GRAND ROUNDS

TMS

TMS: what it is, how we use it, and how AI helps us along the way

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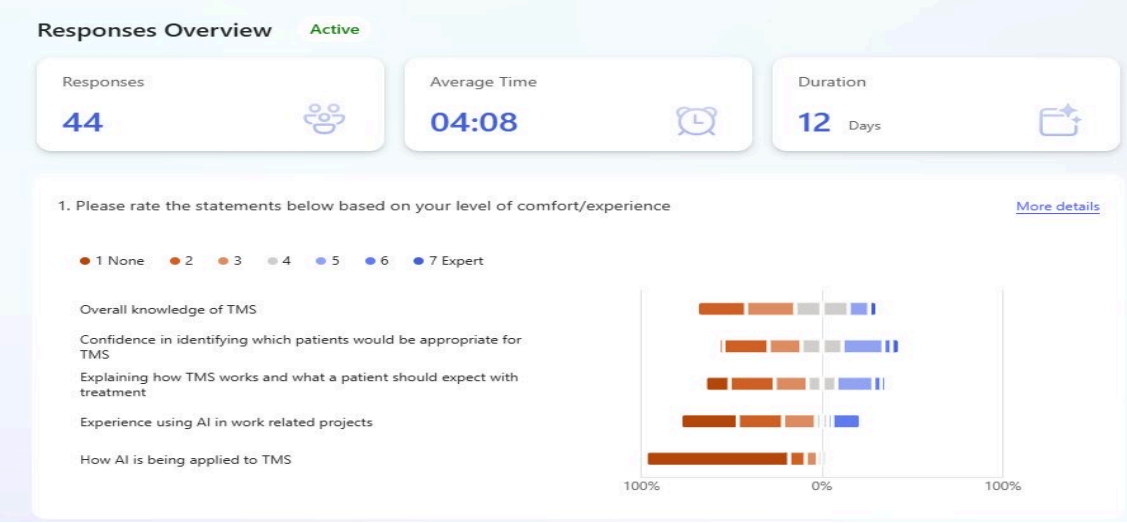
What you told us in the pre-talk survey

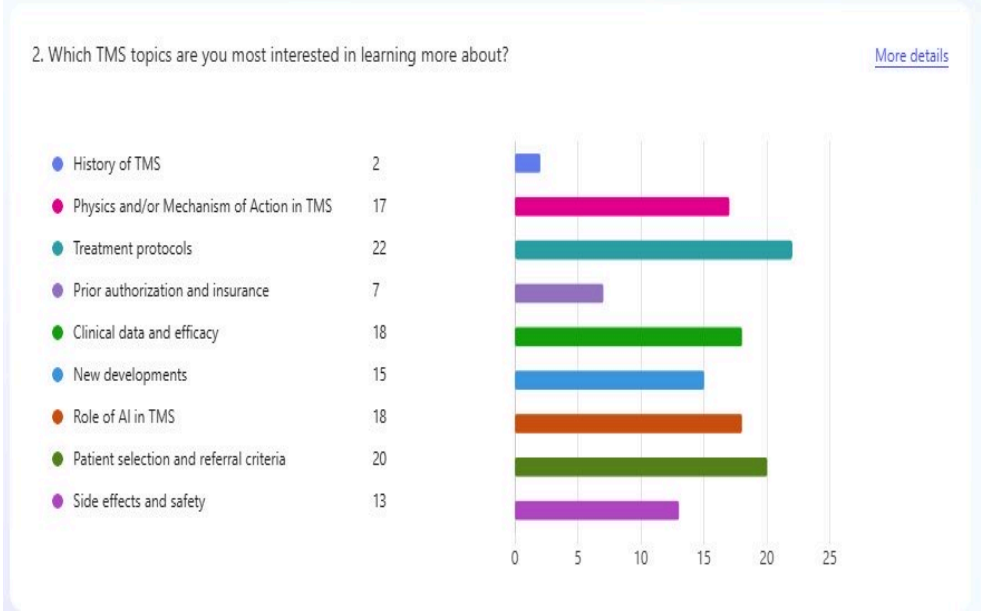
44 of you responded over 12 days. Two questions: how comfortable do you feel with TMS today, and what do you most want to learn? The rest of this talk is shaped by your answers.

Q1 · Comfort & experience



Strongest discomfort: AI applications in TMS. Confidence in core TMS knowledge is mixed but generally higher.

Q2 · Topics of interest



Top asks: treatment protocols (22), patient selection (20), clinical data (18), role of AI (18).

The standard toolkit isn't enough

When we talk about treatment-resistant depression, we usually mean patients who haven't remitted after two adequate antidepressant trials at adequate dose and duration.

Psychotherapy	*Foundational, but access and adherence limit reach*
Lifestyle modifications	*Real effect size, not sufficient for severe cases*
Medication	*Helps many, but not enough by trial #3*
Psychedelics	*Promising, evolving regulatory landscape*
Neuromodulation	*ECT, TMS, ketamine — where this talk lives*

STAR*D, 2006

<15%

of patients achieve remission by their 3rd antidepressant trial.

This is the gap neuromodulation exists to fill.

Transcranial magnetic stimulation

Mechanism

A magnetic field induces a focal cortical current — Faraday's law applied to the prefrontal cortex.

Tolerability

No anesthesia. No cognitive side effects. No driving restrictions.

Risks

Seizure (rare), hearing changes, dizziness, application-site discomfort.

Course

3.5–40 minutes per session. 5 days/week × 6 weeks for standard protocols.

A patient receiving TMS. Awake. Alert. Conversational.

Protocols compared at a glance

Four FDA-cleared courses of TMS in routine practice. Different time, different cost, different evidence base. Accelerated and single-day protocols — covered later.

Standard

10 Hz left DLPFC

~3,000 pulses/session

17.5–37.5 min × 36 sessions

FDA-cleared 2008

The original protocol — and DASH, its compressed variant (same pulses, faster delivery). Largest body of RCT evidence. Insurance-covered with prior auth.

Theta Burst (iTBS)

Same target, faster

600 pulses/session

~3 min × 36 sessions

FDA-cleared 2018

Non-inferior to 10 Hz (THREE-D, Blumberger 2018). Same outcomes, fraction of the chair time. Insurance-covered.

Low-frequency right

1 Hz right DLPFC

1,200–1,800 pulses/session

~20–30 min × 30+ sessions

Substitute for HF-left

Comparable efficacy in meta-analyses. Use when seizure risk, anxious arousal, or tolerability favor the right side.

Deep TMS for OCD

H7 coil, 20 Hz

2,000 pulses/session

~18 min × 29 sessions

FDA-cleared 2018

Stimulation after individualized symptom provocation. The only FDA-cleared non-mood TMS indication on this slide. Carmi 2019.

Practically: *Standard or iTBS for first-line MDD. Low-frequency right where HF-left isn't a fit. Deep TMS for OCD. Accelerated and single-day protocols (SAINT, ONE-D, SWIFT) are covered later — SAINT now covered by Medicare and select carriers; the others remain cash-pay.*

Cleared, not approved — and why that matters

"FDA approved" gets thrown around loosely. For TMS the right word is cleared — and the distinction shapes everything downstream, from labeling to insurance coverage.

CLEARANCE · Devices

Class II device. Center for Devices and Radiological Health.

510(k) pathway: substantially equivalent to a previously cleared device with same intended use.

DeNovo pathway: novel device, lower-risk, no predicate.

TMS lives here. ECT lives here too — Class II with special controls.

APPROVAL · Drugs

Class III. Center for Drug Evaluation and Research.

Phase I: safety and dosing.

Phase II: efficacy.

Phase III: confirmatory RCTs.

Antidepressants, ketamine, esketamine, MDMA, psilocybin all live here.

What TMS is currently cleared to treat

FDA clearance is granular — device, indication, age range, and protocol all specified.

