

## INTRODUCTION

Substance Use Disorders (SUDs) among youth often result in severe long-term consequences. Traditional treatment approaches remain with limited efficacy.

Non-invasive neuromodulation techniques, such as transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS), offer promising avenues for targeting the neurobiological underpinnings.

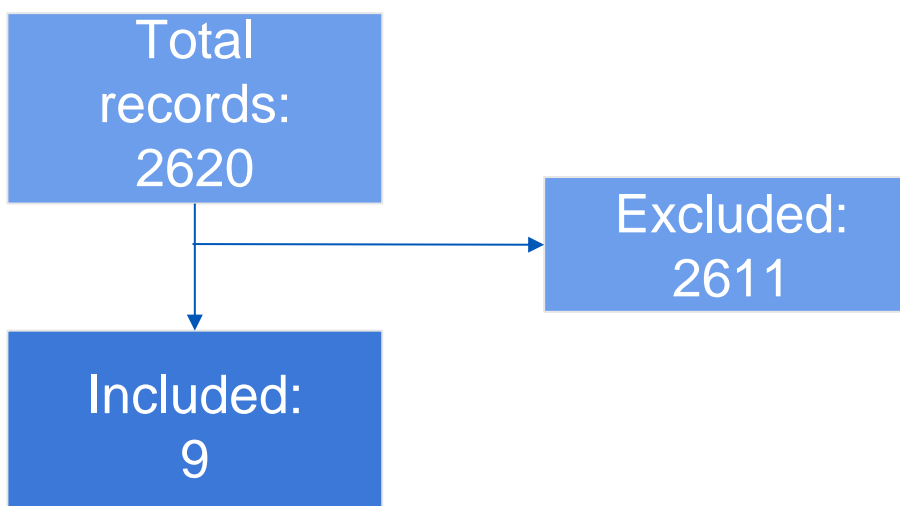
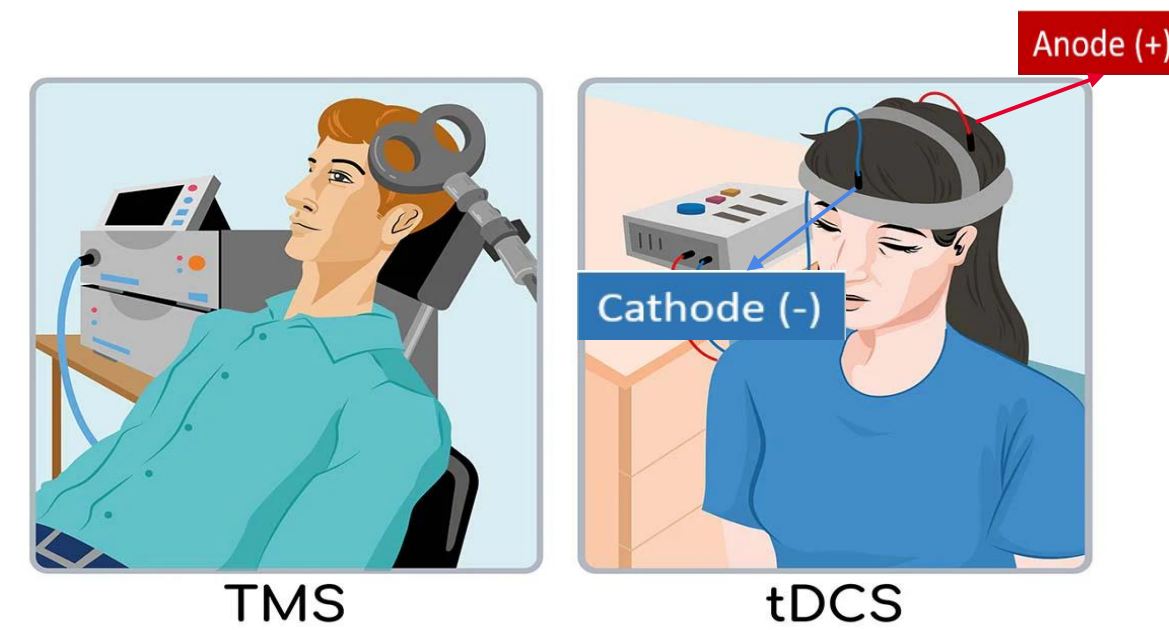
While neuromodulation in adults has yielded mixed results, the potential in younger populations remains largely unexplored. Youth may particularly benefit from these approaches due to their heightened capacity for neuroplasticity.

