Social Needs Analysis in a Transcranial Magnetic Stimulation Patient Cohort with Major Depressive Disorder

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ABSTRACT

BACKGROUND: Social determinants of health play a critical role in mental health outcomes, yet their influence on access to and response to transcranial magnetic stimulation (TMS) for major depressive disorder (MDD) remains poorly understood. As TMS is an effective intervention for treatment-resistant depression and may serve a clinically vulnerable population, characterizing the social context of patients receiving TMS is essential. We examined social needs and assets in a TMS-treated cohort and evaluated their relationship to treatment response, hypothesizing greater social need burden among non-responders.

METHODS: We conducted a retrospective analysis of adults who received an acute course of TMS for MDD at Butler Hospital between 2019 and 2021. Depressive symptom severity, response, and remission were assessed using the Inventory of Depressive Symptomatology–Self Report (IDS-SR). Social needs and assets were measured using a modified Accountable Health Communities Health-Related Social Needs (AHC-HRSN) Screening Tool, including items assessing community engagement.

RESULTS: Seventy-four patients were included in the analysis. Baseline social needs were not significantly associated with TMS response or remission. Patients accessing TMS generally demonstrated high levels of social assets and minimal deficits in basic needs and substance use; however, most reported social isolation and substantial functional impairment. Several domains of self-reported social needs improved following TMS treatment, independent of clinical response.

CONCLUSIONS: Patients receiving TMS exhibited relatively high social assets despite pronounced psychosocial burden associated with depression. Several self-reported psychosocial domains improved following treatment, including isolation/loneliness, difficulty with concentration, and ability to complete errands independently. These findings suggest that TMS may coincide with functional improvements beyond depressive symptom reduction and highlights opportunities to integrate supportive psychosocial services alongside treatment that may further optimize clinical outcomes and reduce social unmet needs. Further investigation is needed to understand how social context influences access to and outcomes of TMS care.

KEYWORDS: Major Depressive Disorder; Social Determinants of Health; Transcranial Magnetic Stimulation

INTRODUCTION

As of 2020, more than 1 in 5 adults in the United States experienced mental illness. Major depressive disorder (MDD) is among the most common psychiatric disorders, and its prevalence continues to rise. In 2017, an estimated 17.3 million U.S. adults (~7% of the adult population) experienced at least one major depressive episode; by 2020, this increased to approximately 21.0 million adults (8.4%).[1,2] Consistent with these trends, data from the National Center for Health Statistics indicate that the proportion of adults receiving mental health treatment within a one-year period increased from 19.2% in 2019 to 21.6% in 2021.[3] Globally, the Global Burden of Disease Study 2019 reaffirmed that mental disorders remain a leading driver of disability; depressive disorders ranked 13th for disability-adjusted life years and were the second leading cause of years lived with disability.[4]

In parallel, clinicians and health systems increasingly recognize that social determinants of health substantially influence both risk for mental illness and downstream outcomes. Social determinants of health refer to the conditions in which people are born, grow, live, work, and age that shape health risks and access to care. Within this framework, "social needs" represent individual-level representations of these broader determinants (e.g., housing instability, food insecurity, transportation barriers, and social isolation), whereas "social assets" refer to supportive resources such as stable housing, reliable transportation, and strong social networks and supports that may help facilitate engagement in care. Higher levels of unmet social needs are associated with an increased likelihood of developing mental illness,[5] and smaller social networks and reduced social support are linked to greater depressive symptom burden.[6] Individuals experiencing more unmet social needs face a higher risk of adverse health outcomes and are less likely to engage in care at the same rates as patients with stronger social supports and assets. Evidence also supports a reciprocal relationship: mental illness can undermine social functioning and economic stability, with cumulative effects over the life

course.[7] Numerous studies have demonstrated associations between mental health and educational attainment, relationship stability, criminal justice involvement, workforce participation, economic status, and housing stability.[8-13] Patients with MDD are more likely to report negative social interactions and diminished social belonging, often worsening as symptom severity increases.[14] This is particularly concerning given longstanding evidence that social support can mitigate depressive symptoms, while a lack of support may contribute to the development of MDD.[15]

Despite available interventions, consistently effective treatment for MDD is not assured. In the STAR*D trial, remission after an initial antidepressant medication trial was estimated to be approximately one-third.[16] In the setting of frequent treatment resistance, transcranial magnetic stimulation (TMS) emerged as an additional treatment modality for MDD.[17] TMS is a neuromodulation procedure that uses magnetic fields to non-invasively stimulate regions in the brain. It is approved for difficult to treat depression among patients who have not benefited from one or more medication trials; clinically, many patients treated with TMS present with long-standing, recurrent, or chronic depressive illness.