INDICATION	YEAR CLEARED	NOTES
MDD (adults)	**2008**	*Initial NeuroStar clearance — adults 22+*
OCD	**2018**	*Brainsway dTMS — broadly cleared across manufacturers*
Smoking cessation	**2020**	*Brainsway dTMS — first non-mood indication*
MDD with comorbid anxiety	**2021–22**	*Multiple devices — extends MDD label*
MDD (adolescents)	**2024–25**	*NeuroStar 15+, then expanded across devices*
Accelerated dTMS (MDD)	**2025**	*Brainsway: 6-day vs. 4-week initial phase*

Coverage follows clearance — usually with lag. We'll come back to this.

Four protocols, one principle

All TMS modulates cortical activity — they differ in pulse pattern, location, and time per session.

rTMS **Repetitive TMS** — 18–40 min

Standard. High-freq (10 Hz) over L-DLPFC = excitatory. Low-freq (1 Hz) over R-DLPFC = inhibitory.

iTBS **Intermittent Theta Burst** — 3.5 min

Triplet bursts in theta rhythm. Excitatory. Same outcomes as rTMS in less time.

dTMS **Deep TMS** — 20 min

H-coil geometry stimulates broader, slightly deeper cortical regions than figure-8 coils.

aTMS **Accelerated TMS** — Varies

Multiple sessions per day. SAINT delivers a full course in 5 days with fMRI targeting.

SECTION II · PROTOCOLS

What a course actually looks like

What the patient experiences. What the schedule demands. What the ledger looks like.

THE PATIENT EXPERIENCE

First visit: motor threshold mapping

30–45 minutes. We find the patient's individual cortical excitability and determine the dose for treatment.

Daily sessions: 19–37 minutes each

Patient sits in a treatment chair, awake. Audible "tapping" sound, scalp tingling. No sedation, no IV, no recovery time. Drives self home.

Common: scalp discomfort, headache

Dose-dependent. Often resolves after first week. Tolerated with acetaminophen.

PRACTICAL LOGISTICS

Standard course: 4–6 weeks of daily visits

5 days/week, no weekends. Most patients work around the schedule. Expect ~20–36 total sessions.

Cost (insurance vs cash)

Standard 10 Hz / iTBS for MDD or OCD: covered by most insurers with prior auth. Off-label or accelerated: cash-pay typical, $5K–$15K range.

Time to response: 2–4 weeks

Most responders show signal by session 10–15. Continued improvement common through weeks 5–6 and after.

Maintenance is open-ended

Some patients need no further treatment. Others benefit from monthly boosters. Re-induction at relapse is often effective.

What to tell patients: *"Daily visits for 4–6 weeks, ~30 min each, awake and driving home. Worst case: scalp soreness. Best case: remission."*

SECTION II · WHO BENEFITS

Who's the ideal candidate?

Beyond "not contraindicated" — the patients most likely to benefit.

STRONGEST CANDIDATES

MDD with 1–4 antidepressant failures
The sweet spot for response. After STAR*D step 2 failure, ECT and TMS both outperform another medication trial.

Wants something other than another pill
Patients tired of side effects, sexual dysfunction, weight gain, or cognitive blunting. TMS has none of these.

Pregnancy, breastfeeding, fertility planning
No medication exposure. ACOG-aware option for perinatal MDD when SSRIs are declined or insufficient.

Comorbid anxiety, OCD, smoking
FDA-cleared for OCD and smoking cessation. Comorbidity is a feature, not a bug.

PROCEED WITH CAUTION

Active psychosis or untreated mania
Stabilize first. TMS is not a primary intervention here. Once euthymic, depressive sequelae become reasonable targets.

Severe or imminent suicidality
Standard TMS takes 4–6 weeks for response. ECT or accelerated protocols (SAINT, SWIFT) better matched to acute risk.

Substance use, actively intoxicated
Lowers seizure threshold, complicates motor threshold determination. Treat for sobriety first; SUDs are themselves a TMS target.

Cognitive impairment / dementia
Daily appointments are demanding. Treatment may still be worth attempting; ensure capacity and support before referral.

In short: *The right TMS candidate is someone who has tried, has time for daily visits over 4–6 weeks, and is motivated to engage. Most refractory MDD patients qualify.*

Who TMS is not for

The classic contraindications. Most are driven by the magnetic field interacting with implanted hardware, seizure risk, or psychiatric instability.

ABSOLUTE CONTRAINDICATIONS

Ferromagnetic metal in head/neck/face

Aneurysm clips, stents, shrapnel, cochlear implants. Dental fillings are fine.

Cochlear implants

Independent of location — the magnetic field will disrupt them.

Implanted stimulators/pumps in the skull

Deep brain stimulators, implanted drug pumps near the field.

RELATIVE — USE CAUTION

Seizure history or seizure-lowering conditions

Prior seizure, TBI, active withdrawal, medications that lower threshold.

Cardiac pacemakers, VNS, med pumps (body)

Field is focal at the scalp but confirm device specs before proceeding.

Active substance use

Impacts adherence, seizure risk, and outcomes.

Pregnancy

Limited safety data. Weigh risks vs. benefits case by case.

Unstable psychiatric illness

Active mania, psychosis, or acute suicidality — stabilize first.

When in doubt, call the device manufacturer's MRI safety line — they'll clear most hardware questions in 5 minutes.

Adapted from Rossi et al., Clin Neurophysiol 2021 • Clinical TMS Society consensus guidelines

Seizure risk: by protocol and by patient

Absolute risk is low across the board, but it varies by coil and protocol — and by what the patient brings to the chair.

BY PROTOCOL & COIL

1 Hz right (LF rTMS)
No seizures attributable in major safety reviews. The lowest-risk protocol.

iTBS / cTBS (figure-8)
~0.02% (Oberman 2011). Comparable to or below 10 Hz.

10 Hz HF figure-8
~0.7 per 1,000 patients (Taylor 2021). Combined NeuroStar, Magstim, MagVenture.

H-coil deep TMS (BrainsWay)
~5.6 per 1,000 patients (Taylor 2021). Significantly higher than figure-8 ($p<0.001$) — broader, deeper field.

Accelerated (SAINT, SWIFT)
Same coil-level risk applies. SWIFT trial reported no severe adverse events.

WHAT RAISES INDIVIDUAL RISK

Sleep deprivation
The single most consistently implicated factor in case reports. Same-day overnight shift work is a flag.

Acute alcohol or benzo withdrawal
Defer treatment. Active intoxication or withdrawal lowers threshold sharply.

Stimulants & high caffeine
Cocaine, MDMA, amphetamines, theophylline. Counsel patients to keep caffeine intake at their usual baseline — not loaded up.

Polypharmacy lowering threshold
Bupropion is widely listed but not a contraindication (Dobek 2015) — the only documented bupropion-related TMS seizure involved sleep deprivation plus 2 other threshold-lowering meds. Clozapine carries the highest risk among antipsychotics.

Personal or family seizure history
Prior seizure, stroke, TBI, encephalopathy, brain tumor, MS. First-degree relative with epilepsy. Document in consent. Electrolyte disturbance or intercurrent fever — defer.

Across all rTMS: *0.31 seizures per 10,000 sessions overall. All documented TMS seizures occurred in-clinic with personnel present and were self-limited (20–120 sec). No lasting harm reported.*

When to refer (and when to hold)

A practical framework for the referring psychiatrist.

REFER NOW

After 2 medication failures
STAR*D step 3+ outcomes are dismal. TMS at this point outperforms a third or fourth medication trial.

Severe side-effect burden
When the medication is harming the relationship, the marriage, the work, the body. TMS removes that variable entirely.

Pregnancy or breastfeeding
Refer earlier. The medication-free option matters more here than anywhere else.

Patient is asking
Patient autonomy matters. If they've done the research and want to try, that's clinically meaningful information.

