

Repetitive Transcranial Magnetic Stimulation for Treatment Resistant Depression: How Patient Characteristics and Elements of Treatment Impact Post-Treatment Outcomes

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Abstract

Introduction: The present study assessed the effectiveness of repetitive Transcranial Magnetic Stimulation (rTMS) in reducing depressive symptoms in patients with treatment-resistant depression.

Methods and materials: A retrospective study conducted at an academic rTMS outpatient clinic. Data were collected from adult patients (≥ 18 years) with treatment-resistant, nonpsychotic unipolar depression. The Montgomery-Asberg Depression Rating Scale (MADRS) and Patient Health Questionnaire (PHQ-9) were administered at the initiation of treatment, at midpoint, and at completion. The Area Deprivation Index (ADI) was calculated to measure neighborhood disadvantage. Independent and paired t-tests were performed to assess the change in MADRS and PHQ-9 scores, for ages of less than or 65 and greater for baseline scores. Participants were assessed at the end of treatment as either full remission, partial response, or lack of response. The effectiveness of rTMS was analyzed with a multivariable general linear model (GLM) fitted to compare change in depression severity, while controlling for confounders.

Results: Sixty patients were included. Forty-five (75%) of the participants completed the 36 or more sessions of rTMS treatment. The end-of-treatment MADRS and PHQ-9 scores were significantly different from the pre-treatment scores ($P < 0.001$). The effect sizes were ($d = 1.70$ and 1.37), respectively. Regression modeling showed age, insurance status, Body Mass Index (BMI), number of sessions and duration of treatment were statistically significant. The MADRS demonstrated better model quality to discriminate good from poor responders than the PHQ-9.

Conclusions: The rTMS was shown to be an effective modality for treatment-resistant depression. The analysis found certain patient characteristics and treatment factors were predictive of the patient response. Future studies should investigate the link between overall functioning, health-related social needs and rTMS response.

Keywords: Transcranial magnetic stimulation, Treatment-resistant depression

1. Introduction

One-third of individuals with Major Depressive Disorder (MDD) fail to respond to first-line treatments (pharmacotherapy or psychotherapy) often leading to treatment-resistant depression (TRD) (Rush et al., 2006). Repetitive TMS has become part of the standard of care for TRD, where response rates of 40% to 60% are characteristic (Marder et al., 2022). Effective treatment, however, requires understanding predictors of treatment response in MDD. Since the effectiveness of rTMS may depend on various demographic,

clinical, and treatment-related factors, it is important for providers to be able to identify optimal patient and treatment parameters.

Repetitive transcranial magnetic stimulation (rTMS) is a widely regarded neuromodulation technique used to treat a variety of psychiatric disorders such as major depressive disorder, anxious depression, and obsessive compulsive disorder (Marder et al., 2022). Other indications for rTMS include migraine with aura and smoking cessation. In

attempts to optimize treatment, a variety of different stimulation protocols have been studied, encompassing different brain targets, stimulation parameters, targeting methods, and treatment schedules. This algorithmic uncertainty leaves treating physicians on their own to decide when to consider rTMS as a treatment modality.

Repetitive TMS involves the application of repetitive magnetic pulses through a coil that is positioned above the left dorsolateral prefrontal cortex (Trapp et al., 2025). This area is a common target for MDD that is responsible for mood regulation, cognitive control, executive functioning, and emotion processing (Fitzgerald et al., 2006). However, determining the exact positioning of rTMS within treatment algorithms for TRD remains largely unconfirmed. Dunner et al. (2012) found approximately two-thirds of responders or remitters continued to show a treatment response over time. On the other hand, prolonged periods of inadequate treatment contributed to a higher risk of chronicity, comorbidity, and suicidality, affirming the need for more effective treatment options for patients with TRD (Eaton et al., 2008).

Additionally, no unified criteria for the definition of TRD has affected the prior authorization process by various insurance carriers (Smith et al., 2025). Weissman et al. (2023) reported that insurance status was likely to create such barriers as access to care. Minority groups are often overrepresented in lower socioeconomic categories, which potentially explains their limited ability to undertake such a time- and resource-intensive treatment. As a result, this has led to disparate impact on racial and ethnic minorities who were shown to be underrepresented in treatment (Smith et al., 2025). Work also remains to be done in overcoming stigma, particularly historical mistrust with the mental health care system in minority populations.