To date, little research has examined how social needs and social assets influence access to, adherence to, and benefit from TMS. Given the effectiveness of TMS for a subset of patients with MDD and the potential vulnerability of individuals who pursue this specialized treatment, it is important to better understand the social context surrounding TMS care. Characterizing social needs and assets in this cohort may inform holistic psychiatric care, aid in the identification of barriers to TMS access, and clarify the relationship between health-related social needs and treatment response. Such findings may also help identify opportunities for integrated supportive interventions and inform policies that promote more equitable access to effective treatment.

Accordingly, this study aimed to characterize social determinants in a TMS-treated patient population and to evaluate changes in these determinants following TMS treatment. A secondary aim was to test whether baseline social needs were associated with clinical outcomes following a standard course of TMS therapy.

METHODS

Study Design and Population

We performed a retrospective analysis of data obtained from patients who underwent an acute series of TMS therapy for MDD at the Butler Hospital TMS Clinic between 2019 and 2021. The Butler Hospital Institutional Review Board (IRB) approved the use of clinical data for this purpose. Data were collected at the beginning of the TMS course and again after the final treatment session as part of routine clinical care. Treatment was naturalistic and delivered according to standard-of-care TMS clinical practice.

Sample Characteristics

We included all consecutively admitted adult patients (≥18 years) who received an acute series of TMS at the Butler Hospital TMS Clinic and completed the modified Social Determinants of Health questionnaire. Patients were either self-referred or referred by community providers. All patients were required to meet insurance (Medicaid, Medicare, and commercial plans) coverage for criteria for TMS, which included a primary diagnosis of MDD (single or recurrent episode, without psychotic features, consistent with DSM-V criteria), and documentation of inadequate response or intolerance to >2 antidepressant medical trials. Patients were excluded if they had medical (e.g., seizure disorder) or other (e.g., intracranial metal) conditions that would preclude safe administration of TMS. Patients were required to have MDD symptoms at a moderate or severe level after consultation with a TMS psychiatrist based on clinical assessment and measured by standardized self-report depression measures. Patients must also be sufficiently stable to engage in outpatient care.

TMS Device and Treatment Protocol

Data were collected as part of routine screening and ongoing clinical care. Butler Hospital is a private, non-profit psychiatric and substance use hospital that also serves as a teaching and research facility for Rhode Island and Southeastern Massachusetts.

TMS sessions were delivered once daily as an adjunct to ongoing psychiatric medications. Patients typically received five treatment sessions per week for a total of 30 sessions over six weeks, followed by a taper phase comprising six additional sessions over three weeks. In cases where patients improved but had not achieved remission, the course could be extended by an additional 10 sessions; notably, this course extension was not available to patients with Medicare or Medicaid. Given the retrospective and naturalistic design, patients continued other aspects of mental health care, including pharmacotherapy and psychotherapy.

All treatments were delivered using the NeuroStar TMS Therapy system (Neuronetics, Inc., Malvern, PA). Motor threshold (MT) was determined over the left primary motor cortex during the initial session and used to set stimulation intensity. The system incorporates an iterative, automatic software-based algorithm (MT Assist, Neuronetics) to support MT determination. Head measurements were used to identify a scalp location corresponding to the left dorsolateral prefrontal cortex (DLPFC), over which the coil was positioned for treatment sessions. The standard protocol specifies stimulation at 120% of MT. The on-label stimulation parameters consisted of 10 pulses per second with a cycle of 4 seconds on and up to 26 seconds off, totaling 3000 pulses per session. Although all patients initiated treatment with left-sided 10 Hz stimulation, protocol modifications were made as clinically indicated to manage side effects or optimize outcomes.

Data

Depressive symptom severity and treatment outcomes were assessed using the Inventory of Depressive Symptomatology-Self Report (IDS-SR) and the Patient Health Questionnaire-9 (PHQ-9).[18,19] Consistent with definitions used in large clinical trials of TMS, IDS-SR response was defined as a ≥50% reduction from baseline to endpoint, and remission was defined as an endpoint IDS-SR score ≤14. Percent change was calculated as ((baseline – endpoint)/(baseline) × 100%). PHQ-9 response was defined as a ≥50% reduction from baseline, and remission as an endpoint score ≤4. Patients were grouped for analyses based on whether they met response or remission criteria at the end of treatment.

Chart abstraction included age, gender, race, primary language, ethnicity, educational attainment, employment status, marital status, insurance type, comorbid psychiatric conditions, antidepressant use, and home address. Home addresses were mapped using ArcGIS (Esri, Redlands, CA) to identify U.S. Census block group (BG).

To assess social needs and assets, we used a modified version of the Accountable Health Communities Health-Related Social Needs (AHC-HRSN) Screening Tool as a self-report measure, adding items to assess community engagement to measure social needs burden.[18] Social-need variables were created from questionnaire items and coded for hypothesis testing [**Figure 1**].