## METHODS

Comprehensive searches were conducted up to January 2025 across the following databases: Ovid MEDLINE®, Embase, Cochrane Central Register of Controlled Trials and Database of Systematic Reviews, APA PsycINFO, Web of Science Core Collection (Clarivate Analytics), and Scopus (Elsevier).

We included clinical trials and case studies focused on transitional age youth (TAY) that investigated the use of rTMS, tDCS, transcranial alternating current stimulation (tACS), or transcranial focused ultrasound (tFUS) to treat SUDs or their directly associated comorbid symptoms.

## RESULTS



rTMS (N=5)

tDCS (N=4)

### Clinical Trials (N=3)

**HF-rTMS**, single session (N=1)<sup>1</sup>  
**rDLPFC**: reduced cocaine cravings, improved anxiety, and increased happiness immediately after treatment.  
**IDLPFC**: increased sadness after treatment.  
**ctBS**, single session (N=2)<sup>2,3</sup>  
**rLDLPC**: reduced inhibitory control, increased ad libitum alcohol consumption in one study<sup>2</sup> but not the other<sup>3</sup>  
**IDLPFC**: reduced inhibitory control, increased craving, increased ad libitum alcohol consumption<sup>3</sup>  
**mOFC**: decreased attentional bias<sup>3</sup>

### Case Studies (N=2)

**LF-rTMS**, multiple sessions (N=1)<sup>4</sup>  
**rDLPFC**: Reduced cravings noted after the 2nd-5th sessions. Effect sustained for at least 3 months. Abstinence for 14 weeks after treatment termination  
**HF-rTMS**, multiple sessions (N=1)<sup>5</sup>  
**IDLPFC**: reduction in cue-induced opioid and cocaine cravings immediately after treatment, with further reduction observed up to ten minutes after treatment. Complete abstinence for one month after treatment termination.

### Clinical Trials (N=3)

**IDLPFC**, multiple sessions (N=2)<sup>6,7</sup>  
**combined** with Mindfulness-Based Substance Abuse Treatment (MBSAT) led to significant improvements in cognition, mood, and craving compared to sham stimulation.  
**tDCS-only** groups also led to improvement with a smaller effect size.  
**Bilat. DLPFC**, single session (N=1)<sup>8</sup>  
 Did not show any effect on alcohol craving.

