school students vaping during the last 30 days, 2017–19 (%)



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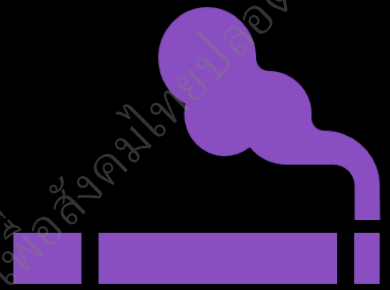
Leslie, F. M. (2020). Unique, long-term effects of nicotine on adolescent brain. *Pharmacology Biochemistry and Behavior*, *197*, 173010. https://doi.org/10.1016/j.pbb.2020.173010



Vaping is widespread among adolescents due to **product appeal** (flavors, design) and **peer influence**.

No form of tobacco is safe for youth – their brains and bodies are still developing, and nicotine exposure at this age can cause lasting harm

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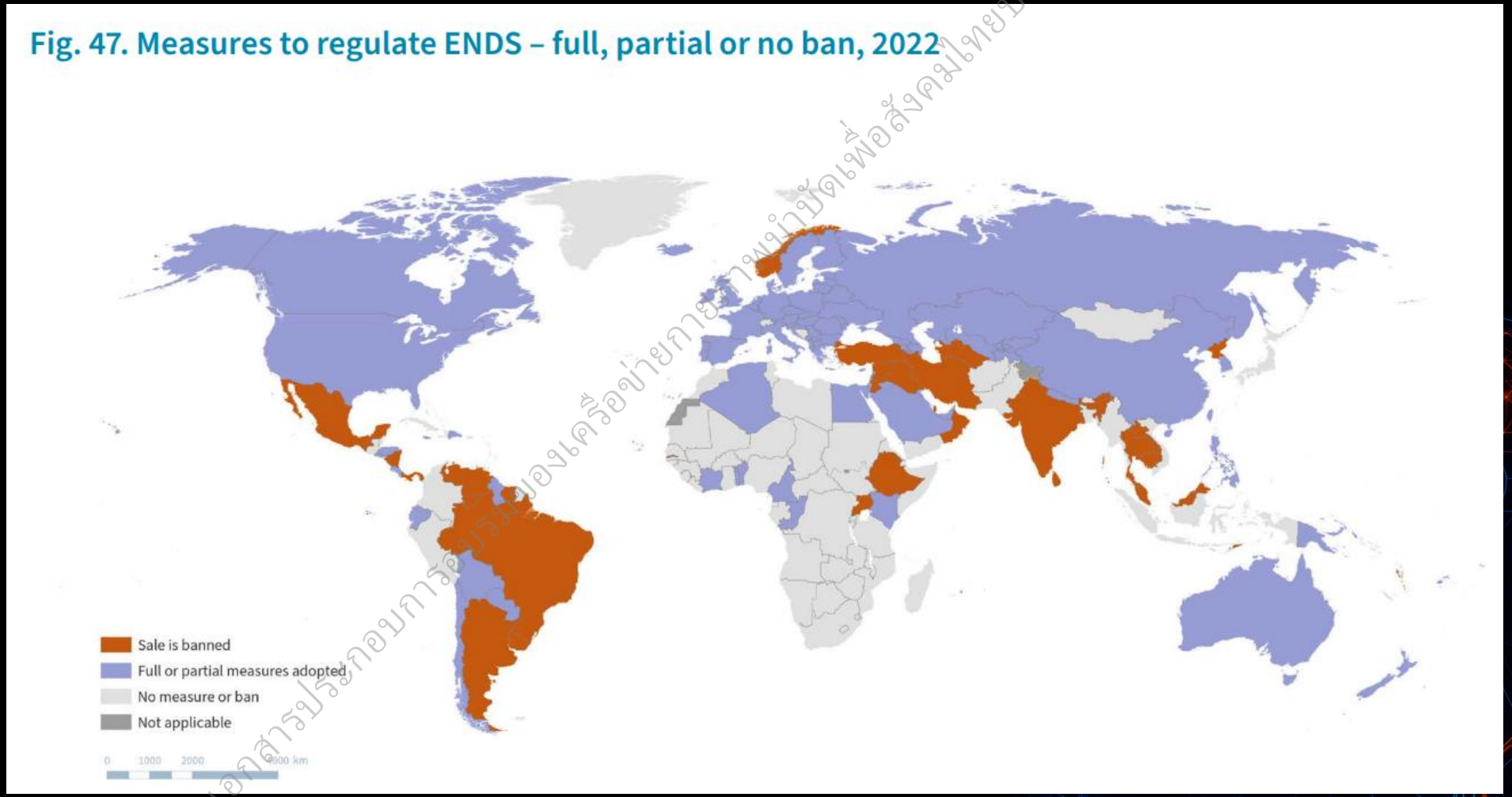
Tobacco: e-cigarettes. (2025, May 30). https://www.who.int/news-room/questions-and-answers/item/tobacco-e-cigarettes

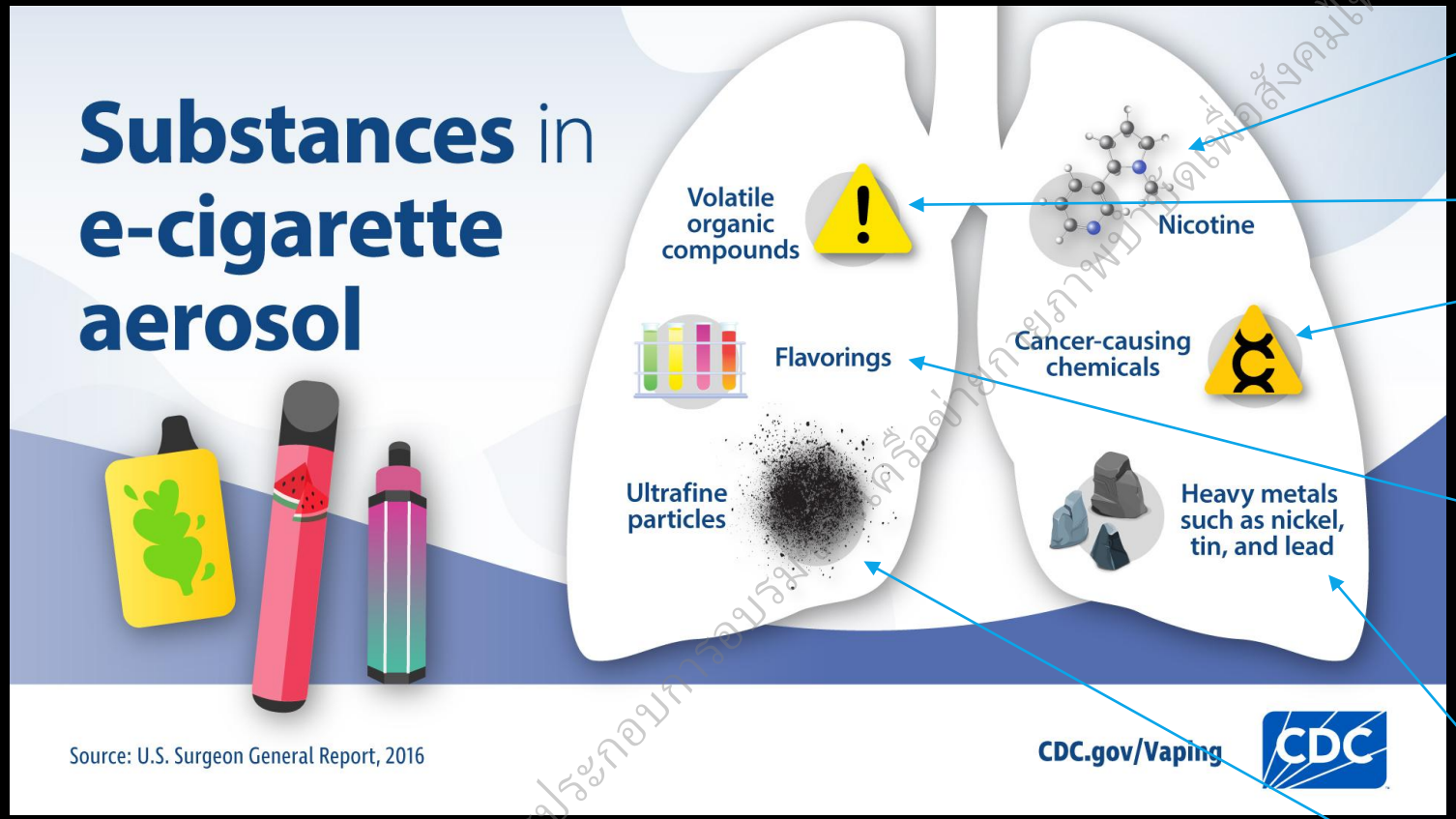
Measures to regulate ENDS – full, partial or no ban, 2022



เอกสารประกอบการอบรมเครือข่ายการสื่อสารเพื่อสังคมไทยปลอดบุหรี่

World Health Organization (2023). *WHO report on the global tobacco epidemic, 2023: protect people from tobacco smoke*. World Health Organization.

E-cigarette aerosol is NOT harmless “water vapor



Nicotine, a highly addictive chemical that can harm adolescent brain development

Volatile organic compounds

Cancer-causing chemicals

Flavorings such as diacetyl, a chemical linked to a serious lung disease. Some flavorings used in e-cigarettes may be safe to eat but not to inhale.