Figure 1. Modified Accountable Health Communities Health-Relates Social Needs Screening Tool (AHC-HRSN)

Questions on TMS Patient Social Determinants of Health Survey	Subcategory
What is your living situation today?	Basic Needs
Think about the place you live. Do you have problems with any of the following: 1) Pests such as bugs, ants, mice 2) mold 3) lead paint 4) lack of heat 5) oven or stove not working 6) smoke detectors missing or not working 7) water leaks 8) none of the above	Basic Needs
Within the past 12 months, you worried that your food would run out before you got money to buy more:	Basic Needs
Within the past 12 months, the food you bought just didn't last and you didn't have money to get more:	Basic Needs
In the past 12 months, has lack of reliable transportation kept you from medical appointments, meetings, work or from getting things needed for daily living?	Basic Needs
In the past 12 months has the electric, gas, oil, or water company threatened to shut off services in your home?	Basic Needs
How hard is it for you to pay for the very basics like food, housing, medical care, and heating?	Basic Needs
Do you want help finding or keeping work or a job?	Basic Needs
If for any reason you need help with day-to-day activities such as bathing, preparing meals, shopping, managing finances, etc., do you get the help you need?	Basic Needs
Do you want help with school or training? For example, starting or completing job training or getting a high school diploma, GED or equivalent.	Basic Needs
How often does anyone, including family and friends, physically hurt you?	IPV
How often does anyone, including family and friends, insult or talk down to you?	IPV
How often does anyone, including family and friends, threaten you with harm?	IPV
How often does anyone, including family and friends, scream or curse at you?	IPV
How often do you feel lonely or isolated from those around you?	Isolation and Stress
Stress means a situation in which a person feels tense, restless, nervous, or anxious, or is unable to sleep at night because his or her mind is troubled all the time. Do you feel this kind of stress these days?	Isolation and Stress
In the last 30 days, other than the activities you did for work, how many days during the week on average did you engage in moderate exercise (like walking fast, running, jogging, dancing, swimming, biking, or other similar activities)? On average, how many minutes did you usually spend exercising at this level on one of those days?	Behavior
In the past 3 months, have you engaged in any volunteering?	Behavior
How likely are you to vote in the upcoming election?	Behavior
How connected do you feel to your community?	Behavior
Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions	Disability
Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	Disability
How many times in the past 12 months have you had 5 or more drinks in a day (males) or 4 or more drinks in a day (females)? One drink is 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of 80-proof spirits.	Substance Use
How many times in the past 12 months have you used tobacco products (like cigarettes, cigars, snuff, chew, electronic cigarettes, vaping)?	Substance Use
How many times in the past year have you used prescription drugs for non-medical reasons?	Substance Use
How many times in the past year have you used illegal drugs (e.g., ecstacy, heroin, cocaine, LSD)?	Substance Use
Over the past 12 months, how many times have you been admitted to a hospital for inpatient psychiatric care?	Psych History
Over the past 12 months, have you been treated in a psychiatric day hospital or intensive outpatient program?	Psych History
Over the past 12 months, have you made a suicide attempt or suicide gesture?	Psych History

Questions were compiled into 7 subcategories: Basic Needs, Interpersonal Violence (IPV), Exposure, Isolation and Stress, Health-Related Behaviors, Psychiatric History, Substance Use, and Other

Statistical Analysis

Descriptive statistics characterized the sample at baseline. Continuous parametric variables are reported as mean (SD), continuous non-parametric variables as median (IQR), and categorical variables as proportions.

To compare remitters versus non-remitters, chi-square tests were used for categorical variables. Bonferroni correction was applied to reduce type I error from multiple comparisons. Paired t-tests examined within-subject changes over time (pre- versus post-treatment) in each social-need domain; a second Bonferroni correction was applied to these comparisons. Independent-sample t-tests compared mean AHC-HRSN total scores between outcome groups (responders vs non-responders and remitters vs non-remitters).

Regression models were used to identify predictors of treatment outcomes. Linear regression with backward elimination evaluated predictors of percent change in IDS-SR and PHQ-9. Stepwise forward binomial logistic regression evaluated predictors of IDS-SR and PHQ-9 response and remission status. Covariates included: age, gender (Male=0, Female=1); race (unavailable/other=0, White=1, Black=2); ethnicity (Not Hispanic/Spanish/Latino=0, Hispanic/Spanish/Latino=1); state of residence (Rhode Island=0, Massachusetts=1); total number of treatments, severe history of depression defined by previous psychiatric hospitalization or ECT (yes/no); insurance type (Private=1, Medicare=2, Medicaid=3, Dual Eligible=4); education level (High School=0, Some college=1, Technical college/Associate Degree=2, Bachelor's Degree=3, Graduate school=4), and SSDI enrollment (yes/no).