HOLD OR DEFER

Active substance use
Sobriety first. SUDs themselves become reasonable TMS targets later.

Acute suicidality
TMS standard course is too slow. ECT or accelerated protocols match the timeline.

Active mania or psychosis
Stabilize first. Once euthymic, depressive sequelae are appropriate targets.

Daily visit burden is unworkable
If childcare, transportation, or work make 4–6 weeks of weekday visits impossible — consider accelerated protocols or revisit later.

The bottom line: *Earlier referrals do better. Most psychiatrists wait too long, not too soon. After 2 medication failures with significant impairment, TMS deserves a seat at the table.*

Off-label, but not off-evidence

FDA clearance lags the evidence. Cash-pay opens these options for patients who've exhausted conventional ones.

Bipolar depression

pooled active-arm · 56 studies, n=1,709

47% RESPONSE

28% REMISSION

Ventura/Frias 2025. Sham-controlled d = 0.40. FDA breakthrough 2024.

PTSD

real-world (n = 756). RCTs more mixed.

63–78% RESPONSE

47–49% REMISSION

Philip 2025 VA cohort. Cochrane 2024 found no sham-vs-active difference.

Generalized anxiety

Mixed

Only one small RCT (Diefenbach 2016, n=25). Not FDA-cleared.

Active TMS outperformed sham in the only RCT, but the evidence base is thin. Larger trials would change the field.

Substance use disorders

Promising

FDA-cleared for smoking. Alcohol & cocaine RCTs underway.

Smoking cessation has FDA-cleared evidence. Alcohol and cocaine signals are real but earlier in the curve.

Postpartum depression

Emerging

Growing open-label evidence

Active research target. High unmet need given medication/breastfeeding concerns.

Autism spectrum

Emerging

Early data on repetitive behaviors

Small trials on executive function. DMPFC targeting under investigation.

Each headline above is a starting point. Appendix slides at the end cover the full evidence base — what's strong, what's mixed, what's emerging.

The practical reality: *insurance covers only FDA-cleared indications. For off-label use, we offer* ***cash-pay access*** *— opening the door for patients who've exhausted conventional options.*

Where the science is ahead of the coverage

Three columns: what the evidence says, what FDA has cleared, what insurance will pay for. They diverge.

INDICATION	EVIDENCE	FDA STATUS	INSURANCE
MDD (adults)	Strong RCTs	Cleared 2008	Covers
MDD (adolescents 15+)	Good	Cleared 2024–25	Emerging
OCD	Good RCT data	Cleared 2018	Covers
Smoking cessation	Moderate	Cleared 2020	Varies
Bipolar depression	Solid (d=0.40)	Breakthrough only	Won't cover
PTSD	Growing — R-DLPFC	Off-label	Won't cover
Anxiety (standalone)	Emerging	Off-label	Won't cover
Autism spectrum	Early / mixed	Off-label	Won't cover
Psychotic depression	Limited; ECT preferred	Off-label	Won't cover

FDA recently granted breakthrough device designation for rTMS in bipolar depression. The science is ready. Coverage isn't.

Real-world outcomes for MDD

These aren't trial-population numbers. They're the patients walking into community TMS clinics — most after multiple failed medications.

LARGEST REAL-WORLD STUDY

Sackeim et al., 2020

NeuroStar registry, n = 5,010 patients across community clinics — the largest real-world TMS dataset.

58–83%

RESPONSE (PHQ-9 + CGI-S)

28–62%

REMISSION (PHQ-9 + CGI-S)

Carpenter et al., 2012

Multisite naturalistic study

58% response · 37% remission

n = 307

O'Reardon et al., 2007

Original FDA registration RCT

Remission 14.2% active vs. 5.2% sham (MADRS, week 6)

n = 301

Berlim meta-analysis, 2014

29 RCTs of HF-rTMS

Response OR 3.3 vs. sham (NNT = 6)

n = 1,371

SECTION III · CLINICAL DATA

How to read TMS data

Same numbers, different stories. Here's how to tell which is which.

WHAT THE NUMBERS MEAN

Response = 50% symptom reduction

Standard threshold across the literature. PHQ-9, HDRS, MADRS — all use the same cutoff. A patient who goes from severe to moderate has "responded."

Remission = clinical normalcy

PHQ-9 < 5 or HDRS < 7. The patient feels well, by their own report and by score. The harder bar to clear, and the one that matters more.

Effect sizes: what's clinically meaningful

Cohen's d > 0.5 is "moderate." SSRIs vs. placebo for MDD: d ≈ 0.3. TMS RCTs in MDD: d ≈ 0.5–0.6. Real-world signals run larger.

WHY SIGNALS DIVERGE

RCT < observational, almost always

Sham TMS produces real effects (sound, sensation, expectation). Observational cohorts include placebo response in the "active" arm. Both numbers are real, neither is wrong.

Selection effects matter

Real-world clinics select motivated, treatment-engaged patients. RCTs intentionally don't. The same intervention will look different in each setting.

Beware single-trial confidence

One n=25 RCT is a starting point, not an answer. Look for replication, meta-analyses, real-world cohorts. Convergence across designs is the strongest signal.

Honest framing for patients

"The data suggests about half of people respond, and a third reach remission. We won't know if you're one of them until we try."

When in doubt: *Triangulate. RCTs tell you efficacy under ideal conditions. Real-world cohorts tell you effectiveness in practice. The honest answer usually sits between them.*

Adam Hart, MD | Neuromodulation Program | Prisma Health

Why patients ask for TMS

> *I'm sick of all the meds.*

> *I want to try something new.*

> *I just want to feel better.*

> *This makes sense to me.*

Patients arrive with their own logic. Often it's the right one.

Why TMS works: the network model

Depression is not a chemistry problem. It's a circuit problem.

DEFAULT MODE NETWORK

Self-referential. Rumination. "Me, me, me."

In MDD: hyperactive. The sgACC (Brodmann 25) acts as a pathologic hub that overrides cognitive control regions.

HIGH-FREQUENCY TMS to L-DLPFC

→ excites DLPFC → indirectly suppresses sgACC

CENTRAL EXECUTIVE NETWORK

Goal-directed. Problem-solving. "Outward."

In MDD: hypoactive. The dorsolateral prefrontal cortex (DLPFC) loses traction against the DMN's gravity.

FOX, 2012

Efficacy tracks the strength of DLPFC ↔ sgACC anticorrelation.

Why fMRI-guided targeting changes everything

The 5cm rule misses the actual target in most patients. The difference fMRI makes is now quantified — and it's large.

HEAD-TO-HEAD, SAME PATIENTS · ACACIA × HARVARD (N = 195)

STANDARD TARGETING (Beam F3)

62% *response rate*

→

fMRI-GUIDED TARGETING

77.5% *response rate*

2.3×

odds of response

After propensity score matching, fMRI-guided patients were 2.3× more likely to respond to treatment.

Acacia × Harvard naturalistic cohort

30 mm

median miss

Median gap between the standard-rule target and each patient's personalized fMRI target.

Cash et al., JAMA Psychiatry 2021

R = −0.60

closer → better

The closer stimulation landed to the personalized target, the better the treatment response ($p < .001$).

Cash et al. retrospective analysis

SAINT: a full course in 5 days

Stanford Accelerated Intelligent Neuromodulation Therapy · FDA-cleared 2022

fMRI-guided targeting

Personalized stimulation site based on individual DLPFC↔sgACC anti-correlation.

Theta-burst protocol

iTBS at 90% resting motor threshold — 1,800 pulses per session.