Heavy metals such as nickel, tin, and lead

Tiny particles that can be inhaled deep into the lungs

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About E-Cigarettes (Vapes). (2024, October 24). Smoking and Tobacco Use. https://www.cdc.gov/tobacco/e-cigarettes/about.html

Nicotine's Mechanisms

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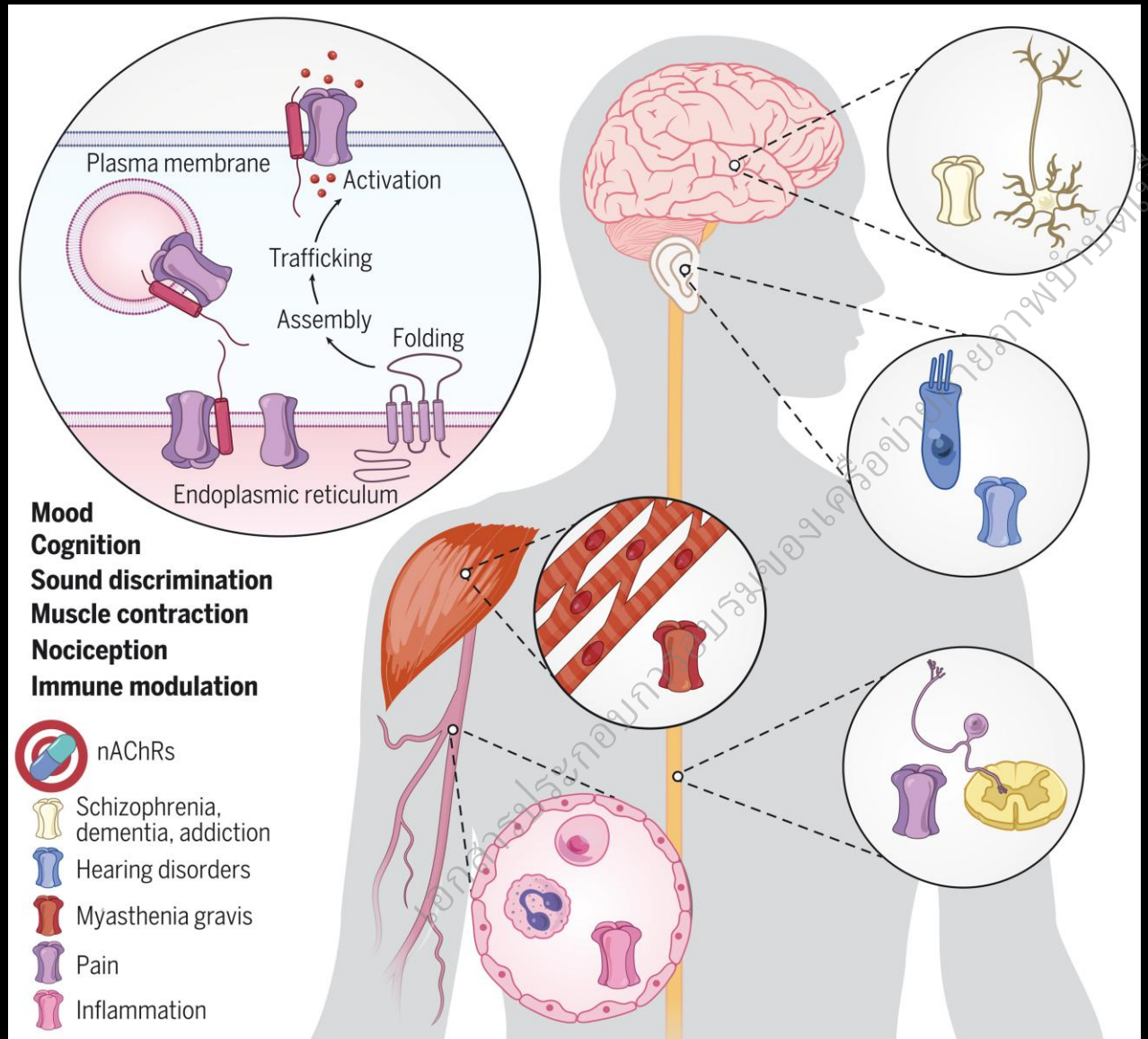
Nicotinic Acetylcholine Receptors (nAChRs)



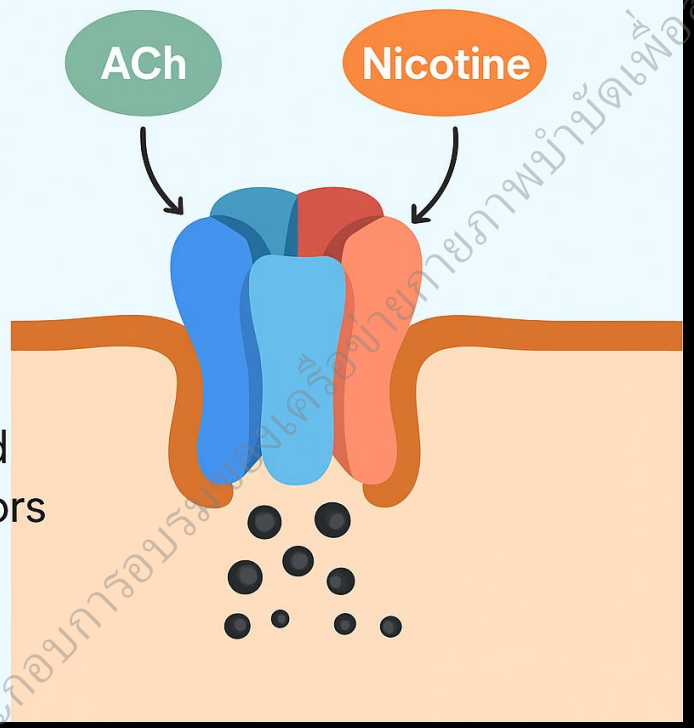
- **nAChRs** = pentameric ligand-gated ion channels widely expressed in the brain.
- Activated by acetylcholine (ACh) and nicotine.
- Control ion flow: Na^+, K^+, and Ca^{2+} → influence neuron excitability.

Matta, J. A., Gu, S., Davini, W. B., & Bredt, D. S. (2021). Nicotinic acetylcholine receptor redux: Discovery of accessories opens therapeutic vistas. *Science*, *373*(6556). https://doi.org/10.1126/science.abg6539

Nicotine's Actions on nAChRs

Nicotine's Actions on nACHRs

- Nicotine can activate, inactivate, or desensitize nAChRs depending on:
  - Dose
  - Subunit composition
- Unlike ACh, nicotine has longer-lasting effects and can overstimulate receptors



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Leslie, F. M. (2020). Unique, long-term effects of nicotine on adolescent brain. Pharmacology Biochemistry and Behavior, 197, 173010. https://doi.org/10.1016/j.pbb.2020.173010

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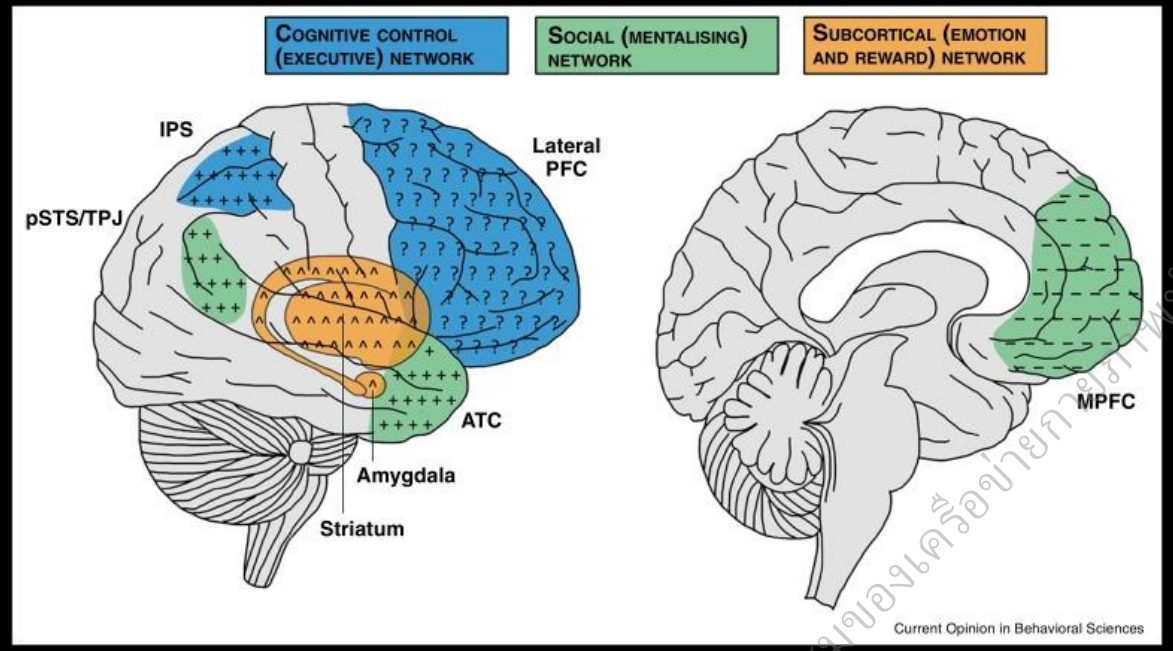
Incomplete Brain Maturation



Dumontheil, I. (2016). Adolescent brain development. *Current Opinion in Behavioral Sciences*, *10*, 39–44. https://doi.org/10.1016/j.cobeha.2016.04.012

- The **adolescent brain is still developing, especially the prefrontal cortex (PFC).**
- PFC governs executive functions, including:
  - Decision-making
  - Attention
  - Impulse control
- PFC is one of the last regions to fully mature — continues into the mid-20s.

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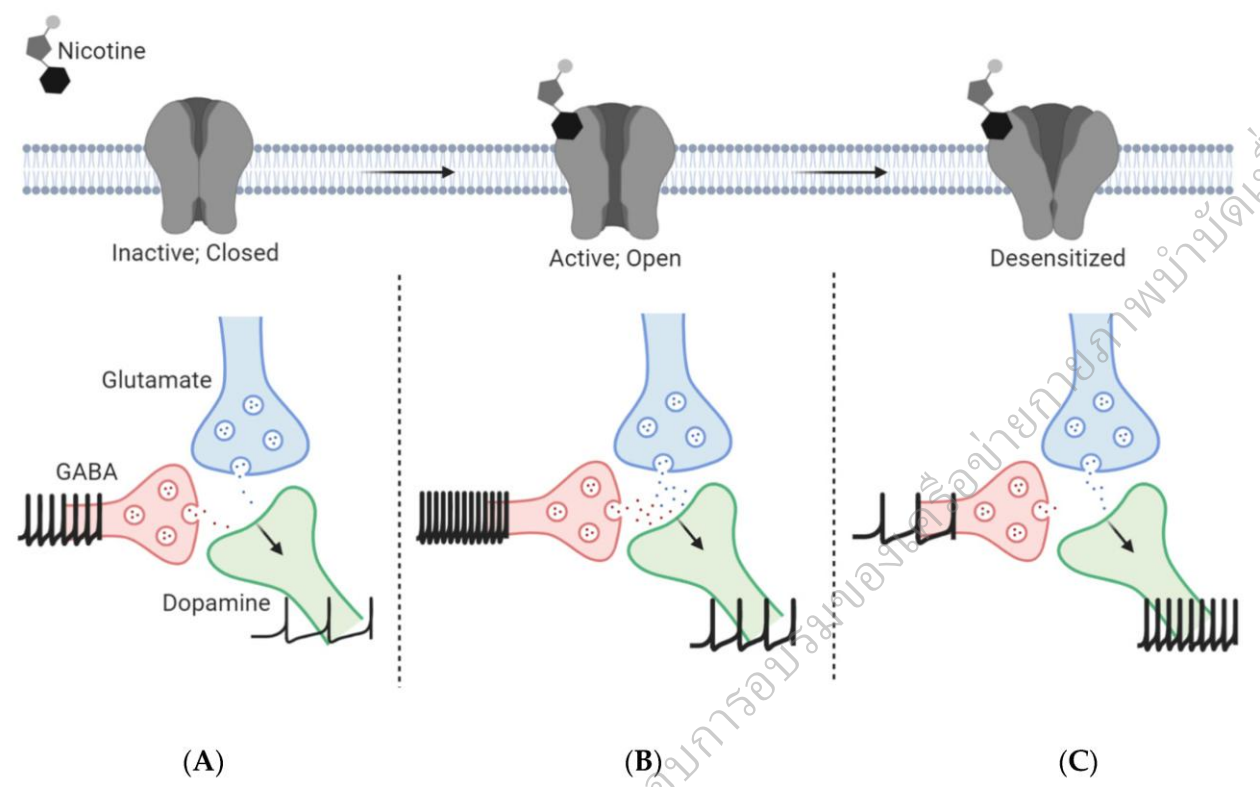
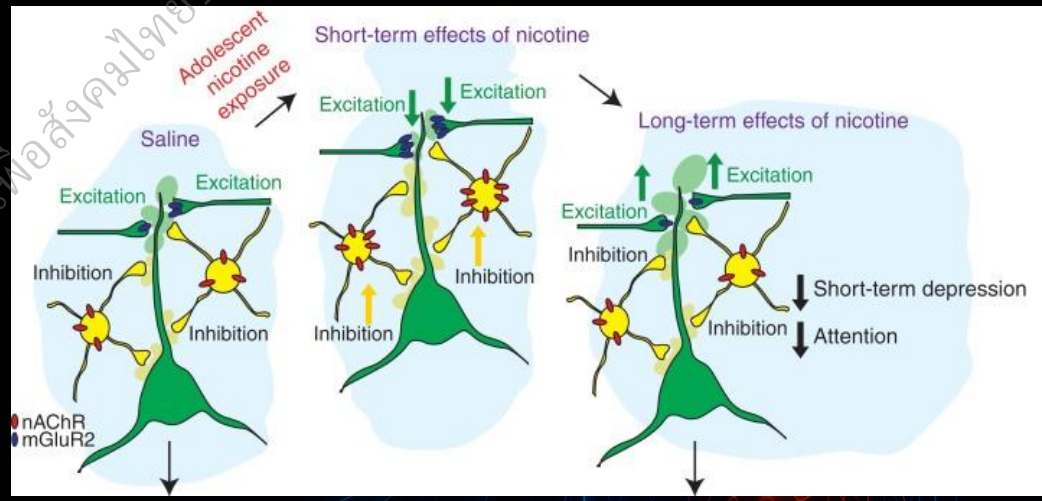
Short-term and long-term adaptations in prefrontal cortex (PFC) neuronal networks caused by nicotine exposure during adolescence