Domain scores were defined as follows: Housing Insecurity (Item 1; range 0–2); Unsafe Housing (Item 10 endorsements; range 0–7); Food Insecurity (Item 3; range 0–2); Financial Strain due to Cost of Living (Item 5; range 0–2); Assistance with ADLs (Item 8; range 0–3); Interpersonal Violence Exposure (sum of Items 11–14; range 0–16)[20,21]; Isolation (Item 15; range 0–4); Stress (Item 16; range 0–4); Lack of Community Connection (Item 17; range 0–2); Lack of Community Engagement (Item 21; range 0–1); Lack of Political Engagement (Item 22; range 0–3); Days without Moderate Exercise per week (Item 20; range 0–7); and Substance Use (sum of Items 23–26; range 0–16). A total basic-needs score ("AHC-HRSN Screening Tool Total Score") was calculated as the sum of Items 1–26 (range 0–79). While the aggregate score provides a pragmatic summary measure of social needs burden, the items capture multiple distinct domains, including poverty-related material needs (Items 1–10), interpersonal and internal dynamics and community engagement (Items 11–22), and substance use behaviors (Items 23–26). See **Figure 1** for item descriptions.

For backward elimination, all variables were entered initially; at each step, the least significant variable (highest p-value) was removed, using $p>0.10$ as the criterion for exclusion. For forward stepwise logistic regression, variables entered the model at $p<.05$. Correlation coefficients were interpreted using standard criteria: $r<0.3$ (weak), 0.3–0.7 (moderate), >0.7 (strong). All p-values were two-sided, with statistical significance defined as $p<.05$. Analyses were performed in SPSS version 24 (IBM Inc.).

RESULTS

Patient Sample

From September 2019 to August 2021, 82 patients initiated a course of TMS. Of these, 81 completed baseline social needs screening, 74 had clinical outcome data (IDS-SR, PHQ-9) available for analysis, and 40 completed endpoint social needs screening.

The mean age was 42.82 (15.71) years. The sample was 67.6% female; 1.4% identified as Black and 4.1% as Hispanic. Sixty-nine (93.2%) were adults aged 18–65 years, and five (6.8%) were older adults (>65 years). Demographic and clinical characteristics are summarized in **Table 1**.

TMS Treatment Outcomes

Mean (SD) percent change in IDS-SR from baseline to endpoint was 53.1% (31.3%). Mean percent change in PHQ-9 was 59.6% (36.1%). Forty-one (55.4%) met IDS-SR response criteria and 50 (67.6%) met PHQ-9 response criteria. Thirty-two (43.2%) met IDS-SR remission criteria and 33 (44.6%) met PHQ-9 remission criteria. Treatment outcomes are summarized in **Table 2**.

Reported Social Needs at Baseline

Fewer than one-quarter endorsed housing insecurity concerns, with only one patient endorsing active housing instability. Fewer than one-quarter endorsed food insecurity. Only one patient lacked reliable transportation, and only one endorsed difficulty affording utilities. However, just over one-third reported some difficulty paying for basic needs (e.g., medical, food, housing, heating). The most endorsed domains were isolation/loneliness and stress, each reported by 94.6% of the sample. Similarly, 90.8% reported low or no community connection and 86.2% reported no volunteer activity in the prior three months. Baseline responses to the modified AHC-HRSN tool are summarized in **Figure 2**.

Changes in Social Needs Following TMS Treatment

Paired t-test results assessing change in social needs from pre- to post-treatment are summarized in **Table 3**, after Bonferroni correction, adjusted $\alpha=0.003$. Exposure to physical violence did not change significantly (0.05±0.32 vs 0.00±0.00; $t(39)=1.00$, $p=0.32$), though it was endorsed by only two patients at baseline and none at endpoint. No significant changes were observed for threats of physical harm (0.05±0.22 vs 0.05±0.22; $t(39)=0.00$, $p=1.00$) or verbal abuse (0.43±0.75 vs 0.40±0.71; $t(39)=0.37$, $p=0.74$).

Difficulty paying for basic needs decreased (0.63±0.77 vs 0.43±0.59; $t(39)=2.24$, $p=0.031$), though not at the corrected

Table 1. Demographics and Clinical Characteristics of Study Population (n=74)