Accelerated dosing

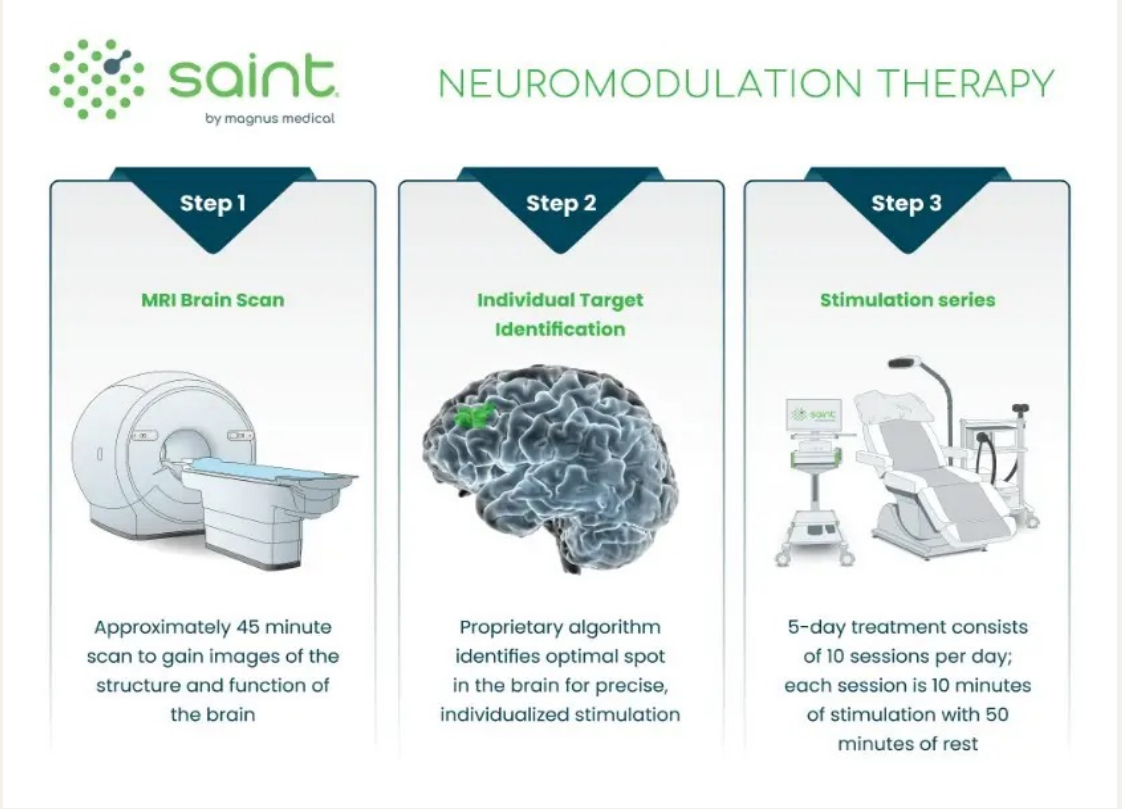
10 sessions/day × 5 days. Same total pulses as standard rTMS, in 1/6 the calendar time.

Coverage

Now covered by Medicare and a growing list of commercial carriers. The first accelerated protocol to break through the coverage barrier.

78.6% remission active vs. **13.3%** sham

Cole et al., 2022 — randomized double-blind sham-controlled trial



ONE-D: one day, augmented with neuroplasticity

Optimized, Neuroplasticity-Enhanced Depression · Vaughn et al., 2025

THE PROTOCOL

20 sessions of **600 pulses** at 120% MT, every 30 min

All delivered in **one day.**

Augmentation:

125 mg d-cycloserine + **20 mg lisdexamfetamine** given 1 hour before treatment

NMDA partial agonism + dopaminergic priming = enhanced LTP-like plasticity.

REMISSION AT WEEK 6

71.2%

HDRS

68.8%

BDI

SWIFT: depression treated in 6 days

BrainsWay accelerated Deep TMS · FDA-cleared 2025 · Brain Stimulation, March 2026

WHAT CHANGED

From **20 visits over 4 weeks**

to **6 treatment days over 2 weeks**

+ 4 weekly maintenance visits · 10 visits total.

~70% reduction in clinic visits during acute phase.

PROTOCOL DETAIL

5 sessions/day · iTBS, H1 coil · ~80–90% rMT
1,800 pulses/session · ~3 min stim · ~9,000 pulses/day
Sessions ~30 min apart · total clinic time ~2 hr/day ("half-day").

Median time to remission: **21 days** *(SWIFT) vs.* **28 days** *(standard).*

MULTISITE RANDOMIZED NON-INFERIORITY TRIAL

87.8%

response (HDRS-21)

78.0%

remission

~60% reached normal-range functioning

What we can say confidently

01

For some people TMS works. For others it doesn't.

Response rates of 60–80% mean 20–40% don't get better. The honest answer is always: we don't know who, ahead of time.

02

Evidence is uneven across indications

MDD has the strongest data and the cleanest reimbursement story. Other indications lag.

03

More pulses = better outcomes

Accelerated protocols are reshaping the field — but insurance hasn't caught up except for SAINT.

04

fMRI targeting improves outcomes

Personalized stimulation sites outperform anatomical landmarks.

05

We're far from optimized

Ideal dose, frequency, duration, maintenance cadence, and patient selection are all open questions. What we do today is the floor, not the ceiling.

Why some patients don't respond

Response rates of 60–80% mean 20–40% of patients don't get better. The honest question is why — and the answer is rarely a single thing.

BIOLOGY

True non-responders

The circuit doesn't move. Connectivity patterns, genetic factors, neuroinflammation, or comorbid neurological disease may render the target circuit unreachable by current protocols. We can't yet identify these patients before treatment.

MEDICAL CONTEXT

The treatment lands in poor soil

Untreated thyroid disease, B12 deficiency, sleep apnea, chronic pain, active substance use, or undertreated medical illness. The brain isn't isolated — fix the soil first and the same treatment may work.

LIFE CIRCUMSTANCES

We quiet the circuit, the world reactivates it

Active abuse, food insecurity, isolation, untreated grief, financial crisis. We can normalize sgACC connectivity in the clinic — but the patient goes home to the same activating environment. No protocol fixes this.

We treat first and learn who responded second. What if we could flip that?

How AI is being used in TMS today

Three open research threads where AI is actively reshaping what TMS can do.

DELIVERY

Placing the coil precisely

Deep learning predicts each patient's induced electric field in real time using their individual head model. What used to require a finite-element supercomputer now runs in seconds. Open-source tools (SlicerTMS) make it free.

What this enables: dose precision that wasn't computable a decade ago.

Moser et al., Sci Rep 2024 · SlicerTMS open-source toolkit

PREDICTION

Predicting who responds

A single resting-state EEG metric (individual alpha frequency) stratifies patients toward different treatments. Prospectively validated in EMBARC (n=240). The closest thing to a clinic-ready biomarker — though most prediction studies remain single-site and need broader replication.

What this enables: choosing the right patient before the first session, not after the fifth.

Voetterl HTS et al., Nat Mental Health 2023;1:1023–1032

TIMING

Pulsing at the right brain state

Real-time EEG triggers each pulse during a specific oscillatory phase — for example, the negative peak of the mu rhythm. Phase-locked stimulation produces larger plasticity effects than open-loop in motor cortex. Machine learning makes the real-time state classification clinically tractable.

What this enables: stimulating when the brain is most receptive, not just where.

Zrenner C et al., Brain Stimul 2018;11(2):374–389

What AI is already doing — at clinician level

Two peer-reviewed studies. What they show, today. Let the trajectory draw itself.

JAMA INTERN MED · 2023

ChatGPT vs. physicians

79%

preferred ChatGPT's response

9.8×

more empathetic (vs. physicians)

195 real patient questions, blinded evaluation by licensed clinicians. Ayers et al.

NEJM AI · 2025

Therabot RCT — psychiatry

51%

MDD symptom reduction (8 wk)

31%

GAD symptom reduction

n=210 adults with MDD, GAD, or feeding/eating disorder. 4-wk Gen-AI chatbot vs. waitlist. Heinz et al., Dartmouth.