This retrospective observational study examined predictors of rTMS treatment response, including patient characteristics, treatment setting, and treatment factors. We evaluated outcomes at treatment initiation and completion in a newly established outpatient rTMS clinic among patients with severe, nonpsychotic unipolar treatment-resistant depression. We also assessed the roles of symptom duration, failed medication trials, state Area Deprivation Index (ADI), and concurrent psychotherapy. These findings may help guide more personalized treatment approaches based on individual patient and clinical characteristics.

2. Methods

2.1 Study Design

This retrospective, observational study consisted of data from patients diagnosed with MDD who received care at the UF Health Jacksonville rTMS clinic between December 2021 and February 2025. The study was approved by the University of Florida Institutional Review Board (IRB202500308).

2.2 Participants

The study included encounters of adult patients (≥ 18 years) with treatment-resistant depression. Patient information included age, sex, race/ethnicity, Body Mass Index (BMI), insurance status, and state ADI. Inclusion criteria were patients diagnosed with MDD, severe, single episode or recurrent episode without psychotic symptoms. Major Depressive Disorder was diagnosed based on the DSM-5 symptoms during a structured clinical interview fashioned to match insurance preauthorization. The Maudsley Staging Method (MSM) was also utilized to stage treatment-resistant depression that incorporates three factors: medication failures, severity of illness, and duration of depressive episode (Fekadu et al., 2009). Participants demonstrated an inadequate response to antidepressant trials, augmentation with a second antidepressant, anticonvulsant, lithium, or an atypical neuroleptic during this depressive episode. The exclusion criteria included patients with seizure disorders or embedded ferromagnetic material that would be within 30 cm of the treatment coil. Additional exclusion criteria were previous failure of rTMS treatment and pregnancy.

2.3 Instruments

The Montgomery-Asberg Depression Rating Scale (MADRS) is a clinician-administered instrument that consists of 10 items, each rated on a scale from 0 to 6, with higher scores indicating more severe symptoms (Montgomery & Asberg, 1979; Bondolfi et al., 2008). The total score, ranging from 0 to 60, indicates depression severity (0-6 normal, 7-19 mild, 20-34 moderate, 35+ severe).

The Patient Health Questionnaire (PHQ-9) is a self-reported, widely recognized and well validated test of depression that has been used across many conditions (Kroenke et al., 2001). The test consists of 9 items. The scores range from 0 to 27 with cutpoints of 5, 10, 15 and 20 that represent mild, moderate, moderately severe and severe levels of depressive symptoms, respectively.

The Generalized Anxiety Disorder-7 (GAD-7) is a 7-item self-report questionnaire used to screen for and assess the severity of anxiety symptoms over the last 2 weeks with well established validity and reliability (Löwe et al., 2008). Scores are categorized as: 0-4 (minimal), 5-9 (mild), 10-14 (moderate), and 15-21 (severe). The GAD-7 was used to screen for the presence of anxiety symptoms.

The Maudsley Staging Method (MSM) was developed to define and stage treatment-resistant depression. The MSM is calculated based on duration and severity of illness, medication failures, augmentation, and ECT usage (Fekadu et al., 2009). The overall maximum score for MSM is 15. Fekadu et al. (2018) standardized the MSM by adding severity score categories of Mild (3-6), Moderate (7-10), and Severe (11-15).

The Area Deprivation Index (ADI) measures neighborhood disadvantage using a combination of 17 variables such as

income, education, employment, and housing quality. The Centers for Medicare and Medicaid Services have used this validated measure to determine neighborhood disadvantage and inform health delivery and policy, especially for the most disadvantaged neighborhood groups (Knighton et al., 2016). Neighborhoods are ranked relative to others within a specific state then grouped into deciles (1 to 10), where higher numbers indicate greater disadvantage. The ADI is found at <https://www.neighborhoodatlas.medicine.wisc.edu/>

2.4 Procedure

Participants completed the MADRS, PHQ-9, and GAD-7 at the initiation of treatment, at the treatment midpoint, and at the completion of treatment. Psychiatrists supervising rTMS administered the clinician-rated MADRS. Information also collected included duration of depression measured in years, antidepressant medication trials, type of insurance (commercial, Medicare, Medicaid), additional psychiatric diagnoses, number of Emergency Department (ED) visits, readmissions to a psychiatric hospital, and concomitant psychotherapy. The primary outcomes were change in depression severity based on the MADRS and PHQ-9 depression inventories. Secondary outcomes included the responses to rTMS according to age, sex, race, insurance status, MSM, GAD-7, number of medications, psychotherapy, and state ADI. To manage missing data, analyses were performed with data from the intention-to-treat sample.