Characteristic	n (%) or mean ± SD
Age, years	42.82 ± 15.71
Gender	
Female	50 (67.6%)
Male	24 (32.4%)
Race	
White	69 (93.2%)
Black	1 (1.4%)
Other/Unavailable	4 (5.4%)
Ethnicity	
Hispanic, Latino, or Spanish	3 (4.1%)
All Other	71 (95.9%)
Primary language	
English	72 (97.3%)
French	1 (1.4%)
Other	1 (1.4%)
English not spoken at home	7 (9.5%)
Marital status	
Married	31 (41.9%)
Single	35 (47.3%)
Divorced	8 (10.8%)
Insurance	
Private Insurance	35 (47.3%)
Medicare only	17 (23.0%)
Medicaid only	16 (21.6%)
Dual Eligible	6 (8.1%)
Education	
High School	9 (12.2%)
Some College	16 (21.6%)
Technical College/Associates	4 (5.4%)
Bachelor's	30 (40.5%)
Graduate School	15 (20.3%)
Geography	
Living in RI	64 (86.5%)
Living in MA	10 (13.5%)
Treatment history	
Prior Psychiatric Hospitalization	46 (62.2%)
Prior Electroconvulsive Therapy	18 (24.3%)
Baseline IDS-SR score	45.81 ± 9.38
Baseline PHQ-9 score	18.91 ± 4.75
Concurrent Use of Antidepressant Medications*	64 (86.5%)
Any Comorbid Psychiatric Diagnosis	32 (43.2%)
Number of Treatments	35.20 ± 7.63
Employment status	
Employed	26 (35.1%)
Unemployed	15 (20.3%)
Disabled (no SSDI)	1 (1.4%)
SSDI recipient	20 (27%)
Student	2 (2.7%)
Retired	4 (5.4%)
Leave of Absence	6 (8.1%)

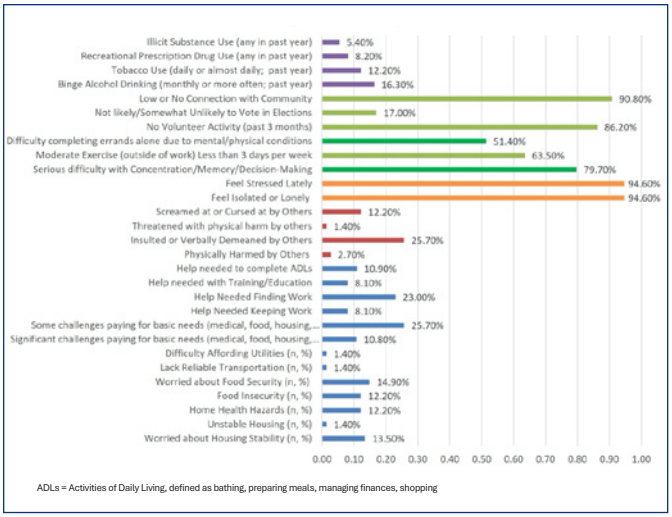
* Defined as prescription use at any dose of any antidepressant medication in one of the following classes: Selective serotonin reuptake inhibitors, Serotonin and norepinephrine reuptake inhibitors, Norepinephrine-dopamine reuptake inhibitors, Tricyclic Antidepressants, Noradrenergic and specific serotonergic antidepressants, Serotonin Antagonist and Reuptake Inhibitor, Monoamine oxidase inhibitors.

Table 2. TMS Treatment Outcomes (n=74)

IDS-SR Responder (n, %)	41 (55.4%)
PHQ-9 Responder (n, %)	50 (67.6%)
IDS-SR Remitter (n, %)	32 (43.2%)
PHQ-9 Remitter (n, %)	33 (44.6%)
%Change IDS-SR (mean ± SD)	53.1 ± 31.3
%Change PHQ-9 (mean ± SD)	59.6 ± 36.07

IDS-SR = Inventory of Depressive Symptomatology–Self-Report; remission=<14
PHQ-9 = Patient Health Questionnaire–9; remission=<4
Response defined as a ≥50% reduction from baseline score on the respective clinical rating scale.

Figure 2. Baseline Prevalence of Social Needs in the Cohort (n=74) by Modified AHC-HRSN Questionnaire



threshold. Similar decreases were observed in needing help finding/keeping employment (0.63±0.90 vs 0.28±0.68; t(39)=3.01, p=0.005) and need for assistance with ADLs (0.62±0.85; t(38)=2.77, p=0.009).

There was a significant reduction in isolation/loneliness (2.90±0.73 vs 1.73±1.10; t(39)=7.86, p<0.001) and stress (3.23±0.81 vs 1.54±1.06; t(38)=8.25, p<0.001). Community connection did not change significantly (1.25±0.62 vs 1.09±0.70; t(31)=1.54, p=0.134).

There was also a significant decrease in difficulties with concentration/memory/decision-making (0.79±0.41 vs 047±0.51; t(37)=3.39, p=0.002) and in inability to complete errands alone (0.56±0.50 vs 0.18±0.39; t(38)=4.42, p<0.001).

Volunteer activity did not change (0.31±0.90 vs 0.34±0.87; t(31)=–2.73, p=0.79), and political engagement did not change (0.88±0.34 vs 0.84±0.37; t(31)=0.571, p=0.572).