### Case Study (N=1)

**rDLPFC**, multiple sessions (N=1)<sup>9</sup>  
 reduced methamphetamine cravings.

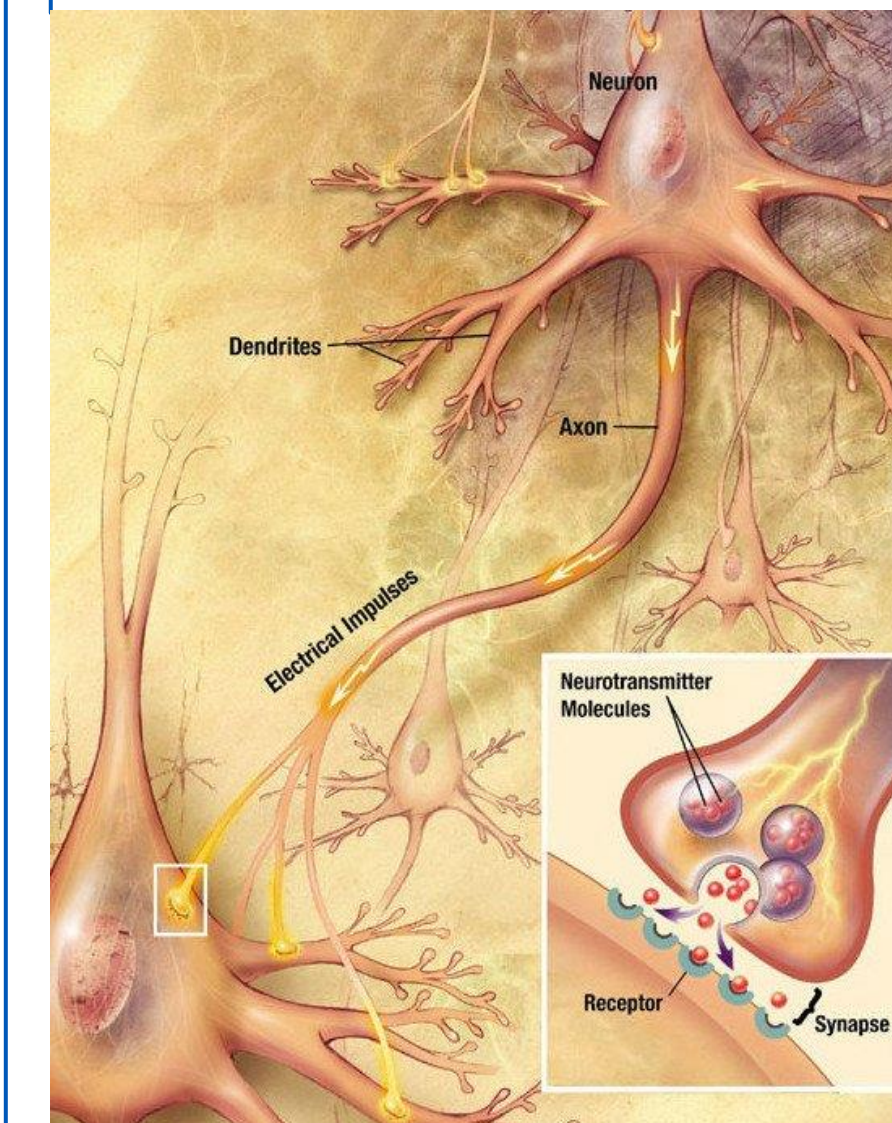


TABLE 1: REPORTED SIDE EFFECTS AND ADVERSE EVENTS

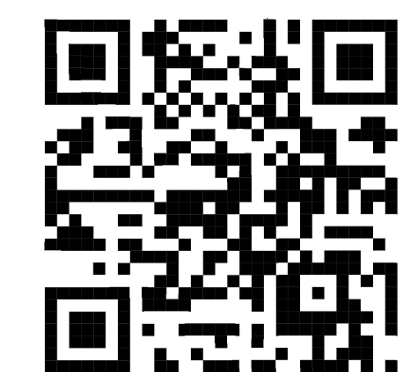
	SUD	Intervention	Target	Side Effects
Camprodon et al., 2007	Cocaine	HF-rTMS	rDLPFC and IDLPFC	No adverse effects
Hone Blanchet, Mondino, and Fecteau, 2017	Alcohol, BDZ, cocaine, heroin, marijuana	LF-rTMS	rDLPFC	Mild sleepiness and drowsiness
Mahoney et al. 2020	Cocaine, opioid	HF-rTMS	IDLPFC	Well-tolerated with no adverse events
Alizadehgoradel et al. 2021	Methamphetamine	tDCS (+ MBSAT)	IDLPFC	No significant side effects
Alizadehgoradel et al. 2021	Methamphetamine	tDCS (+ MBSAT)	bilateral	No significant side effects
Shariatirad et al., 2016	Methamphetamine	tDCS	rDLPFC	Headache

## DISCUSSION

- TMS and tDCS show some promise in treating SUDs in TAY, but evidence is limited and mixed. No literature was found for other neuromodulatory treatments
- Limitations:
  - Did not fully employ a systematic search strategy
  - Paucity of available literature
  - All TMS trials focused only on the effects of a single session
  - One study included participants as old as 27, which is outside of the usual accepted age range for “transitional age youth”

## REFERENCES

For a list of references, please scan the following QR code:



The authors (K.B. Ahern, I. Deniz, N. Bormann, L.C. Hassett, S.J. Scaletty, and T.S. Oesterle) have no financial conflicts to disclose.