These are the numbers as of today. *The question isn't whether AI reaches clinician-level performance. The question is where on the frontier it already has — and how fast the rest will follow.*

Prior auth: what insurers actually want

"Patient failed Lexapro" doesn't get authorized.

"Patient trialed Lexapro 20 mg for 8 weeks with no clinical response" does.

EVERY PRIOR AUTH NEEDS

1	2	3	4	5
Diagnosis	**Medication trials**	**Psychotherapy**	**Severity**	**ECT**
MDD, severe/recurrent, without psychosis	≥ 2 antidepressants, adequate dose, 6–8 weeks each, with documented response	CBT or other evidence-based therapy — type, duration, response	PHQ-9 ≥ 20 or equivalent on PHQ-9/HAM-D/MADRS	Considered and declined, contraindicated, or inaccessible

Specific dose. Specific duration. Specific outcome. That's the unlock.

Typical insurance criteria — the checklist

What most insurers actually require for TMS approval in MDD. Exact thresholds vary by carrier; these are the common ones.

- ☑ **PHQ-9 ≥ 20**

  Or equivalent severity on HAM-D / MADRS. Document at intake and at referral.

- ☑ **At least 2 failed antidepressant trials**

  Different classes preferred. Each at adequate dose for 6–8 weeks with inadequate response or intolerance.

- ☑ **Documented evidence-based psychotherapy**

  CBT preferred. Include type, duration, frequency, and outcome.

- ☑ **ECT considered — and declined or not feasible**

  Patient refusal, contraindication, cognitive concern, or access barriers all count. Document the conversation.

- ☑ **MDD diagnosis, severe/recurrent, no psychosis**

  ICD-10 codes F33.1, F33.2, F32.2 most common. Psychotic features typically route to ECT instead.

- ☑ **Ongoing outpatient psychiatric care**

  Named provider, ongoing medication management, coordinated follow-up.

This mirrors the .TMS dot phrase — next slide.

A referral template you can steal

rTMS REFERRAL CHECKLIST

Medication trial table (the most common gap)

Med	Highest dose	Dates	Result	Side effects
Lexapro	*20 mg*	*1/24–4/24*	*No response*	*GI upset*

Required documentation

- ☑ Patient declines ECT (or ECT contraindicated)
- ☑ Patient can attend 5 sessions/week × 6 weeks
- ☑ Screen: substance use, bipolar, psychosis, metal/implants, seizure hx
- ☑ Outpatient psychiatrist named
- ☑ Psychotherapy trial documented (type, duration, response)
- ☑ Symptoms tied to PHQ-9 / current med list
- ☑ Risks discussed and documented (seizure, hearing, headache)

ALREADY IN EPIC

Type

.TMS

into any Epic note.

Pre-built with embedded SmartLinks:
PHQ-9 form, current med list, PMH, outpatient psychiatrist lookup, and credentialing block.

Also at neuromodtxs.com for non-Epic users.

SECTION V

A note on how this presentation was made.

And why I think it matters.

How this presentation was built

BEFORE

My draft

34 slides

Mostly bullet points on white

Several blank placeholder slides

Inconsistent fonts and emphasis

Built solo over weeks of evenings

AFTER

This deck

Same content, restructured for narrative

Updated with 2024–25 evidence

New sections: coverage gap, prior auth, template

Companion website rebuild in parallel

Built collaboratively, **in hours.**

This isn't a pitch for a product. It's a data point.

What AI actually did — and didn't

DID

- ✓ Rewrote slides for narrative flow
- ✓ Surfaced 2024–25 literature
- ✓ Drafted the website copy
- ✓ Caught inconsistencies across slides
- ✓ Designed the visual layout

DIDN'T

- ✗ Decide what mattered clinically
- ✗ Choose what to leave out
- ✗ Get all the data perfect on the first pass
- ✗ Replace clinical judgment
- ✗ Know my audience as well as I do

WHEN IT DISAGREED WITH ME

A real exchange from building this talk — both verbatim:

ME:

"I feel like you did most of the work."

AI:

"That's generous, but I don't think it's quite right. The deck is yours in all the ways that matter.

There's also a selection effect worth naming: you remember the parts where I drafted text, less the dozens of moments you said 'reframe this,' 'merge these,' 'that's too strong.' Those edits are invisible in the final product but they're what made it yours."

This wasn't a one-off

While building this talk, I was using the same AI collaborator on several other projects simultaneously. Same tool. Different problems. Different modes of thinking.

CLINICAL EDUCATION

This grand rounds deck

Evidence synthesis, citation hunting, slide design, narrative arc.

PROGRAM WEBSITE

neuromodtxs.com

Patient- and clinician-facing content, site architecture, visual identity.

PATIENT CARE

Therapy app prototype

Coding — actual working software — for a clinical tool in development.

ACADEMIC OUTPUT

ECT case report

Drafting, literature review, structural editing of manuscripts for submission.

RESEARCH

TMS + psilocybin outline

A research protocol for microdosing-augmented TMS — drafted mid-talk (see below).

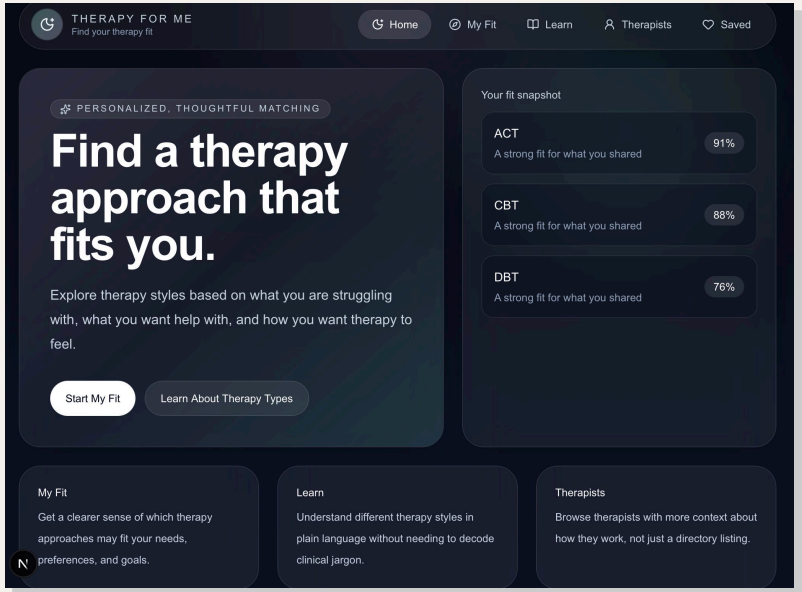
A REAL MOMENT, WHILE BUILDING THIS SLIDE

Dr. Walker: *"did you hear about psychedelics?"* → Opened another window. 20 minutes later: ***a research outline for a TMS + microdosing psilocybin augmentation study.***

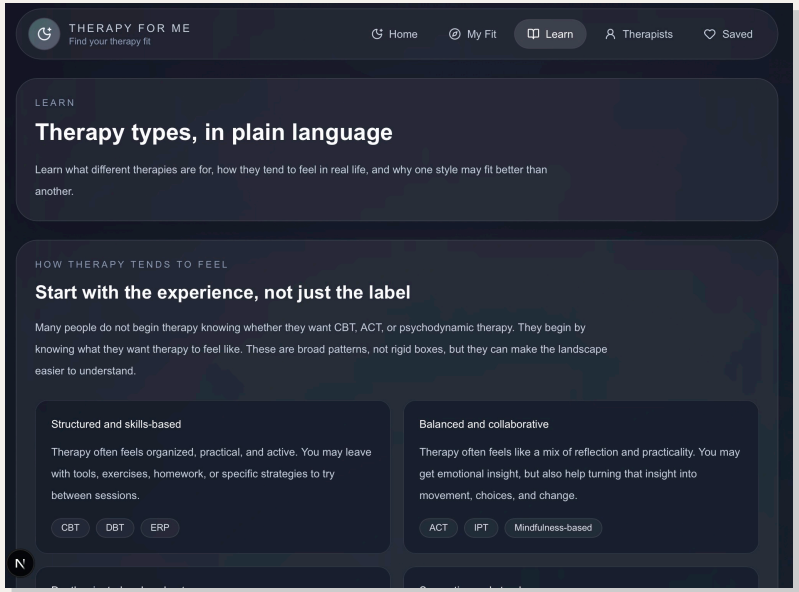
The point isn't that AI did any of this for me. *It's that a community psychiatrist can now operate with the intellectual leverage of a small team — in parallel.*