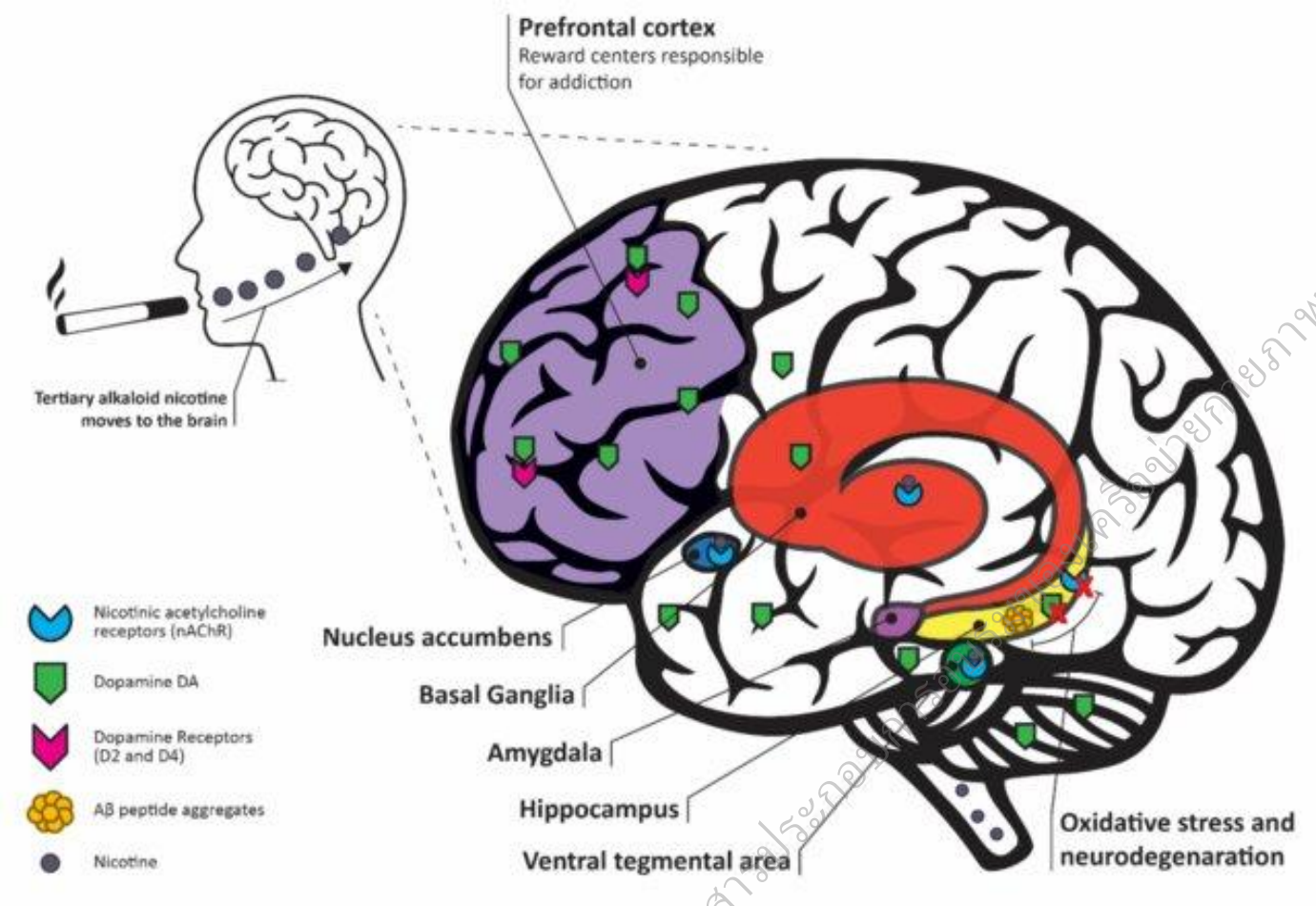


Cooper, S. Y., & Henderson, B. J. (2020). The Impact of Electronic Nicotine Delivery System (ENDS) Flavors on Nicotinic Acetylcholine Receptors and Nicotine Addiction-Related Behaviors. *Molecules*, *25*(18), 4223. https://doi.org/10.3390/molecules25184223



Goriounova NA, Mansvelder HD. Short- and long-term consequences of nicotine exposure during adolescence for prefrontal cortex neuronal network function. Cold Spring Harb Perspect Med. 2012 Dec 1;2(12):a012120. doi: 10.1101/cshperspect.a012120.

Adolescent Brain: Unique Sensitivity

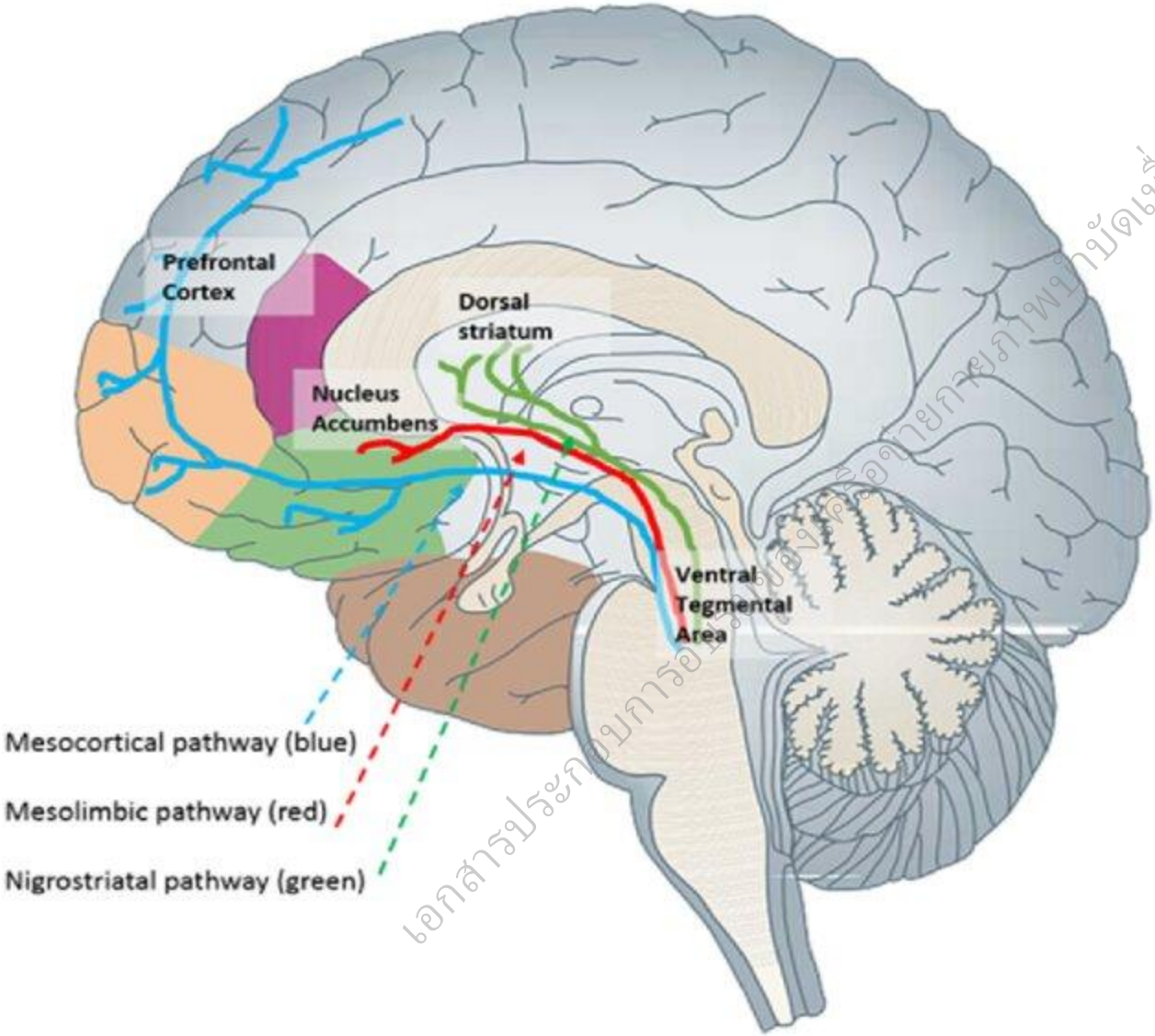


- **nAChRs are highly expressed during adolescence**, a critical brain development stage.
- **Adolescents show higher expression of nAChRs in:**
  - **Ventral tegmental area (VTA)** – dopamine-producing region
  - **Basal ganglia, Nucleus accumbens and prefrontal cortex (PFC)** – linked to motivation, reward, and executive function

Almahasneh, F., Gerges, R. H., Abu-El-Rub, E., & Khasawneh, R. R. (2023). Nicotine Abuse and Neurodegeneration: Novel pharmacogenetic targets to aid quitting and reduce the risk of dementia. *CNS & Neurological Disorders - Drug Targets*, *23*(1), 2–8. https://doi.org/10.2174/1871527322666230220121655