Comparison of Response Groups

Independent-samples t-tests comparing responders versus non-responders found no significant baseline differences in AHC-HRSN total score using either definition of response:

Table 3. Changes in Subscale and Selected Item Scores From Baseline to Post-Treatment Following TMS Therapy (n = 40; adjusted $\alpha = 0.003$)

Subscale Items	Mean	Std. Deviation	T	Df	Sig
Housing Insecurity	0.2	0.464	1.955	39	0.058
	0.075	0.267			
Exposure To Physical Violence	0.05	0.316	1	39	0.323
	0	0.000			
Insults and Verbal Demeaning	0.9744	1.013	2.817	38	0.008
	0.5641	0.852			
Threats of Harm	0.05	0.221	0	39	1
	0.05	0.221			
Verbal Abuse	0.425	0.747	0.374	39	0.711
	0.4	0.709			
Financial Strain Due to Cost of Living	0.625	0.774	2.243	39	0.031
	0.425	0.594			
Needs Employment Help	0.625	0.897	3.009	39	0.005
	0.275	0.679			
Needing Assistance with ADLs	0.6154	0.847	2.768	38	0.009
	0.3077	0.614			
Isolation	2.925	0.730	7.856	39	<0.001*
	1.725	1.062			
Stress	3.2308	0.810	8.253	38	<0.001*
	1.5385	1.253			
Community Connection	1.25	0.622	1.539	31	0.134
	1.0938	0.689			
Difficulty Concentrating, Remembering, or Making Decisions (n=38)	0.7895	0.413	3.389	37	0.002
	0.4737	0.506			
Difficulty Doing Errands (n=39)	0.5641	0.502	4.418	38	<0.001*
	0.1795	0.389			
Days without Moderate Exercise Per Week (n=38)	4.9474	2.105	2.479	37	0.018
	3.9737	2.137			
Minutes of exercise (n=39)	1.8718	0.951	2.061	38	0.046
	1.5128	0.790			
Community Engagement (n=32)	0.3125	0.896	-0.273	31	0.786
	0.3438	0.865			
Political Engagement (n=32)	0.875	0.336	0.571	31	0.572
	0.8438	0.369			

IDS-SR responders 16.21±5.72 vs non-responders 15.14±7.55; t(59)=–6.29, p=0.532. PHQ-9 responders 15.88±5.69 vs non-responders 15.43±8.17; t(59)=–2.50, p=0.804.

Similarly, remitters and non-remitters did not differ at baseline: IDS-SR remission groups 15.46±5.49 vs 15.91±7.37; t(59)=0.264, p=0.793. PHQ-9 remission groups 15.44±7.18 vs 15.92±5.75; t(59)=0.276, p=0.784. Chi-square analyses comparing domain-level endorsements between IDS-SR remitters and non-remitters showed no significant differences [**Table 4**].

Table 4. Association Between Social Needs and IDS-SR Remission Status: Chi-Square Analyses (adjusted $\alpha = 0.002$)

Social Need Domain	Remitters, n (%) (n=32)	Non-Remitters, n (%) (n=42)	p-value
Housing Insecurity			0.156
Worried about Housing	2 (6)	8 (19)	
Unstable Housing	1 (3)	0 (0)	
Unsafe Housing	3 (9)	6 (14)	0.724
Food Insecurity			0.174
Sometimes True	2 (6)	7 (17)	
Food Security Worry			0.291
Sometimes True	4 (13)	4 (10)	
Often True	0 (0)	3 (7)	
Unreliable Transportation	0 (0)	1 (2)	1.000
Difficulty Affording Utilities	1 (3)	0 (0)	0.432
Financial Strain due to Cost of Living			0.716
Somewhat Hard	7 (22)	12 (29)	
Very Hard	3 (9)	5 (12)	
Need Help Finding Work	10 (31)	7 (17)	0.281
School Help Needed	2 (6)	4 (10)	0.693
Needing Assistance with ADLs			0.503
Little more help needed	3 (9)	2 (5)	
A lot more help needed	1 (3)	2 (5)	
Physically Harmed [a]	0 (0)	2 (5)	0.502
Insulted or Verbally Demeaned [a]	17 (53)	20 (48)	0.578
Threats of Harm [a]	0 (0)	4 (10)	0.200
Verbally Abused [a]	7 (22)	12 (29)	0.543
Isolated or Lonely			0.535
Rarely	1 (3)	1 (2)	
Sometimes	10 (31)	12 (29)	
Often	12 (38)	20 (48)	
Always	7 (22)	9 (21)	
Stress			0.637
A little bit	1 (3)	3 (7)	
Somewhat	3 (9)	5 (12)	
Quite a bit	15 (47)	14 (33)	
Very much	13 (41)	20 (48)	
Difficulty Concentrating, Remembering, or Making Decisions	26 (81)	33 (79)	1.000
Days without Moderate Exercise			0.525
Two or less	8 (25)	10 (24)	
Seven	13 (41)	11 (26)	
Difficulty Doing Errands	18 (56)	20 (48)	0.491
Binge Alcohol Drinking	10 (31)	16 (38)	0.901
Tobacco Use (daily)	3 (9)	6 (14)	0.260
Recreational Prescription Drug Use	2 (6)	5 (12)	0.075
Illicit Substance Use	2 (6)	2 (5)	1.000