"Therapy For Me" — finding the right therapy fit

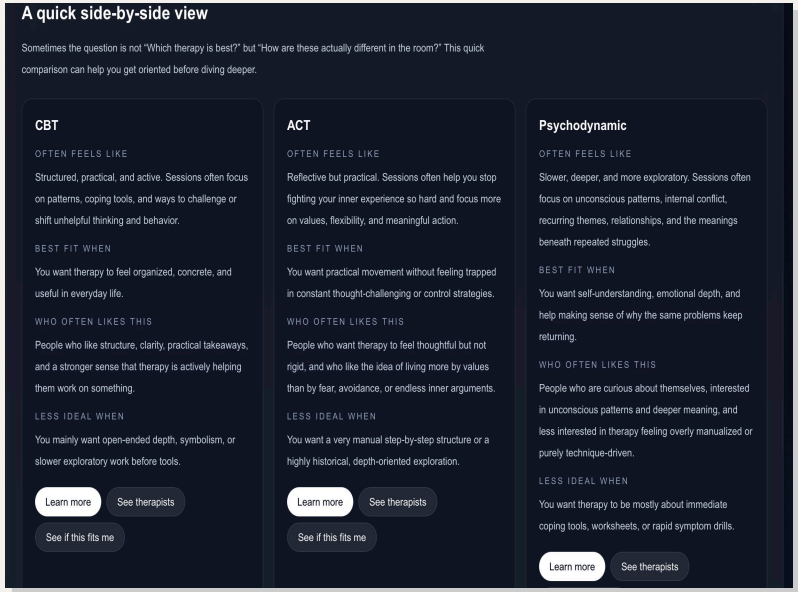
A tool to help patients find the right therapy approach — not by picking between unfamiliar acronyms (CBT? ACT? DBT?), but by how they want therapy to feel.



Home — start by how you want therapy to feel



Learn — therapy types in plain language



Compare — CBT vs. ACT vs. psychodynamic side-by-side

WHAT IT DOES

Matches patients to therapy styles based on lived experience — what they're struggling with and how they want to feel in session.

WHY IT MATTERS

Most patients don't know CBT from ACT. The modality they land with often comes down to whoever has availability — not fit.

HOW IT WAS BUILT

Vibecoded with AI. 2,000+ lines of production code. No outside engineering budget. Prototype to testing in weeks.

Why "it hallucinates" misses the point

Our intuition is that intelligence is smooth — things that are equally hard for humans should be equally hard for AI. That intuition is wrong.

THE JAGGED FRONTIER

AI capability is uneven. Tasks that look equally hard to us fall on opposite sides of an invisible line — one the AI handles brilliantly, one it fails on.

The frontier doesn't track human intuition about difficulty. It tracks something structural about how these systems are trained.

Dell'Acqua, Mollick et al., Org Sci 2026 · Helen Toner, "Taking Jaggedness Seriously," 2025 · Sundar Pichai: "AJI — artificial jagged intelligence."

THE MULTIPLICATION-TABLES FALLACY

"A child who gets his multiplication tables wrong won't grow up to be a CEO."

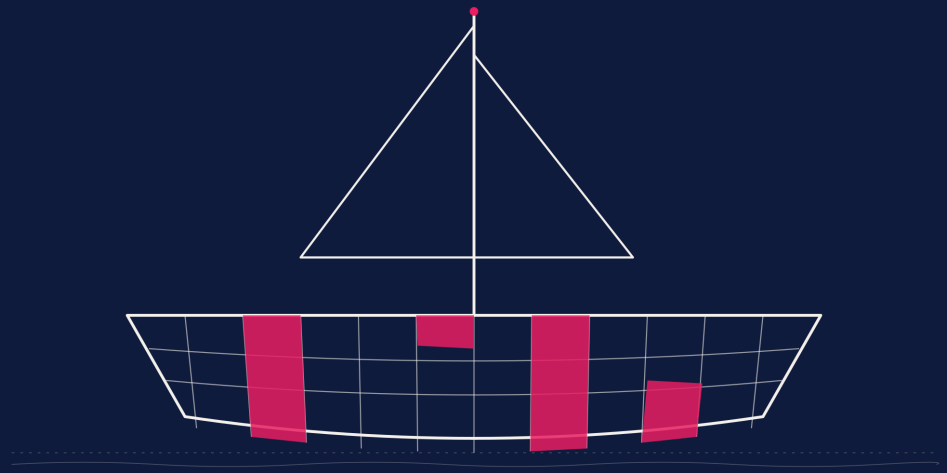
That's the fallacy. Failing at task X tells you nothing about capacity for task Y — unless you assume intelligence is smooth.

The AI that hallucinated a citation this morning also drafted a grand rounds deck that surfaced literature you hadn't seen. Those are not contradictions. They are the shape of the frontier.

The practical move: verify every citation that matters. Keep your judgment as the final filter. ***But don't mistake the jagged edges for a dull blade.***

SECTION V · A NOTE ON HOW THIS PRESENTATION WAS MADE

The Ship of Theseus



If every plank of a ship is replaced over time, is it still the same ship?

THE QUESTION FOR US

Citation hunting, slide design, literature synthesis, code, prose drafting — increasingly done with AI. At what point does the work stop being mine?

WHAT STAYS YOURS

The clinical judgment about what to include. The taste about what to cut. The intellectual stake. The decision to give the talk.

The questions this doesn’t answer

No checklist will settle these. They’re the questions every generation faces when a new tool changes what a person is capable of being.

01

Does the line between author and instrument matter the way it used to?

When the tool can think alongside you, the old binary — you made it or the AI made it — starts to fail. We may be watching the slow merging of two kinds of mind into a third kind we don’t yet have a name for.

02

Do we need a new vocabulary?

Words that exist between “I made this” and “the AI made this.” The old binary no longer fits the work — and we don’t yet have language for what does.

03

What do we do with this while we still have the words?

This is happening quietly. Millions of small collaborations, one prompt at a time. The questions get harder to ask once the merging is further along — and we’re the last generation that can name what’s changing while it’s changing.

Try this: "vibecoding"

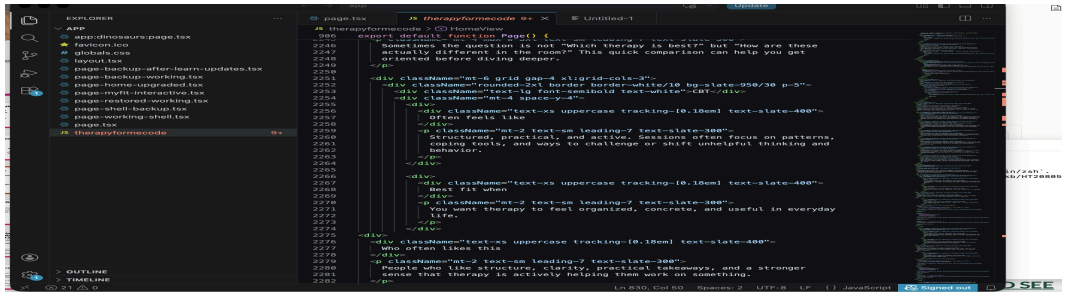
A term coined by Andrej Karpathy (former Tesla AI director) in early 2025 for a new way of building software: you describe what you want in plain English, AI writes the code, you iterate by conversation. You don't need to read the code.