Leslie, F. M. (2020). Unique, long-term effects of nicotine on adolescent brain. Pharmacology Biochemistry and Behavior, 197, 173010. https://doi.org/10.1016/j.pbb.2020.173010

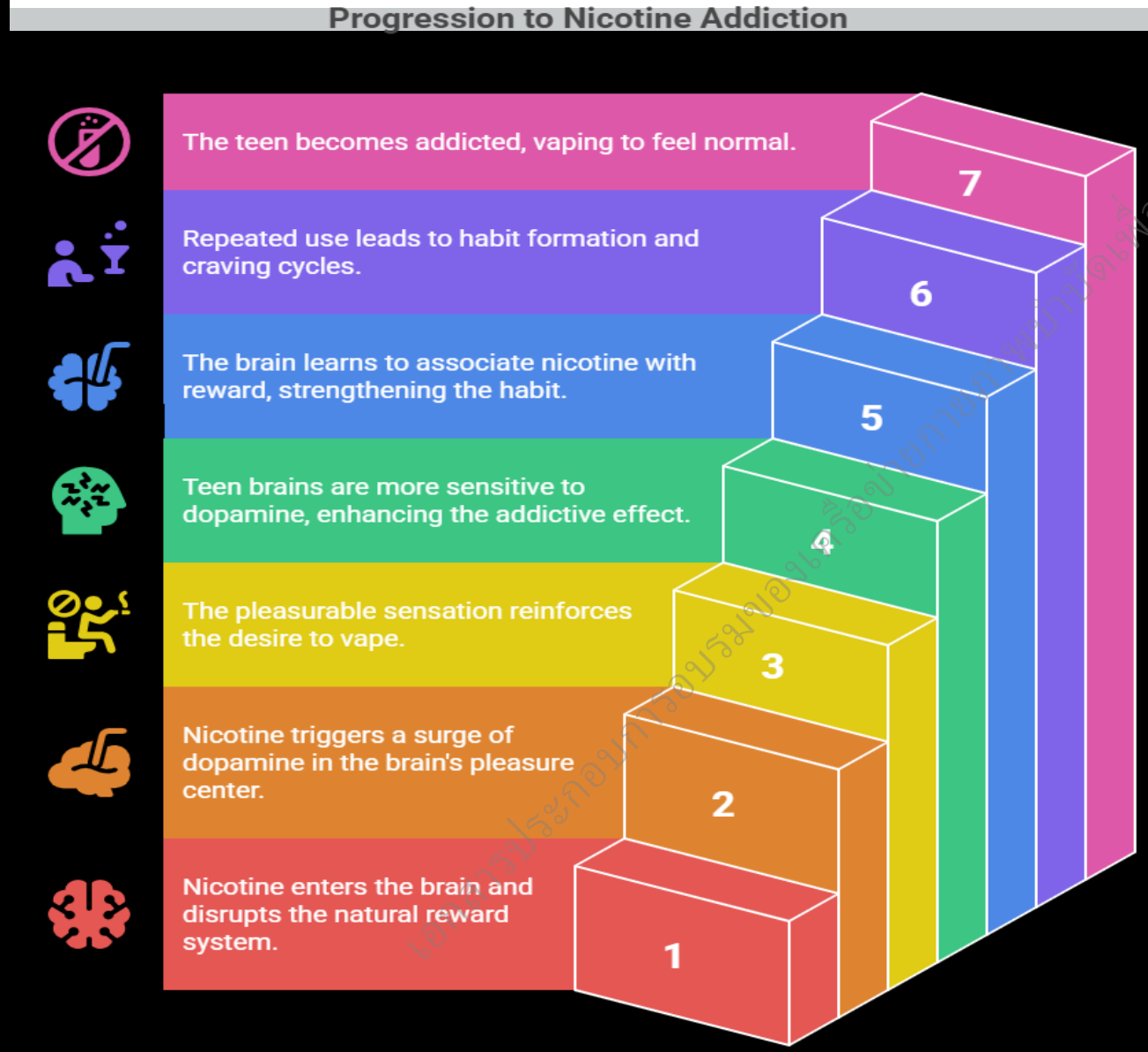
Dopamine & the Reward Pathway



เอกสารประกอบการอบรมของศูนย์การอาหารและยาพบำบัดเพื่อสังคมไทยปลอดบุหรี่

Ferrer-Pérez, C., Montagud-Romero, S., & Blanco-Gandía, M. C. (2024). Neurobiological Theories of Addiction: A Comprehensive Review. *Psychoactives*, *3*(1), 35–47. https://doi.org/10.3390/psychoactives3010003

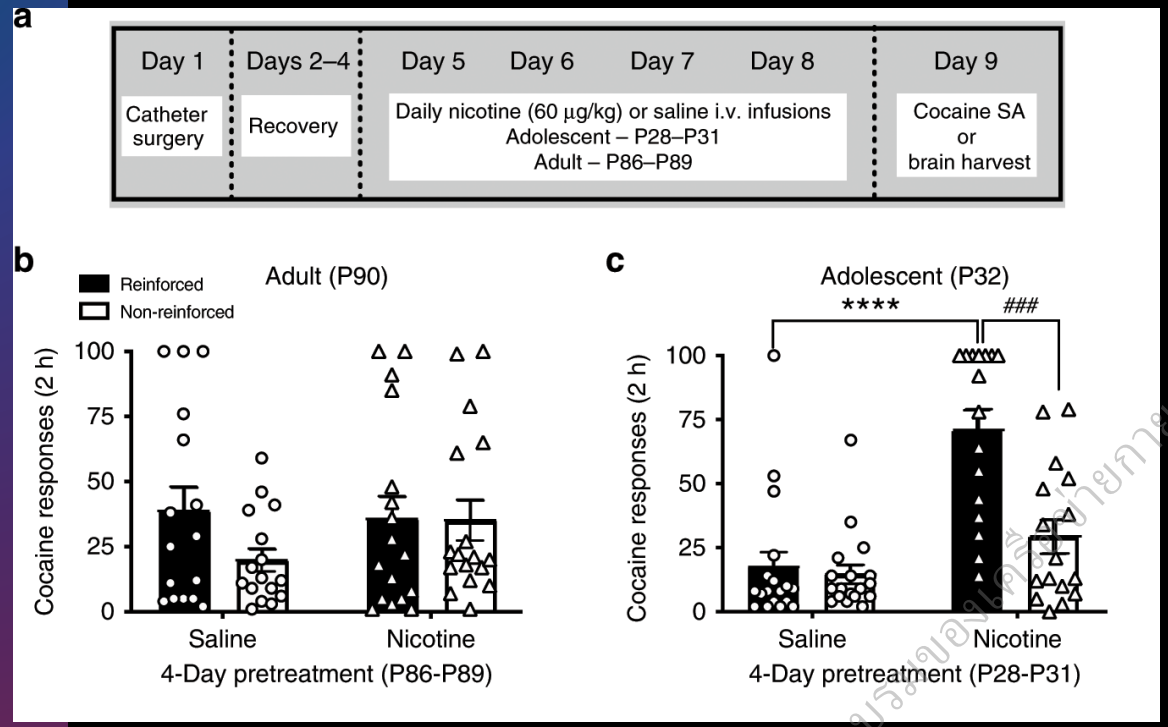
Addiction Mechanism

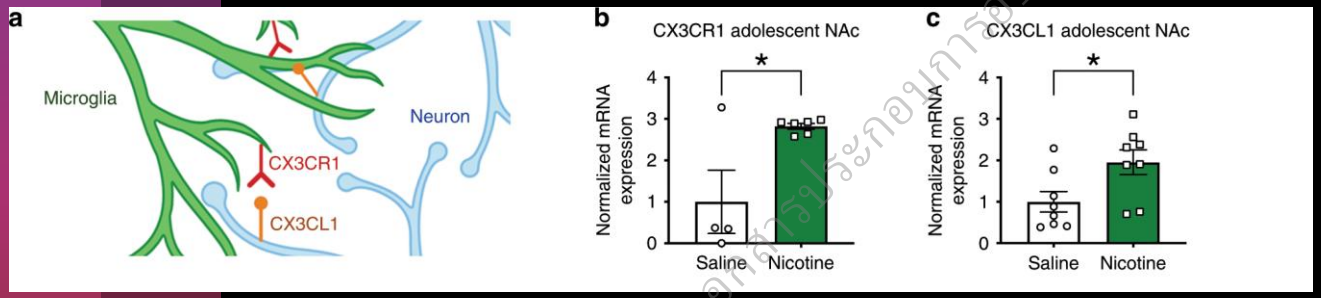


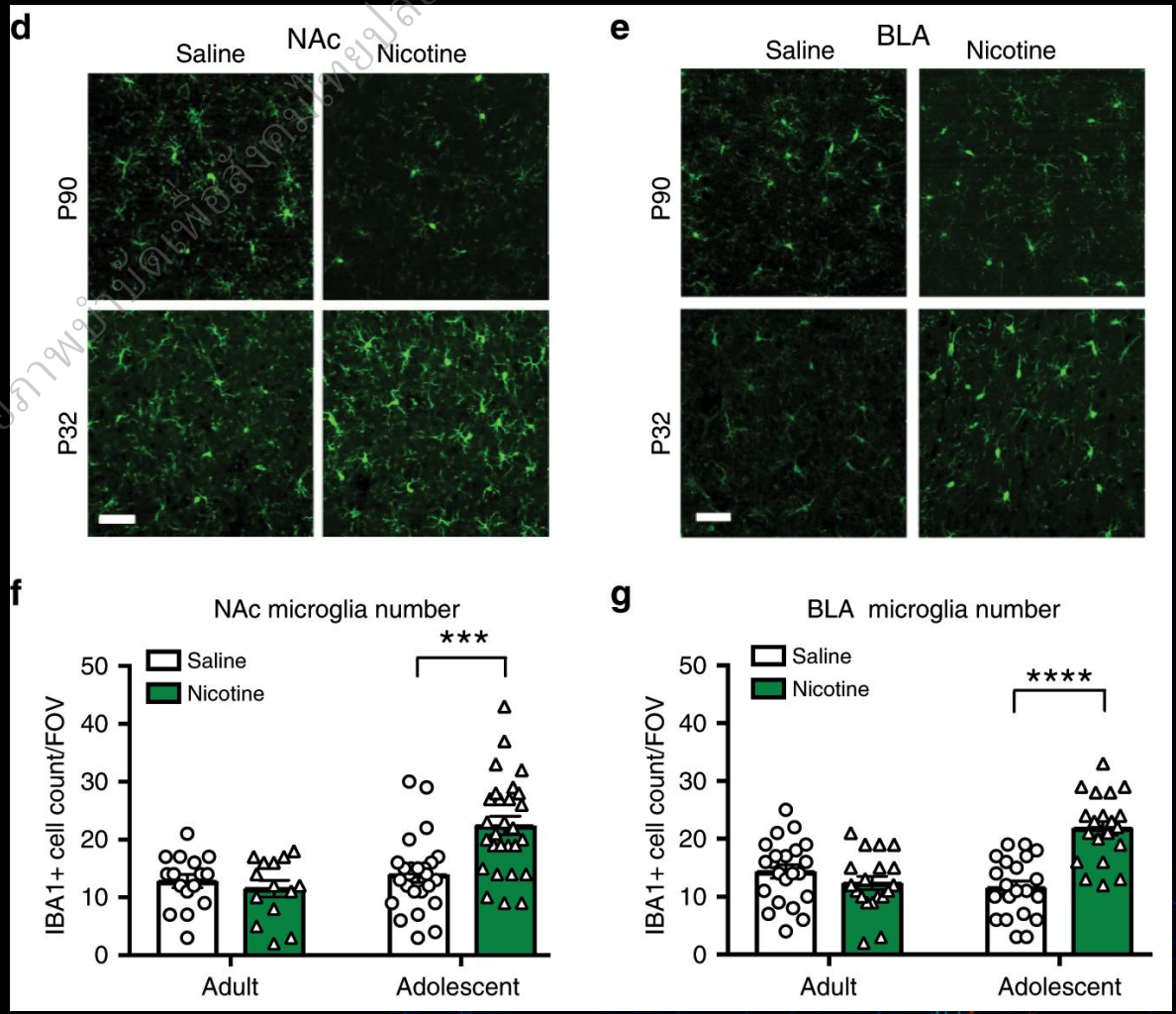
Linker, K. E., Gad, M., Tawadrous, P., Cano, M., Green, K. N., Wood, M. A., & Leslie, F. M. (2020). Microglial activation increases cocaine self-administration following adolescent nicotine exposure. *Nature Communications*, *11*(1). https://doi.org/10.1038/s41467-019-14173-3