ADLs = Activities of Daily Living: defined as bathing, preparing meals, managing finances, shopping

[a] counted as present if endorsed as happening "sometimes," "fairly often" or "frequently"

Social Determinants as Predictors of TMS Outcomes

A significant linear regression model predicting percent change in IDS-SR (Adjusted R^2=0.382, F(9,51)=5.12, p<0.001) retained eight variables. Age-predicted percent change (β=0.66, p=0.004), lack of community connection (β=–17.10, p=0.004), housing insecurity (β=–24.30, p=0.042), and food insecurity (β=–29.06, p=0.029) were negative predictors.

A significant linear regression model predicting percent change in PHQ-9 (Adjusted R^2=0.391, F(7,53)=6.51, p<0.001) retained seven variables. Age-predicted percent change (β=0.52, p=0.044), insurance type (β=12.81, p=0.002), and days without moderate exercise (β=6.67, p=0.001) were positive predictors. Severe history of depression (i.e., past ECT or inpatient psychiatric hospitalization) (β=–22.97, p=0.009), housing insecurity (β=–24.299, p=0.042), lack of community connection (β=–2.681, p=0.097), and food insecurity (β=–15.03, p=0.026) were negative predictors.

A significant forward stepwise logistic regression predicting IDS-SR responder status (Cox & Snell R^2=0.280, Nagelkerke R^2=0.374, overall correct=74.2%, p<0.001) retained four variables. Total treatments (B=0.12, $\chi^2(1)$=5.35, p=0.021) and days without moderate exercise (B=0.474, $\chi^2(1)$=7.068, p=0.008) were positive predictors. Lack of community connection (B=–1.36, $\chi^2(1)$=4.97, p=0.056) was a negative predictor.

A significant forward stepwise logistic regression predicting PHQ-9 responder status (Cox & Snell R^2=0.338, Nagelkerke R^2=0.464, overall correct=74.2%, p<0.001) included four variables: total treatments (B=0.16, $\chi^2(1)$=7.87, p=0.005), state of residence (B=3.97, $\chi^2(1)$=4.92, p=0.027), and insurance type (B=1.35, $\chi^2(1)$=6.76, p=0.009) were positive predictors; housing insecurity (B=–2.64, $\chi^2(1)$=5.20, p=0.023) was a negative predictor.

A significant logistic regression predicting IDS-SR remission status (Cox & Snell R^2=0.315, Nagelkerke R^2=0.424, overall correct=75.8%, p<0.001) included five variables. Housing insecurity (B=–2.39, $\chi^2(1)$=5.12, p=0.024), lack of community engagement (B=–2.68, $\chi^2(1)$=5.61, p=0.018), food insecurity (B=–3.09, $\chi^2(1)$=4.59, p=0.032), and past psychiatric hospitalization or ECT (B=–2.51, $\chi^2(1)$=9.39, p=0.002) were negative predictors. A significant logistic regression predicting PHQ-9 remission status (Cox & Snell R^2=0.117, Nagelkerke R^2=0.158, overall correct=69.4%, p<0.006) retained one predictor: age (B=0.05, $\chi^2(1)$=6.758, p=0.009).

DISCUSSION

This study aimed to characterize social needs in a TMS-treated cohort, evaluate the relationship between a patient's social needs and social assets to clinical treatment outcomes, and examine changes in self-reported social determinants before and after a course of TMS for MDD. We anticipated that this cohort would include patients with relatively higher social assets, given their ability to access a specialty clinic and engage in a treatment requiring weekday attendance during standard business hours for at least six consecutive weeks. We further hypothesized that higher baseline social assets would be associated with greater response and remission.

Consistent with published naturalistic response rates of approximately 45–60%, our cohort demonstrated response rates of 55.4% (IDS-SR) and 67.6% (PHQ-9). Remission rates were 43.2% (IDS-SR) and 44.6% (PHQ-9), within or slightly above typically reported remission ranges of 30–40% in clinical practice.[22,23]

Notably, the cohort was disproportionately White (93.2%). In 2019, when recruitment began, the proportion of individuals self-identifying as solely White was 78.5% in Massachusetts and 80.9% in Rhode Island. Similarly, only 4% of the cohort identified as Latino/Hispanic/Spanish, substantially lower than the 11.6% and 15% in Massachusetts and Rhode Island, respectively. English was the only language spoken at home for 90.5% of patients, compared with 76.4% in Massachusetts and 77.9% in Rhode Island.[32] These disparities suggest structural barriers to access for TMS treatment and are consistent with broader inequities in mental health care. Individuals from racial and ethnic minority groups have lower access to care, experience lower quality treatment, and have higher rates of discontinuation and lower satisfaction.[24-29] These findings reinforce the need for outreach and strategies to improve equitable access to specialty neuromodulation services.