2.5 Interventions

The study participants completed the UF Health psychiatry rTMS protocol (see Table S1 for the delivery protocol). The rTMS device, the MagStim Horizon Performance Model 5263-00 with navigation, uses high frequency (10 Hz) transcranial magnetic stimulation over the left dorsolateral prefrontal cortex (DLPFC), which has been shown to be clinically effective for depression. The trial of rTMS consisted of a course of 36 rTMS sessions over 9 weeks of treatment and, if insurance covered less sessions, treatment continued until completion. Study participants were assessed at the end of treatment as either full remission, partial response, or no response. Pharmacological therapy for MDD consisted of continuing the current antidepressant medication prescribed that included selective serotonin reuptake inhibitors (SSRIs), serotonin-norepinephrine reuptake inhibitors (SNRIs), norepinephrine-dopamine reuptake inhibitors (NDRIs), and tricyclic antidepressants (TCAs). A participant's treatment may have also been augmented with lithium, an anticonvulsant or with a second-generation antipsychotic. Those with additional comorbid psychiatric diagnoses such as attention deficit disorder, GAD, or post-traumatic stress disorder were to continue their current medication regime according to standard of care. Participants who received individual psychotherapy which might have consisted of cognitive-behavioral therapy, behavioral activation therapy, or supportive therapy, followed up as during usual care.

2.6 Statistical Analysis

For continuous variables, the data was summarized with means and standard deviations. For categorical variables, data was summarized using the sample size (n) and percentage (%). To evaluate concordance between the MADRS clinician ratings and the self-reported PHQ-9, the correlation between these scores was computed using Pearson r statistic. The chi square test was used to determine differences among the classification percentages. Independent and paired t-tests were performed to assess the change in MADRS and PHQ-9 scores for ages <65 years and ≥65 years and baseline scores. A paired-sample t-test was utilized to assess the effectiveness of rTMS treatments in reducing depressive symptoms by comparing the initial treatment MADRS and PHQ-9 with the endpoint MADRS and PHQ-9 scores at treatment termination. Cohen's d were calculated to determine the effect size of the difference. A clinically relevant effect for treatment of depression was defined by the minimal important difference from a patient perspective, which corresponds to a Cohen's d of 0.24 (Cuijpers et al., 2014).

Using a data-driven approach, optimal cutpoints were identified to classify patients into three distinct categories. The definition of full remission on the MADRS was a cut-off value of <10. Full remission on the PHQ-9 was defined as a final score of less than 5. A partial response rate was defined as a minimum of 50% or more reduction in post-treatment scores on the MADRS. Partial response was defined as ≥ 50% reduction in PHQ-9 scores at final assessment relative to pre-TMS baseline. Treatment non-response was a reduction of less than 50% in the endpoint compared to baseline total score on the MADRS. Nonresponders on the PHQ-9 was a reduction of less than 50% in the endpoint compared to baseline total score on the PHQ-9.

A multivariable general linear model (GLM) fitted to compare change in depression severity and adjusted for all covariates, was used to determine the contribution of the predictor variables with the change in depressive symptom severity over the course of treatment. This analysis was performed with scores on the MADRS and PHQ-9 as the dependent variables to determine the between-subjects main effects. Age, sex, race/ethnicity, BMI, insurance status, GAD-7, MSM, number of medications, number of sessions, duration of treatment, psychotherapy, and state ADI were added to the regression model as covariates to control for confounding. Statistical analyses were performed with SPSS, version 30.0, and R 4.5.1. Tests were two-tailed with an alpha level of 0.05 for the primary analysis.