เอกสารประกอบการอบรมของเครือข่ายการเฝ้าระวังเพื่อสังคมไทยปลอดบุหรี่

Nicotine increases cocaine responding and microglia in adolescent, but not adult rats







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Nicotine Withdrawal in Youth

- Stopping nicotine use causes withdrawal symptoms
- Withdrawal can begin within hours of last use
- Teens may feel on-edge, "jumpy," or unfocused in class
- Withdrawal discomfort drives relapse, continuing the addiction loop

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7 common withdrawal symptoms | Quit smoking | Tips from Former Smokers | CDC. (n.d.). https://www.cdc.gov/tobacco/campaign/tips/quit-smoking/7-common-withdrawal-symptoms/index.html#:~:text=2,upset

Brain Function Impacts

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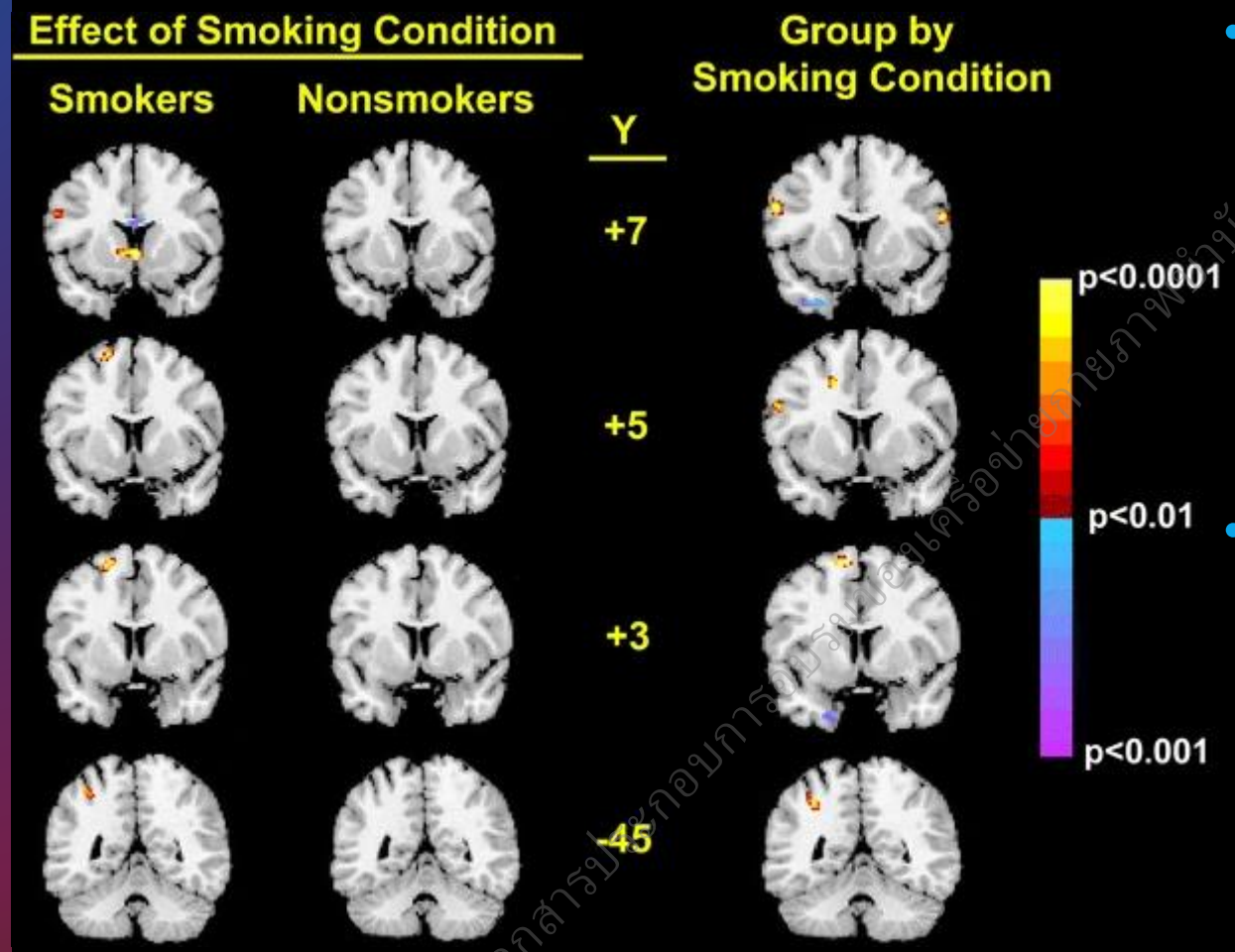
Cognitive Deficits from Adolescent Nicotine Use



- Nicotine exposure during adolescence impairs:
  - Working memory
  - Executive function
  - Attention performance (especially during withdrawal)
- Significant interaction effects at
  - right inferior frontal gyrus (BA 44)
  - right medial frontal gyrus (BA 6)
  - right fusiform gyrus (BA 37)
  - right superior/inferior parietal lobe (BA 7/40)

Jacobsen, L.K., Mencl, W.E., Constable, R.T. *et al.* Impact of smoking abstinence on working memory neurocircuitry in adolescent daily tobacco smokers. *Psychopharmacology* **193**, 557–566 (2007). https://doi.org/10.1007/s00213-007-0797-9

Learning, Attention & Academic Impact

- Nicotine harms brain regions involved in: Attention, Learning, Impulse control
- Consequences in teens: Shorter attention span, Difficulty concentrating in class, Lower academic performance and self-confidence, More frequent mind-wandering during learning tasks

Table 2. Independent samples t-tests comparing user status groups on sociodemographic characteristics and outcome measures.

	Never Users ($n = 344$)		Ever Users ($n = 88$)				95% CI		
Variable	*M*	*SD*	*M*	*SD*	*t*	*p*	*LL*	*UL*	Hedges's *g*
Age (in years)	14.55	1.62	15.45	1.53	**−4.58**	**< .001**	−1.29	−0.51	0.60
What level of approval do you hold for a person of your age using e-cigarettes?	1.51	0.80	2.16	0.74	**−7.09**	**< .001**	−0.83	−0.47	0.85
What level of approval do you believe that your parents or caregivers would hold of children's e-cigarette use?	1.35	0.72	1.60	0.81	**−2.71**	**.008**	−0.44	−0.07	0.35
ECAS Convenience	10.89	3.90	14.82	3.76	**−8.50**	**< .001**	−4.84	−3.02	1.01
ECAS Health	7.67	2.55	8.88	2.58	**−3.95**	**< .001**	−1.80	−0.61	0.47
ECAS Personal	11.71	4.37	15.87	4.28	**−8.02**	**< .001**	−5.19	−3.14	0.96
Academic Self-Efficacy (SEQ-A)	27.42	6.93	24.60	8.28	**3.26**	**< .001**	1.12	4.51	0.39
Social Self-Efficacy (SEQ-S)	26.93	6.59	26.60	8.36	0.34	.69	−1.31	1.97	0.05
Emotional Self-Efficacy (SEQ-E)	23.50	7.61	22.70	8.88	.847	.40	−1.05	2.65	0.10
Mind-Wandering (MWQ)	17.80	6.37	20.42	6.92	**−3.38**	**< .001**	−4.14	−1.10	0.40

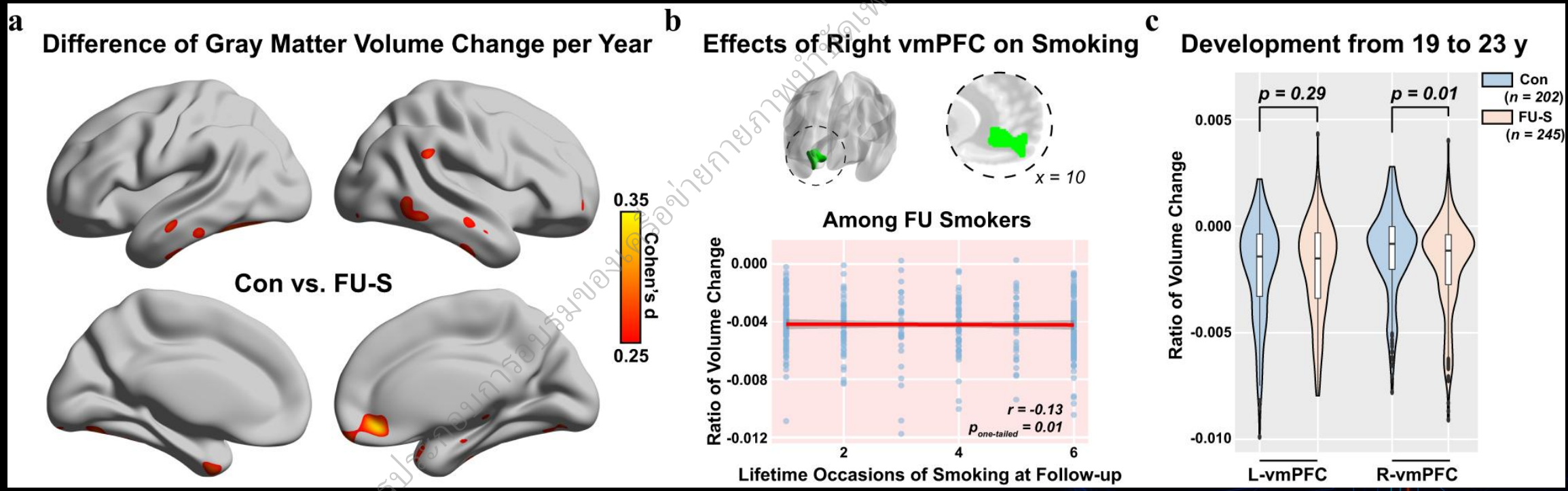
Note. CI = confidence interval. *LL* = lower limit. *UL* = upper limit. ECAS = Electronic Cigarette Attitudes Survey. SEQ-A = Self-Efficacy Survey (Academic). SEQ-E = Self-Efficacy Survey (Emotional). SEQ-S = Self-Efficacy Survey (Social). MWQ = Mind-Wandering Questionnaire. Bold values indicate significant results.