Across many examined determinants, patients reported generally high social assets with relatively low prevalence of basic-need insecurities. Only one patient endorsed active housing instability, lack of reliable transportation, or difficulty affording utilities, and fewer than one-quarter endorsed housing or food insecurity. However, several domains reflected high psychosocial burden: isolation/loneliness, stress, reduced community connection, lack of volunteer activity, and functional impairments. These patterns may reflect common depressive features (e.g., cognitive symptoms, psychomotor retardation) and disability-associated withdrawal from social and community engagement.[10]

Contrary to our hypothesis, baseline social needs did not differ significantly between responders and non-responders or between remitters and non-remitters. This may reflect selection bias related to treatment access, limited variability in social needs within this cohort, or insufficient power (type II error).

Interestingly, several self-reported domains improved following TMS treatment, including isolation, stress, cognition-related difficulty, and functional limitations, and some nonsignificant trends suggested improvement in additional domains. These changes occurred independent of clinical response classification, raising questions about whether extended engagement with clinical staff, structured daily routines, or shifts in perceived social circumstances

contribute to improvement beyond symptom change alone. Further work is needed to clarify mechanisms and reproducibility.

Regression models identified multiple predictors of outcomes. Some predictors (e.g., total treatments, insurance type, state of residence) may reflect access, adherence, and structural determinants of care. Patients with Medicaid or dual eligibility (i.e., individuals who qualify for both Medicare and Medicaid coverage, typically reflecting low income and higher medical or disability-related needs) have documented disparities in mental health care compared to privately insured individuals, including differences in access to services and treatment outcomes that are often associated with broader socioeconomic disadvantage rather than the insurance status itself, and our findings may reflect similar effects.[30] Access to TMS can vary across insurers due to timeline differences in prior authorization approval, which may create structural barriers to timely treatment. Additionally, some insurance companies, with the exception of Medicaid and Medicare, may approve extensions of up to 10 additional treatments if clinically indicated, which may allow some patients to achieve greater clinical improvement and could contribute to disparities in full access to care. The finding that out-of-state residence predicted better response in one model may indicate that patients able to travel across state lines for daily treatment have greater resources or support.

Other predictors—housing insecurity, food insecurity, interpersonal violence, lack of community connection, and psychiatric hospitalization/ECT history—were anticipated negative predictors, as these factors represent established social and clinical stressors associated with greater depressive symptom burden, reduced social support, or trauma exposure, which have been linked to poorer mental health outcomes and barriers to treatment engagement.[5,6,32] Importantly, these findings should not be interpreted as justification for restricting access to TMS among individuals experiencing greater social unmet needs. Rather, they highlight the opportunity to integrate psychosocial supports and addressing social needs alongside TMS Therapy that may help optimize clinical outcomes and reduce disparities in access to care.

Conversely, some variables representing a higher-need burden (e.g., financial strain, lack of political engagement, needing help with ADLs) emerged as positive predictors in certain models, which is counter to our hypothesis and may reflect complex confounding, measurement overlap with depressive symptom domains, or cohort-specific effects. From a clinical perspective in neuromodulation populations, some of these variables may also partially overlap with depressive symptom domains themselves (e.g., reduced activity levels or civic engagement), functioning as proxies for baseline illness severity rather than independent causal predictors. Age also emerged as a positive predictor, despite prior work suggesting limited association with TMS outcomes.[31]

Strengths include a longitudinal design capturing change over time—an important limitation in much research on social determinants.[21] Evaluating social determinants pre- and post-treatment allowed identification of statistically significant improvements in several domains. Additionally, allowing concurrent pharmacotherapy and psychotherapy improves generalizability to real-world clinical care.

Limitations include single-site design, which may reduce external validity. Endpoint survey completion was limited for a subset of the cohort, potentially introducing attrition bias. Additionally, the sample was relatively homogenous with respect to racial, ethnic, and socioeconomic characteristics, and given the generally high social assets of this sample, restricted range may have reduced the ability to detect effects. Finally, while the AHC-HRSN provides a pragmatic framework for measurement of social determinants, refinements to timeframes and scaling may improve clarity and usability for future work.

Future research should further characterize this cohort, including granular socioeconomic indicators (e.g., household income, housing value, homeownership, neighborhood safety/walkability, debt burden). Qualitative approaches may clarify barriers to TMS access and illuminate how social assets are mobilized to engage in treatment. Structured interviews with patients and referring providers may be particularly valuable to understand referral pathways, access inequities, and opportunities to improve equitable linkage to TMS services.

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