3. Results

3.1 Demographic Characteristics

A total of 60 participants were included. Forty-five (75%) of the participants completed the full 36 sessions of rTMS treatment per protocol. Thirteen patients received less than 36 treatments that ranged from 3 to 35 rTMS sessions. Three participants received greater than 36 treatments, specifically, 48, 51, and 64 sessions, respectively. The

average age was 51.9 (SD = 17.7) years. Of the included participants, 37 (61.7%) were female. Regarding race/ethnicity, 54 participants (90.0%) were non-Hispanic White, 5 participants (8.3%) were Non-Hispanic Black, and one was Hispanic (1.7%). The average BMI was 31.0 (SD = 7.7). The insurance status was 42 (70.0%) had commercial insurance, 16 (26.7%) had Medicare, and 2 (3.3%) with Medicaid. The average GAD-7 anxiety score was 14.0 (SD = 5.5). The average MSM was 11.20 (1.3). The median number of psychiatric medications was three. There were 16 participants who received psychotherapy (26.7%). The average state ADI for the sample was 4.8 (SD = 2.7). The average baseline MADRS and PHQ-9 scores were (35.0, SD = 6.4; 20.1, SD =

3.9), respectively. Eight patients had at least one inpatient psychiatric hospitalization and six visited an Emergency Department during the study period.

Table 1 and Table 2 presents the distribution of patients across three rTMS treatment response categories (Full Response, Partial Response, Nonresponse) based on MADRS scores, broken down by demographic and clinical variables. The percentages and chi square values of the patients based on the categorical rTMS response classification for the MADRS and PHQ-9 are summarized in Table 1 and Table 2, respectively. Table S2 lists the prescribed psychiatric medication for each patient.

Table 1: MADRS Categorical rTMS response classification.

Variable: n (%)	Full response	Partial response	Nonresponse	Chi square	P value
Age					
<65	15 (25.0)	13 (21.7)	16 (26.7)	4.173	0.124
≥65	9 (15.0)	1 (1.7)	6 (10.0)		
Gender					
Female	14 (23.3)	8 (13.3)	15 (25.0)	0.629	0.730
Male	10 (16.7)	6 (10.0)	7 (11.7)		
Race					
Black	2 (3.3)	1 (1.7)	2 (3.3)	1.819	0.769
White	22 (3.3)	13 (21.7)	19 (31.7)		
Hispanic	0 (0.0)	0 (0.0)	1 (1.7)		
BMI					
<30	11 (18.3)	6 (10.0)	10 (16.7)	0.035	0.983
≥30	13 (21.7)	8 (13.3)	12 (20.0)		
Insurance					
Commercial	15 (25.0)	12 (20.0)	15 (25.0)	6.141	0.189
Medicare	9 (15.0)	2 (3.3)	5 (8.3)		
Medicaid	0 (0.0)	0 (0.0)	2 (3.3)		
Baseline MADRS					
<35	10 (16.7)	3 (5.0)	5 (8.3)	2.599	0.273
≥35	14 (23.3)	11 (18.3)	17 (28.3)		
Psychotherapy					
No	20 (33.3)	7 (11.7)	17 (28.3)	5.300	0.071
Yes	4 (6.7)	7 (50.0)	5 (8.3)		

BMI-Body Mass Index, MADRS-Montgomery-Asberg Depression Rating Scale.

Table 2: PHQ-9 Categorical rTMS response classification.

Variable: n (%)	Full response	Partial response	Nonresponse	Chi square	P value
Age					
<65	12 (20.0)	11 (18.3)	21 (35.0)	0.105	0.949
≥65	5 (8.3)	4 (6.7)	7 (11.7)		
Gender					
Female	13 (21.7)	5 (8.3)	19 (31.7)	7.124	0.028*

Male	4 (6.7)	10 (16.7)	9 (15.0)		
Race					
Black	1 (1.7)	2 (3.3)	2 (3.3)	1.815	0.770
White	16 (26.7)	13 (21.7)	25 (41.7)		
Hispanic	0 (0.0)	0 (0.0)	1 (1.7)		
BMI					
<30	7 (11.7)	7 (11.7)	13 (21.7)	0.140	0.932
≥30	10 (16.7)	8 (13.3)	15 (25.0)		
Insurance					
Commercial	12 (20.0)	11 (18.3)	19 (31.7)	2.406	0.662
Medicare	5 (8.3)	4 (6.7)	7 (11.7)		
Medicaid	0 (0.0)	0 (0.0)	2 (3.3)		
Baseline PHQ-9					
<20	8 (13.3)	9 (15.0)	14 (23.3)	0.593	0.743
≥20	9 (15.0)	6 (10.0)	14 (23.3)		
Psychotherapy					
No	14 (23.3)	11 (18.3)	19 (31.7)	1.137	0.566
Yes	3 (5.0)	4 (6.7)	9 (15.0)		

BMI-Body Mass Index, PHQ-9-Patient Health Questionnaire. * $p<0.05$.