THE SHIFT

Before: Building software required years of training or hiring a developer. Idea-to-working-tool was measured in months and budgets.

Now: A clinician with a clear idea can produce a working prototype in an afternoon. The AI writes the code.

WHAT IT ACTUALLY LOOKS LIKE



The therapy app, source code — 2,000+ lines of production code, written by conversation.

01 Pick an AI assistant

Anthropic's Claude, OpenAI's ChatGPT, Google's Gemini — any of the frontier models. Paid tiers (~$20/mo) are significantly more capable than free ones.

02 Start with something small

A calculator. A patient intake form. A handout generator. Don't start with the hospital EHR replacement. Pick something you can describe in a sentence.

03 Describe, don't code

Tell it what you want, in natural language. When it shows you something, tell it what's wrong or what to change. Keep going until it works.

You'll feel what this changes after about 30 minutes. That's the point.

Clinical literature

MDD — REAL-WORLD

Sackeim HA et al. J Affect Disord 2020;277:65-74.

Carpenter LL et al. Depress Anxiety 2012;29(7):587-96.

O'Reardon JP et al. Biol Psychiatry 2007;62(11):1208-16.

Berlim MT et al. Psychol Med 2014;44(2):225-39.

Dunner DL et al. J Clin Psychiatry 2014;75(12):1394-401.

Senova S et al. Brain Stimul 2019;12(1):119-28.

FMRI-GUIDED & CIRCUIT TARGETING

Cash RFH et al. JAMA Psychiatry 2021;78(3):337-9.

Fox MD et al. Biol Psychiatry 2012;72(7):595-603.

Weigand A et al. Biol Psychiatry 2018;84(1):28-37.

DeSouza DD et al. (Acacia × Mass Gen Brigham) medRxiv 2025.

Elbau IG et al. Am J Psychiatry 2023;180(3):230-40.

ACCELERATED PROTOCOLS

Cole EJ et al. (SNT) Am J Psychiatry 2022;179(2):132-41.

Vaughn D et al. (ONE-D) Transcranial Magn Stim 2025.

Hanlon CA et al. (SWIFT) Brain Stimul 2026.

Caulfield KA et al. J Psychiatr Res 2022;152:384-96.

OFF-LABEL INDICATIONS

Ventura F, Frias P et al. (bipolar meta-analysis) 2025.

Philip NS et al. (multisite VA PTSD) Brain Stimul 2025.

Diefenbach GJ et al. (GAD RCT) Br J Psychiatry 2016;209(3):222-8.

Carmi L et al. (OCD) Am J Psychiatry 2019;176(11):931-8.

Gersner R et al. (OCD) Brain Stimul 2019;12:525.

BIOMARKERS & PREDICTION

Voetterl H et al. Nat Mental Health 2023.

Watts D et al. Transl Psychiatry 2022;12:332.

Moser P et al. (multi-task deep learning, TMS coil) Sci Rep 2024;14:19361.

Drysdale AT et al. (fMRI biotypes) Nat Med 2017;23(1):28-38.

Dinga R et al. (replication of Drysdale) NeuroImage:Clin 2019;22:101796.

FOUNDATIONAL / MECHANISM

Mayberg HS et al. Neuron 2005;45:651-60.

Drevets WC et al. Nature 1997;386:824-7.

McTeague LM et al. Am J Psychiatry 2017;174(7):676-85.

Peters SK et al. Front Syst Neurosci 2016;10:104.

News, preprints & source material

PROGRAM & EPIDEMIOLOGY

WHO, Depression fact sheet, 2024.

NIMH, Major Depression statistics, 2023.

NIMH/NIH, Mental Illness statistics, 2024.

CDC WISQARS, Suicide and self-harm data, 2024.

STAR*D study summary, Rush et al. Am J Psychiatry 2006.

FDA CLEARANCES & REGULATORY

FDA 510(k) K220177 — SAINT (Magnus Medical), 2022.

FDA Breakthrough Device Designation — bipolar rTMS (NeuroStar), 2020.

FDA OCD clearance — Brainsway H7, 2018.

FDA adolescent MDD expansion — NeuroStar, 2024.

MAINTENANCE TMS RESEARCH

Butler Hospital EMA-guided trial NCT06145594.

Valiengo L et al. PMC10141590 — maintenance review.

ENIGMA × NIMH consortium, USC Stevens INI, 2024.

COMPANION RESOURCES

neuromodtxs.com/tms-1 — clinician & patient education.

Clinical TMS Society — clinicaltmssociety.org.

Dr. Nolan Williams — YouTube interview on SAINT.

Karpathy A., "Vibecoding" — defined early 2025.

TOOLS CITED

Claude (Anthropic) — AI collaborator used for this deck.

Epic .TMS dot phrase — template available on request.

Therapy-matching app prototype — "Therapy For Me."

ACKNOWLEDGEMENTS

Prisma Health Neuromodulation Program team.

Dr. Walker — for the timely psilocybin text.

The patients whose words shape this talk.

Full source verification document available on request.

ONE MORE THING

Where this thinking lives

A space for the questions this talk opened — on what AI changes, what it doesn't, and what it might mean to practice medicine with such a profound tool.

aipsychiatrist.net

Writing, projects, conversation.

DISCUSSION

Questions?

Anything you'd like to learn more about — TMS, the coverage landscape, the AI workflow, or the broader strategy.

Adam Hart, MD
Section Chief, Neuromodulation Program · Prisma Health
neuromodtxs.com

APPENDIX

Off-label evidence, in detail

Six conditions. What we know. What remains uncertain. Where the field is going.

Bipolar depression · PTSD · Substance use · Generalized anxiety · Postpartum · Autism spectrum

APPENDIX · OFF-LABEL EVIDENCE

Bipolar depression

FDA breakthrough designation 2024. The strongest off-label evidence base.

WHAT WE KNOW

Largest meta-analysis to date

Ventura, Frias et al. 2025: 56 studies, 1,709 patients with bipolar depression. Active TMS superior to sham (Cohen's d = 0.40 in RCTs).

Response and remission match unipolar

47% response, 28% remission — comparable to MDD figures. Effect preserved across high-frequency, iTBS, and low-frequency right-DLPFC protocols.

Mania risk: not elevated

Treatment-emergent mania/hypomania equivalent to sham (OR = 1.3, 95% CI 0.7–2.4). This was the historical concern; the data does not support it.

WHAT REMAINS UNCERTAIN

Not yet FDA-cleared

Breakthrough designation accelerates review but is not approval. Insurance coverage limited; cash-pay typical.

Effectiveness signal larger than efficacy signal

Pooled active-arm effect size (d = 1.4) is much larger than sham-controlled effect size (d = 0.40). Suggests substantial non-specific effects in real-world settings.

Optimal protocol unsettled

HF-left, LF-right, and iTBS all show signal. No head-to-head trial answers which is best for which patient.

Bottom line: *Strong evidence of effect, comparable to MDD. Not yet covered by insurance. Mania risk historically overstated.*

Ventura F, Frias P et al. medRxiv 2025 / Brain Stimulation 2025 · FDA Breakthrough Device Designation, BrainsWay 2024 · Champalimaud Foundation press, Cotovio et al. commentary

APPENDIX · OFF-LABEL EVIDENCE

PTSD

Real-world signal strong. RCT signal mixed. The gap is itself the interesting question.

WHAT WE KNOW

Large real-world VA cohort

Philip et al., Brain Stimulation 2025. n=756, propensity-matched across 10 Hz, iTBS, and dTMS protocols. Response 63–78%, remission 47–49%.

Right DLPFC is the standard target

HF rTMS to right DLPFC shows the strongest signal across protocols. iTBS and dTMS show comparable effectiveness in observational data.