Interruption of task-focus by task-unrelated thoughts

Novak, M. L., Gyawali, P., & Wang, G. Y. (2024). Association between E-Cigarettes, cognition and mood in adolescents. *Substance Use & Misuse*, *59*(12), 1820–1827. https://doi.org/10.1080/10826084.2024.2383597

Reduction of gray matter volume in the prefrontal cortex in adolescents

- Smoking was associated with **faster reduction of gray matter volume (GMV) in the right** ventromedial prefrontal cortex (**vmPFC) in adolescents**



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Xiang, S., Jia, T., Xie, C. et al. Association between vmPFC gray matter volume and smoking initiation in adolescents. Nat Commun 14, 4684 (2023). https://doi.org/10.1038/s41467-023-40079-2

Behavioral Effects

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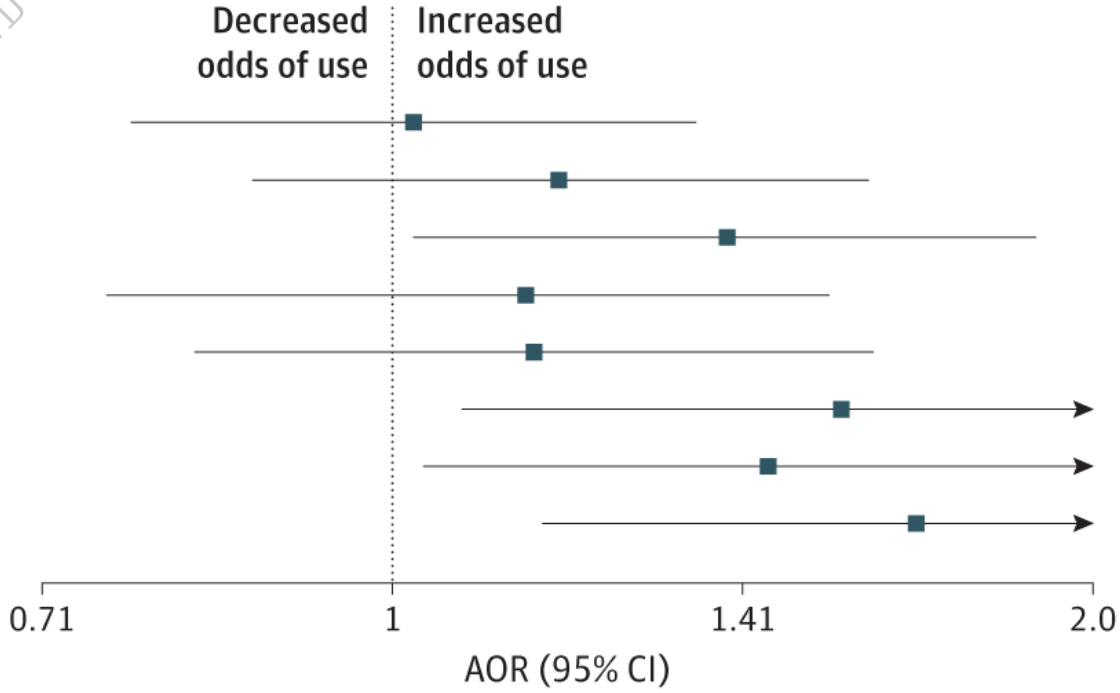
Impulsivity & Impulse Control

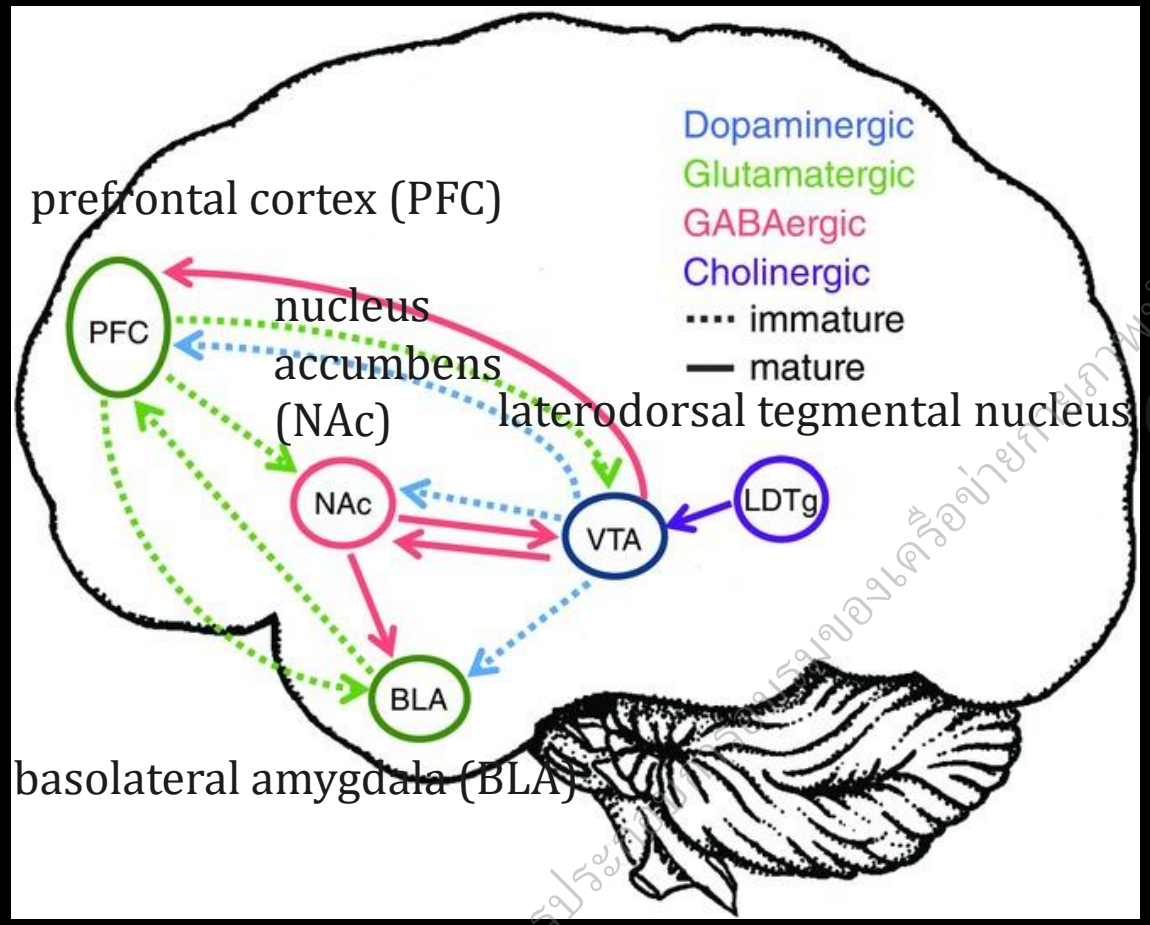
- Association of E-Cigarette Use With **Attention-Deficit/ Hyperactivity Disorder (ADHD)** Diagnosis, Number of Symptoms, and Use of Pharmacotherapy in US Youths (2015-2023)

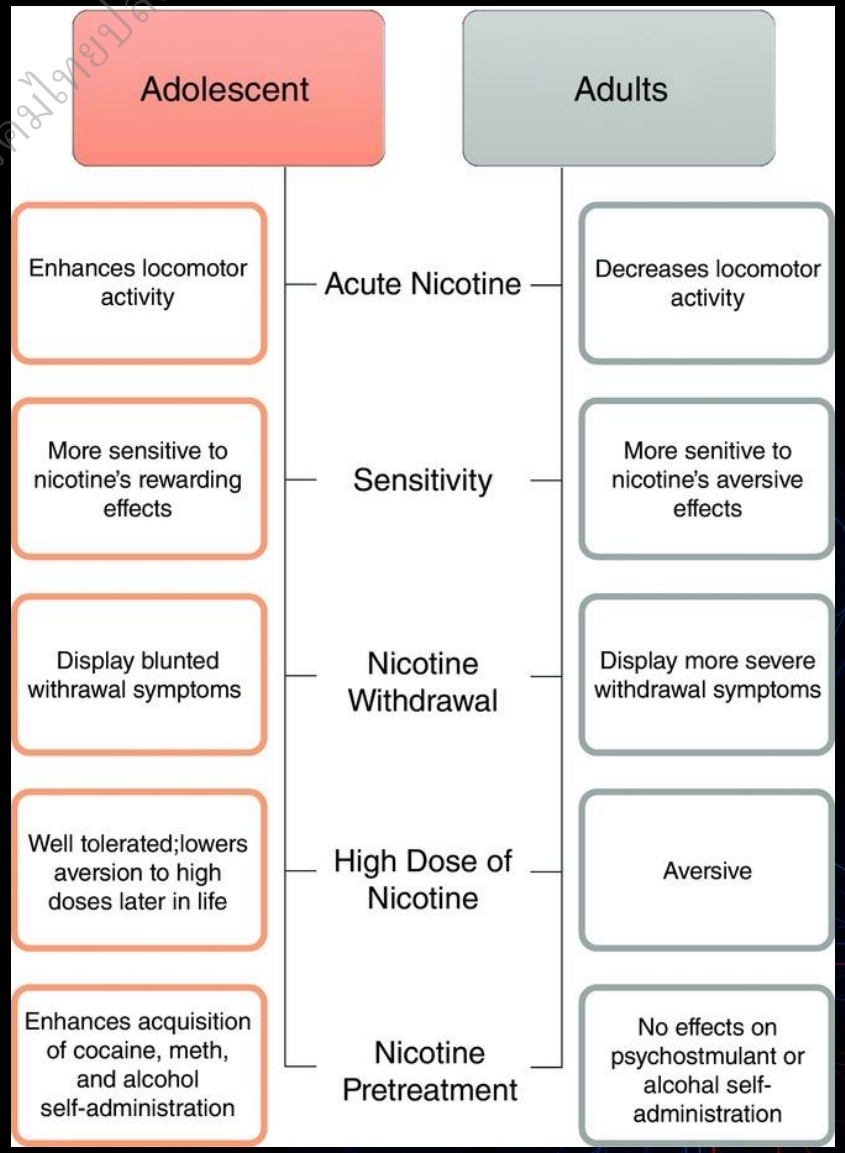
Category	AOR (95% CI)
No ADHD with no symptoms	1.02 (0.77-1.35)
No ADHD with low symptoms	1.18 (0.87-1.60)
No ADHD with high symptoms	1.39 (1.02-1.89)
ADHD with no medications and no symptoms	1.14 (0.75-1.73)
ADHD with no medications and low symptoms	1.15 (0.82-1.61)
ADHD with no medications and high symptoms	1.56 (1.07-2.26)
ADHD with medications and low symptoms	1.45 (1.03-2.03)
ADHD with medications and high symptoms	1.68 (1.16-2.44)



McCabe SE, Pasman E, Wilens T, et al. Attention-Deficit/Hyperactivity Disorder Symptoms and Later E-Cigarette and Tobacco Use in US Youths. *JAMA Netw Open.* 2025;8(2):e2458834. doi:10.1001/jamanetworkopen.2024.58834

Adolescents exhibit greater behavioral sensitivity and susceptibility to other drugs of abuse after nicotine exposure





Yuan M, Cross SJ, Loughlin SE, Leslie FM. Nicotine and the adolescent brain. J Physiol. 2015 Aug 15;593(16):3397-412. doi: 10.1113/JP270492. Epub 2015 Jun 23. PMID: 26018031; PMCID: PMC4560573.