3.2 PHQ-9 and MADRS concordance

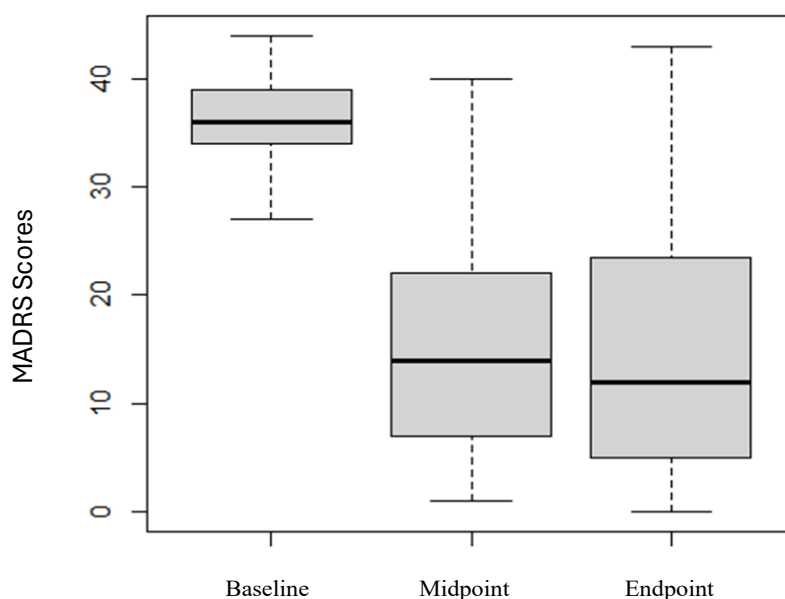
There was strong agreement between the PHQ-9 and MADRS ratings, with a correlation coefficient across all paired ratings of ($r=0.562$, $P<0.001$, (95% CI: 0.359–0.714) at baseline and ($r=0.924$, $P<0.001$, (95% CI: 0.876–0.954) at the end of treatment.

3.3 Change in Depression Severity

Independent t-tests compared age and baseline MADRS and PHQ-9 were not statistically significant ($t=-0.21$, $P=0.84$; $t=-0.26$, $P=0.80$, respectively). Paired-sample t-tests were utilized to assess the effectiveness of TMS treatments in reducing depressive symptoms. The end-of-treatment

MADRS scores were statistically significantly different from the pre-treatment scores ($t=13.13$, $P<0.001$). Furthermore, the effect size of the difference was ($d=1.70$, 95% CI: 1.30–2.09). The end-of-treatment PHQ-9 scores were statistically significantly different from the pre-treatment scores ($t=10.64$, $P<0.001$). Furthermore, the effect size of the difference was ($d=1.37$, 95% CI: 1.02–1.73). The means and standard deviations for MADRS scores at baseline, midpoint of treatment, and endpoint were ($\bar{x}=35.02$, $SD=6.42$; $\bar{x}=15.49$, $SD=10.34$; $\bar{x}=15.08$, $SD=12.10$), respectively. Figure 1 shows the change in depression severity over time with rTMS at baseline, midpoint, and the endpoint.

Figure 1: Depression severity over time with repetitive transcranial magnetic stimulation.^a



^aError bars represent standard deviation.

A multivariate GLM was fitted to compare change in depression severity with the outcome variables MADRS and PHQ-9. Predictor variables, age, sex, race/ethnicity, BMI, insurance status, GAD-7, MSM, number of medications, number of sessions, duration of treatment, psychotherapy, and state ADI were entered to control for confounding. The overall model fit for MADRS and PHQ-9 were statistically significant ($F=21.06$, $P<0.001$; $F=11.53$, $P<0.001$), respectively. Age, insurance status, BMI, number of rTMS sessions, and treatment duration were statistically

significant for MADRS, controlling for all other variables. Age and treatment duration were statistically significant for PHQ-9, controlling for all other variables (See Table 3). Insurance status, BMI, and number of sessions were not statistically significant. Baseline anxiety was not statistically significantly associated with the reduction of depressive symptoms ($P=0.32$ and $P=0.19$), respectively. The state ADI was not statistically significant either ($P=0.83$ and $P=0.88$), respectively. Table 3 displays the regression model results for both the MADRS and PHQ-9.