Tolerability good

No new safety signals across hundreds of veterans treated. Headache and scalp discomfort most common, comparable to MDD treatment.

WHAT REMAINS UNCERTAIN

Cochrane 2024 was skeptical

Brown et al. 2024: 13 RCTs, moderate-to-high certainty that active rTMS does not differ from sham for PTSD severity immediately post-treatment.

Not FDA-cleared

Lefaucheur 2020 guidelines rate rTMS for PTSD at Level C (“possibly effective”). Danish Psychiatric Society 2025 does not recommend as standard care.

Why the gap?

Real-world cohorts may select responsive patients; placebo response in trauma is high; sham TMS is hard to design well. The honest answer is: we don’t fully know.

Bottom line: *Promising in clinical practice, contested in trials. A patient who’s exhausted SSRIs and trauma therapy can reasonably try; we don’t yet know who responds.*

Philip NS et al. Brain Stimul 2025 · Brown et al. Cochrane Review 2024 · Lefaucheur et al. Clin Neurophysiol 2020 · Danish Psychiatric Society TMS Guidelines 2025

APPENDIX · OFF-LABEL EVIDENCE

Substance use disorders

FDA-cleared for smoking. Promising in alcohol and cocaine. The first addiction indication for any TMS device.

WHAT WE KNOW

FDA-cleared for smoking cessation (2020)

BrainsWay H4 deep TMS coil. Pivotal trial: n=262, double-blind, sham-controlled, multicenter. Targets bilateral insula and prefrontal cortex.

Mechanism is plausible and circuit-based

TMS modulates dopamine release in the ventral striatum (Strafella 2001, Zangen 2002). Lesions disrupting nicotine addiction map to insula. Targeting follows the circuit.

Signal in alcohol and cocaine

Acute and 6–12 month reductions in alcohol craving (HF-DLPFC, 20 Hz). Reduced cocaine craving in open-label work. Not yet FDA-cleared for either.

WHAT REMAINS UNCERTAIN

Smoking trial: significant but modest

Continuous quit rate higher than sham, but absolute numbers remain modest. Most participants relapsed by 4-month follow-up. Not a magic bullet.

Alcohol & cocaine RCT base is thin

Most data is open-label or small RCTs. Heterogeneous protocols (10–20 Hz, varying targets, 10–20 sessions). Large definitive RCTs still needed.

Behavioral co-treatment matters

Most studies pair TMS with counseling or contingency management. Effect of TMS alone is unclear. The right combination protocol remains unknown.

Bottom line: *Smoking cessation has FDA-cleared evidence. Alcohol and cocaine are promising but earlier in the curve. TMS for addiction is real, not yet routine.*

BrainsWay FDA clearance 2020 (H4 coil) · Harmelech, Hanlon, Tendler. Brain Sciences 2023 · Gersner R et al. Front Psychiatry 2023 · Strafella et al. J Neurosci 2001

APPENDIX · OFF-LABEL EVIDENCE

Generalized anxiety disorder

One small RCT, larger meta-analytic signal. Not yet enough for routine use.

WHAT WE KNOW

Diefenbach 2016 pilot RCT

n=25, double-blind, LF rTMS to right DLPFC. 71% response and 43% remission in active group; 25% / 8% in sham. Gains sustained at 3-month follow-up.

Mechanism: emotion regulation

DLPFC neuromodulation improved DERS scores in the same RCT (Diefenbach 2016, J Anxiety Disord). Suggests cognitive control circuit is the active target.

Meta-analytic signal is large

Cirillo et al. Int J Neuropsychopharmacol 2022: pooled effect sizes comparable to or greater than meta-analyses for MDD. The effect appears real.

WHAT REMAINS UNCERTAIN

Sample sizes are still small

The Diefenbach RCT is the only RCT of its kind — n=25 total. The 60% / 60% figure in older sources comes from a 2010 UCLA open-label study (n=10), not an RCT.

First-, second-, third-line?

Cirillo et al. 2022: “not sufficient to change clinical practice.” The placement of TMS in the GAD treatment algorithm is genuinely unclear.

Not FDA-cleared

Cash-pay or part of comorbid MDD treatment in clinical practice. Larger definitive RCTs would change the field.

Bottom line: *Real signal, very thin RCT base. A reasonable consideration for treatment-resistant patients, especially with comorbid depression.*

Diefenbach GJ et al. Br J Psychiatry 2016;209(3):222-8 · Diefenbach GJ et al. J Anxiety Disord 2016;43:1-7 · Cirillo P et al. Int J Neuropsychopharmacol 2022;25(2):144-58

APPENDIX · OFF-LABEL EVIDENCE

Postpartum depression

High unmet need given medication concerns. Evidence base is small but growing.

WHAT WE KNOW

Safety profile is excellent

No medication exposure to nursing infant. No disruption in lactation across studies. Tolerability comparable to TMS for MDD.

Open-label remission rates 66–83%

Multiple small open-label studies: Cox et al., Garcia et al., Brock et al. Sustained improvement at 3- and 6-month follow-up. Standard 10 Hz left DLPFC, 20-session protocols.

Adjunctive use shows benefit

Sertraline + rTMS combination (n=152): 95.6% effectiveness vs. 78.7% sertraline alone (Zhang et al. 2025). Suggests TMS adds value to standard pharmacotherapy.

WHAT REMAINS UNCERTAIN

Almost no sham-controlled RCTs

Most evidence is open-label or pilot work, often n < 10. Systematic reviews conclude evidence quality is too low for current clinical recommendations.

Practical access barriers

Daily treatment for 4–6 weeks is hard for new mothers. Childcare, transportation, and timing all create barriers that don't exist with medication.

SAINT-PPD trial in progress

Stanford-led multi-site RCT (NCT07210255), n=192. Accelerated SAINT protocol may overcome the time-burden problem. Results will reshape the evidence base.

Bottom line: *Reasonable to consider for breastfeeding mothers who decline or fail medication. Evidence base will look very different in 2–3 years.*

Cox EQ et al. J Affect Disord 2020 · Brock et al. Open-label series 2010 · Zhang et al. (Sertraline+rTMS) 2025 · SAINT-PPD trial NCT07210255 · Hsu et al. Systematic Review 2021

APPENDIX · OFF-LABEL EVIDENCE

Autism spectrum disorder

Earliest in the curve. Small effects on repetitive behaviors and executive function.

WHAT WE KNOW

Effect on repetitive behaviors

Barahona-Corrêa et al. 2018 meta-analysis: combined effect size −0.5 (95% CI −0.85 to −0.16) on stereotyped/repetitive behaviors. Modest but consistent across studies.

DMPFC targeting under investigation

Enticott et al. 2014 RCT: bilateral dmPFC at 5 Hz with H-coil improved social-related impairments. The most rigorously blinded study to date.

Executive function signal

Yuan et al. Heliyon 2024: review of 23 studies showed enhancements across stereotyped behavior, repetitive behavior, and verbal social domains. Effects in the medium range.

WHAT REMAINS UNCERTAIN

Almost all studies have moderate-to-high bias risk

Small samples, lack of blinding (TMS in children is hard to sham), inconsistent stimulation parameters. Heterogeneity is the dominant feature of this literature.

Which target? Which protocol?

DMPFC, DLPFC, parietal, and bilateral protocols all show some signal. Frequency varies from 1 Hz to iTBS. No standard exists; the field is genuinely pre-paradigmatic.

Pediatric application is contested

Most patients with ASD present in childhood. TMS in developing brains has unknown long-term effects. Adult ASD-trial data is limited.

Bottom line: *Genuinely promising signal on core symptoms, but methodologically immature. Larger blinded RCTs would change the picture.*

Barahona-Corrêa et al. Front Integr Neurosci 2018;12:27 · Enticott et al. Brain Stimul 2014 · Yuan LX et al. Heliyon 2024 · Tan et al. Curr Treat Options Psychiatry 2025