Adolescent who use e-cigarette had a higher likelihood of using other substances and other risk behaviors

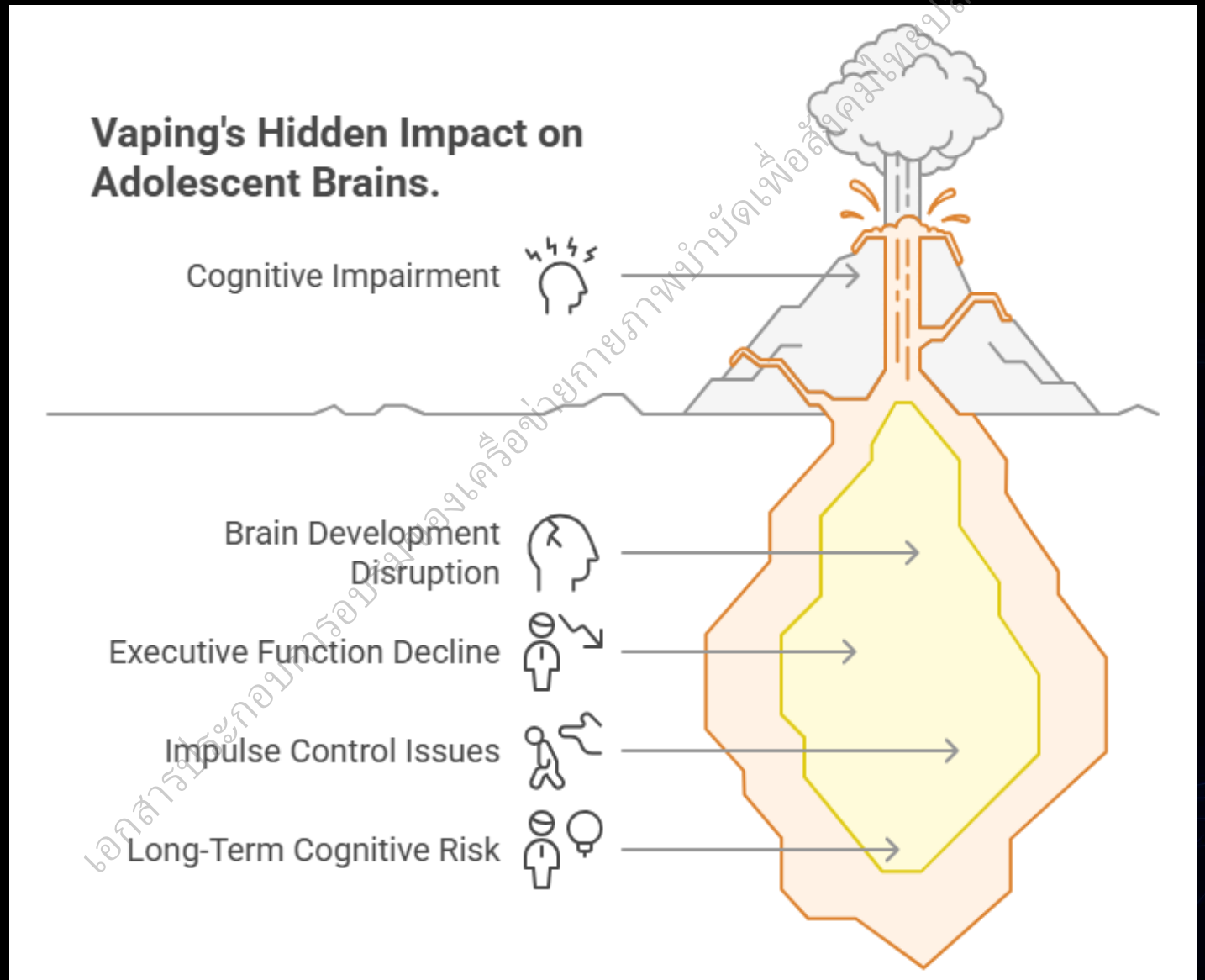
Outcome Variable	E-Cigarette Use (No: 87%)		E-Cigarette Use (Yes: 13%)	
	%	OR (95% CI)	%	OR (95% CI)
Substance use				
Current cigarette use	3.0	Ref.	46.3	**29.98** (19.69, 29.21)
Current smokeless tobacco use	1.7	Ref.	26.8	**16.65** (12.94, 21.41)
Current cigar use	2.8	Ref.	40.8	**21.67** (17.54, 26.77)
Current alcohol use	18.8	Ref.	78.5	**15.73** (13.28, 18.63)
Current marijuana use	11.8	Ref.	59.2	**10.63** (9.07, 12.46)
Risky behaviors				
Riding with a drinking driver	12.7	Ref.	34.0	**3.59** (3.07, 4.21)
Drinking and driving	2.4	Ref.	20.5	**8.03** (6.12, 10.53)
Texting/emailing while driving	30.7	Ref.	59.7	**3.30** (2.77, 3.93)
Driving when using marijuana	6.9	Ref.	41.0	**8.78** (7.14, 10.80)
Having sex before 13	2.4	Ref.	10.8	**5.01** (3.77, 6.65)
Having multiple sex partners	16.7	Ref.	50.5	**5.28** (4.45, 6.26)
Weapon carrying	10.9	Ref.	36.0	**3.67** (3.12, 4.31)
Gun carrying	2.8	Ref.	15.8	**5.24** (4.12, 6.66)
Physical fighting	18.8	Ref.	47.8	**4.06** (3.50, 4.72)

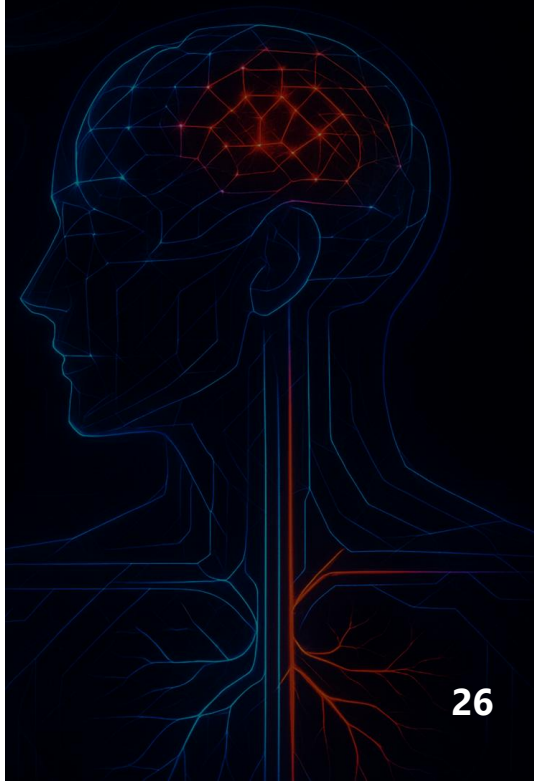
Weighted Logistic Regression Predicting Risky Behaviors by E-cigarette Use Status (N = 14,638)

เอกสารประกอบการอบรมเครือข่ายภาคีเพื่อสังคมปลอดบุหรี่

Chang, Y., & Seo, Y. S. (2020). E-cigarette use and concurrent risk behaviors among adolescents. *Nursing Outlook*, *69*(3), 302–310. https://doi.org/10.1016/j.outlook.2020.09.005

Summary – Brain Function Impacts





เอกสารประกอบการอบรมเครือข่ายภาพบำบัดเพื่อสังคมไทยปลอดบุหรี่

Mental Health Effects

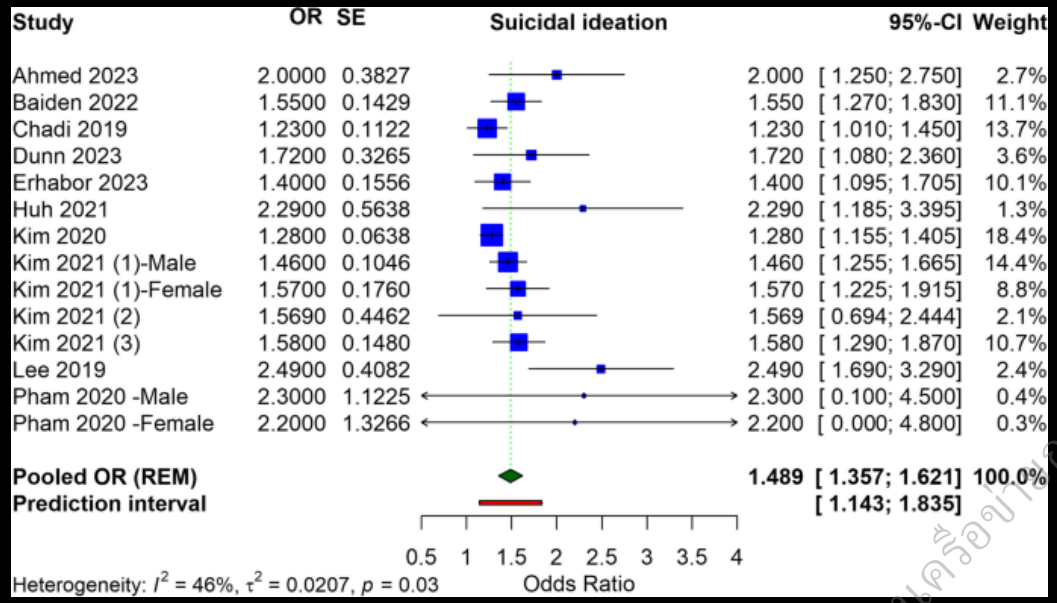
เอกสารประกอบการอบรมของเครือข่ายกายภาพบำบัดเพื่อสังคมไทยปลอดบุหรี่