Table 3: MADRS and PHQ-9 General Linear Model results.

Variable	MADRS		PHQ-9	
	<i>F</i>	Sig.	<i>F</i>	Sig.
Age	209.13	<0.001***	118.31	<0.001***
Race	0.12	0.732	0.05	0.820
Gender	2.28	0.138	2.18	0.146
BMI	8.03	0.007**	2.78	0.102
Insurance	9.62	0.003**	3.32	0.075
GAD7	1.01	0.321	1.78	0.189
Maudsley	0.00	0.975	0.15	0.697
Number				
sessions	14.15	<0.001***	3.47	0.068
Duration	5.03	0.030*	5.55	0.023*
Medications	2.57	0.115	0.59	0.447
Psychotherapy	0.80	0.375	0.13	0.721
ADI	0.04	0.834	0.02	0.882

MADRS-Montgomery-Asberg Depression Rating Scale, PHQ-9-Patient Health Questionnaire, BMI-Body Mass Index, GAD7-General Anxiety Disorder, ADI-Area Deprivation Index. * $p<0.05$, $p<0.01$, *** $p<0.001$.

3.4 Sensitivity Analyses

We conducted a sensitivity analysis with the initial dataset of 60 patients. First, the analysis identified four outliers that were 3 standard deviations either above or below the average number of rTMS sessions, specifically, 3, 4, 6, and 64. Second, the outliers were removed to examine the strength of a prediction effect without session number in the analysis and ensure there was no potential undue influence on the regression results. This left 56 patients in the sample. Age, insurance status, BMI, number of rTMS sessions, treatment duration and number of psychiatric medications were statistically significant for MADRS, while controlling for all other variables. Age was statistically significant for PHQ-9, controlling for all other variables

4. Discussion

4.1 Effects of rTMS treatment on depression

In this retrospective analysis of existing data in the EMR, treatment-resistant depressed psychiatry patients receiving rTMS treatments at a large urban academic outpatient clinic experienced statistically significant improvements in depression severity. Repetitive TMS was shown to be effective in reducing symptoms of depression, based on the pre- and post-MADRS and PHQ-9 inventories for depressive

disorder. The improvement demonstrated in this study of rTMS was not only statistically significant but also highly clinically relevant as exhibited by a Cohen's *d* value greater than one. In our sample of patients with nonpsychotic severe unipolar depression, recurrent and severe treatment resistance, 63% responded to treatment, of which 40% achieved full remission for MADRS and 53% responded to treatment, of which 28% achieved full remission for PHQ-9. These results correspond to the earlier studies of real-world efficacy, which demonstrated response rates of 58% to 83% and remission rates of 28% to 62% (Sackeim et al., 2020).

Our data showed patient characteristics were strongly related to rTMS response. A greater treatment response among older patients with higher BMI was observed. Moreover, there were differences in the results between clinician and patients appraisals. Although not directly examined in the present study, variation in treatment response between gender and age could be moderated by other factors such as hormonal fluctuations. For example, Huang et al. (2008) and Hanlon et al. (2022) showed a relationship between female hormones level, but not age in the therapeutic response. Furthermore, while rTMS does not seem to affect weight, it was found to alter lipid metabolism

and thyroid function (Nakazawa et al., 2025). Thus, age and weight alone should not be considered a poor prognostic factor of the antidepressant efficacy of rTMS.

Our research suggests the type of insurance was statistically predictive of response to treatment. The treatment outcome of those with commercial insurance versus Medicare showed a link between insurance status and rTMS response. Our results show better response rates for patients with private insurance versus government-funded, primarily Medicare, on the MADRS. Since none of the patients treated in our clinic were self-paid, uninsured status likely presented a barrier to this treatment modality. Equally relevant, many of the participants in the present research resided in modestly affluent neighborhoods. These complex interactions of patient-level characteristics intertwined with community-level health-related social needs, allow for disparities in outcomes to occur (Kreuter et al., 2021). Insurance plans might consider broadening coverage, lessening over-restrictiveness through the prior authorization process and enhancing access for rTMS to less treatment-resistant patients.

Most of the reduction in depression severity occurred between baseline and midpoint, then was sustained until the end of treatment. Even though our study did not fully support considering rTMS earlier in the treatment algorithm for TRD. It is evidence for patients with severe, chronic, and refractory depression who already failed multiple psychotropic medication trials to benefit from early intervention (Dalhuisen et al., 2024). Notwithstanding this evidence and FDA clearance for use after one failed antidepressant trial, many patients in our clinic were restricted by insurance companies to receive rTMS access through a prior authorization process requiring high disease severity. These often included a minimum of four failed antidepressant trials from different medication classes, failed attempts at augmentation strategies and lack of response to psychotherapy. This disconnect was evident in the present study as we documented a failure to respond to at least four adequate antidepressant trials with different mechanisms of action, and one or more augmentation strategies using an atypical antipsychotic, lithium, an anticonvulsant, or two antidepressants simultaneously.

In our study, psychotherapy for the rTMS cohort was not found to have a significant impact on rTMS response. Cuijpers et al. (2014) found concurrent psychotherapy appeared to be more effective than treatment with antidepressant medication alone suggesting a synergistic effect. The number of medication failures was not linked to patient outcome. This finding supports prior research, demonstrating rTMS is more effective for patients with less treatment resistance (Grammer et al., 2015). Baseline anxiety was not shown to significantly predict the reduction in symptoms of depression either. Moreover, use of inpatient and emergency room services over the study duration did not indicate over-utilization of psychiatric resources.

4.2 Health-related social needs on treatment effectiveness

Race/ethnicity was not found to be predictive of the patient response. However, the racial and ethnic makeup of our sample was noticeably unrepresentative of the urban core we serve. The surrounding metropolitan area is estimated to be 21.8% African American, 12.9% Hispanic or Latino, and 69.9% White inhabitants (U.S. Census Bureau, 2023). In the present study, only 12% of patients belonged to a minoritized racial group in our study. The finding that Blacks were less likely to demonstrate an improvement in depression when compared to White race seems consistent with common findings where patients from marginalized groups are more likely to experience barriers to care, leading to disparities. Smith et al. (2025) similarly described racial and ethnic disparities in the administration of rTMS at an urban academic center. Minority groups may experience heightened transportation burdens, lack of insurance coverage, lower mental health literacy or poor understanding of the intervention. Possible interventions to remediate these disparities could target increasing awareness of rTMS amongst people of color and improving the racial diversity of TMS referrals and employees in rTMS clinics.

4.3 Strengths and Limitations

This study was conducted at a large, single academic institution with a predominantly underserved and minority patient population that promotes the strength of the sample. A limitation was the retrospective nature of the study design, which predisposed the study to biases inherent to retrospective cohort studies, including incomplete documentation, misclassification, and unmeasured confounding. Regression to the mean, expectancy effects, concurrent medications, psychotherapy, spontaneous improvement, and selective completion have to be considered. The second limitation was the sample size of 60 patients that was determined by convenience and not by statistical power, in particular, the small number of minority participants. Due to the small number of patients comprising a minoritized racial group ($n = 6$), individual groups were unable to be examined separately. The smaller sample of patients included decreased our statistical power as evidenced by the varying regression results between the MADRS and PHQ-9. This may have contributed to the non-statistical differences in the model and increased the probability of a Type I or II error. Although MADRS/PHQ-9 scores fell significantly during treatment, without a control, sham, or comparator group, a causal relationship cannot be determined. Furthermore, the model differences when outliers were removed required care in the interpretation of the findings. The limited dataset that was collected at a single urban center constrains the ability to extrapolate the findings beyond that sufficiently supported by the data. Finally, the generalizability of the results is similarly restricted to comparable patients. Therefore, caution must be taken when drawing conclusions.

5. Conclusions

This real-world study supports the effectiveness of rTMS

as a treatment modality for severe treatment-resistant depression in an outpatient clinical setting. The findings suggest that treatment response is influenced by both patient-level and clinical factors, with more favorable outcomes observed among individuals who completed a full course of treatment. These results underscore the need to reevaluate insurance coverage policies and access barriers related to rTMS, while also drawing attention to the broader role of social determinants of health in shaping depression outcomes. Future research should extend beyond symptom reduction to examine functional status, quality of life, healthcare utilization, and economic outcomes following treatment.

Ethics approval and consent to participate

The study was approved by the University of Florida Institutional Review Board (IRB202500308), and the research was conducted in accordance with the Declaration of Helsinki. Informed consent was waived by IRB for retrospective analysis of anonymized data.

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Clinical trial number: not applicable.

Declaration of competing interests: None

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