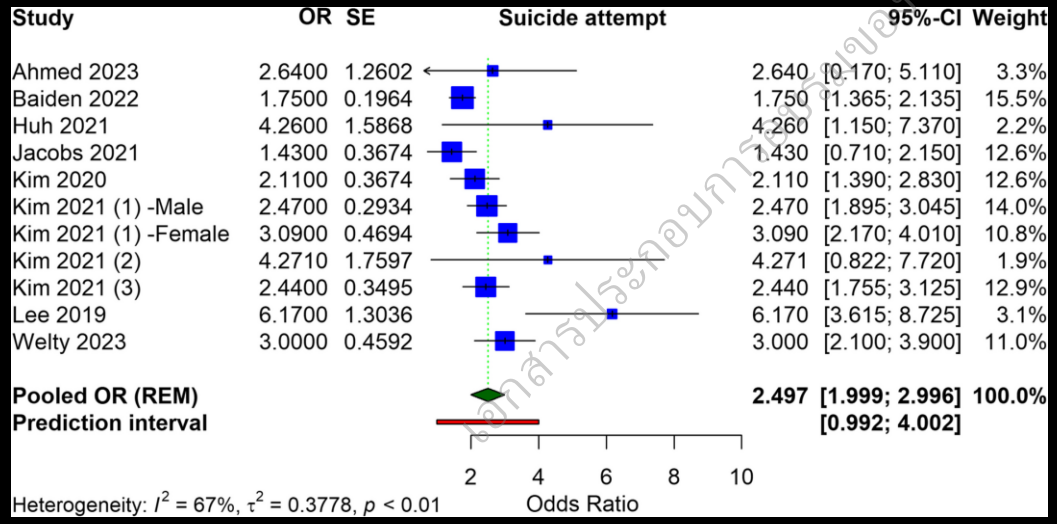
Depression & Anxiety in Teen Vapers

	Total sample (N = 4198)		Never used ENDS (N = 2306)		No current ENDS use (N = 1137)		Current ENDS use (N = 755)		F-statistic, p-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
DASS-21 continuous scores									
Depression subscale	**6.2**	8.1	**5.2**	7.1	**7.1**	8.9	**8.5**	9.3	28.8, <0.001
Anxiety subscale	**5.1**	6.8	**4.1**	5.7	**5.9**	7.8	**7.2**	7.9	37.2, <0.001
Stress subscale	**8.1**	7.8	**6.9**	7.1	**9.2**	8.4	**10.2**	8.5	32.4, <0.001
Total score	**19.4**	20.9	**16.2**	18.2	**22.2**	23.3	**25.8**	23.9	38.3, <0.001

K, E., DO, Tulsiani, S., Koris, K., Minter, T., & Hair, E. C. (2024). Depression, anxiety, stress, and current e-cigarette use: Results from the Truth Longitudinal Cohort of youth and young adults (2022−2023). *Journal of Affective Disorders*, *365*, 628–633. https://doi.org/10.1016/j.jad.2024.08.127

Suicidal Ideation



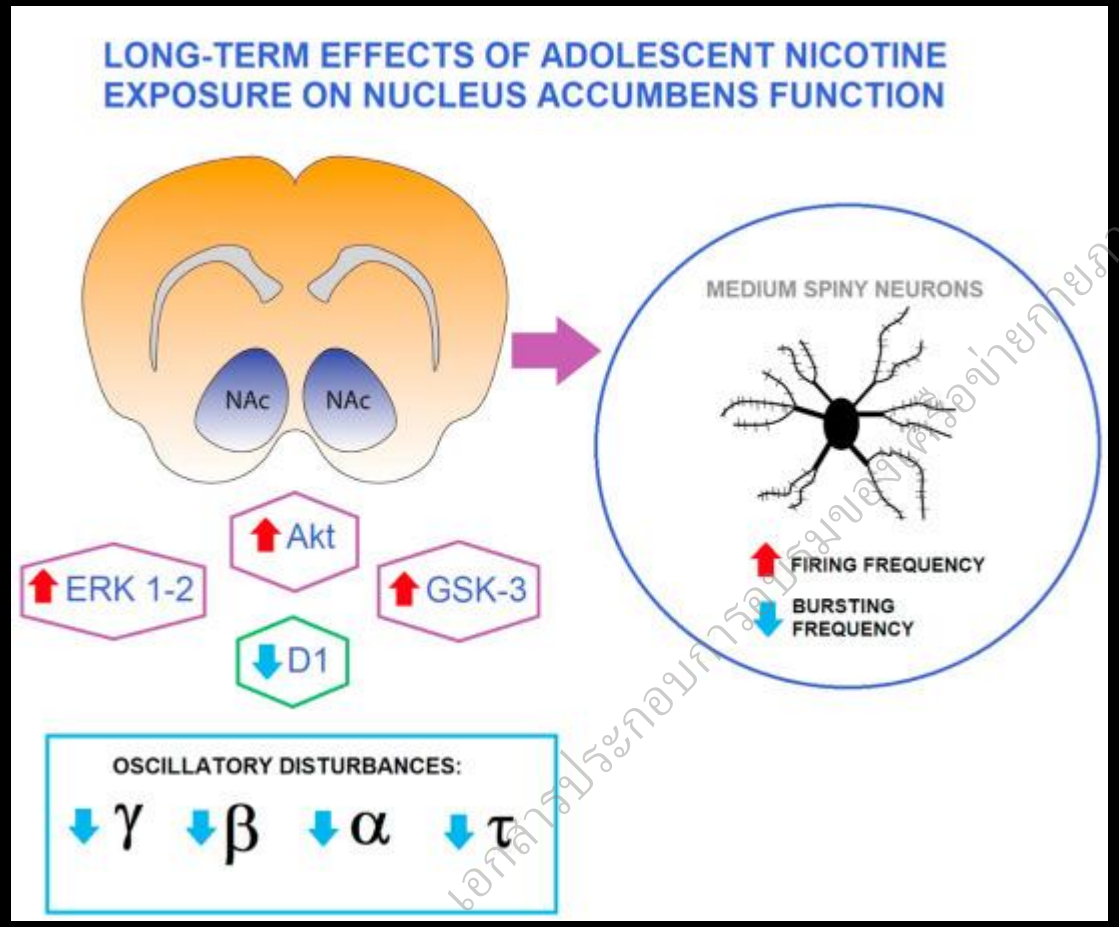


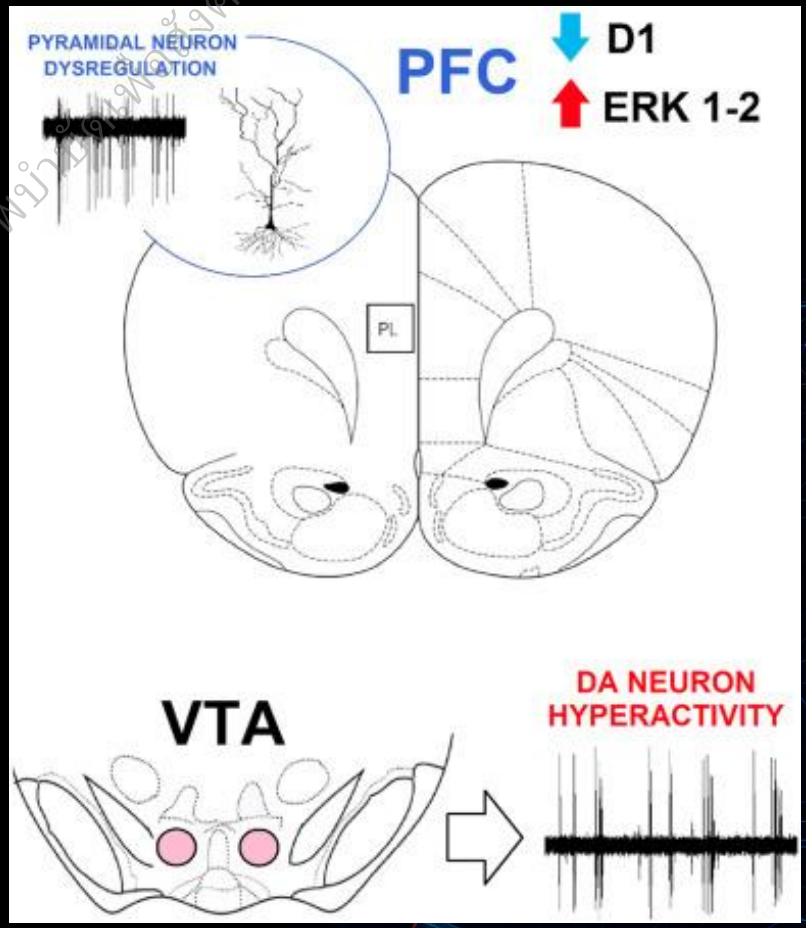
- Studies link e-cigarette use with **higher rates of suicidal thoughts and attempts**
- Nicotine may worsen psychiatric issues by disrupting:
  - **Reward pathways**
  - **Stress regulation systems**
- Vaping not proven to "cause" suicide, but contributes to **mental health burden**

Awad, A.A., Itumalla, R., Gaidhane, A.M. *et al.* Association of electronic cigarette use and suicidal behaviors: a systematic review and meta-analysis. *BMC Psychiatry* **24**, 608 (2024). https://doi.org/10.1186/s12888-

Stress, Self-Medication & the Mental Health Cycle

•Animal studies show adolescent nicotine exposure → **long-term depression/anxiety-like behavior**





Laviolette, S. R. (2020). Molecular and neuronal mechanisms underlying the effects of adolescent nicotine exposure on anxiety and mood disorders. *Neuropharmacology, 184*, 108411. https://doi.org/10.1016/j.neuropharm.2020.108411

Take-home message

เอกสารประกอบการอบรมของเครือข่ายสุขภาพบำบัดพอสังเขป

E-Cigarettes & the Adolescent Brain

▲ Not Safe for Youth
E-cigarettes are **not harmless**—even though they're marketed as a "safer" alternative. Youth, pregnant women, and non-smokers **should not use** them.

Brain Still Developing
The brain matures into the **mid-20s**—especially the prefrontal cortex (decision-making, attention). **Nicotine disrupts** development, affecting memory, focus & impulse control.

⚠ Highly Addictive
Adolescents are **more vulnerable to addiction** due to higher brain sensitivity to nicotine. Nicotine **overstimulates receptors**, causing long-lasting brain changes.

✸ Mental Health Risks
Linked to **anxiety, depression, and suicidal thoughts**. Can worsen stress and emotional regulation.

⊘ Toxic Exposure
Not just "vapor": contains **nicotine, metals, carcinogens, and lung irritants**. Flavorings may be safe to eat—but **harmful to inhale**.

Academic & Behavioral Effects
Vaping youth show **shorter attention spans**, lower grades, and **increased impulsivity**. Often co-occurs with **other risky behaviors**.

💬 Bottom Line
No level of e-cigarette use is safe for youth.
Prevention starts with awareness and education.

Thank you for your attention.

Akkradate.s@chul.ac.th

เอกสารประกอบการอบรมของเครือข่ายการภาพบำบัดเพื่อสังคมไทยปลอดภัยหรี่