Social Needs Analysis of a Transcranial Magnetic Stimulation Patient Cohort

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Abstract of Social Needs Analysis of a Transcranial Magnetic Stimulation Patient Cohort

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Background: Health practitioners have a growing understanding of the impact of social determinants on patients' mental health outcomes. However, little research exists on how a depressed patient's social wealth affects their access to and clinical benefit from Transcranial Magnetic Stimulation (TMS) therapy. TMS represents an effective treatment for potentially vulnerable patients with Major Depressive Disorder (MDD). An analysis of a TMS patient cohort's social needs could offer valuable insights to inform holistic mental health care and aid in the identification of barriers to TMS. In this pursuit of comprehensive psychiatric care, it is important to understand the effect of social needs on patient response to TMS treatment; we anticipated that TMS treatment non-responders have greater social needs than responders.

Methods: We performed a retrospective analysis of data obtained from patients who underwent an acute series of TMS therapy at Butler Hospital between 2019 and 2021 for MDD. Inventory of Depressive Symptomatology-Self Report (IDS-SR) scores were utilized to measure depressive symptom severity and to define response and remission. To assess patients' levels of social assets, we implemented a modified version of The Accountable Health Communities

Health-Related Social Needs (AHC-HRSN) Screening Tool as a self-report measure, with questions added to explore community engagement.

Results: Data was collected for n=74 patients. We found that patients who had accessed TMS were generally characterized by minimal deficits regarding basic needs and substance use. A majority reported social isolation and disabling symptom burden. Our regression models identified thirteen possible predictors of response to TMS. Patients in our cohort showed areas of significant improvement in self-reported social needs after a series of TMS treatments.

Conclusion: This cohort had elevated levels of social assets, though depressive symptoms may contribute to disengagement with others and the community. Depressed patients show some areas of significant improvement in self-reported social needs after a series of TMS treatments. These results highlight the potential to provide additional patient support and for creating opportunities to connect patients with higher social burdens to TMS. Further exploration is needed to fully elucidate the relationship between determinants and TMS patient outcomes.

INTRODUCTION

As of 2020, more than 1 in 5 adults in the United States suffer from mental illness. Major depressive disorder (MDD) is one of the most common forms of mental illness and unfortunately its prevalence continues to rise. In 2017, 17.3 million adults in the United States (~7% of the adult population), experienced at least one major depressive episode. In 2020, that figure grew to roughly 21.0 million adults, increasing to 8.4% of adults in the U.S. [1,2] According to data collected by The National Center of Health Statistics the percentage of adults who had received treatment for mental health conditions within a one-year period increased from 19.2% in 2019 to 21.6% in 2021. [3] The Global Burden of Disease Study 2019 found that mental illness remains a primary driver of global disability. Not only were depressive disorders 13th as the leading driver of Disability Adjusted Life years, but also the second leading causes of Years Lived with Disability. [4]

As a community, health practitioners are increasingly recognizing the crucial role of social determinants of health on patients' overall health outcomes. This effect of social determinants is well studied in patients with mental illness. The risk of developing mental illness is increased in patients with poor social determinants of health. [11] Smaller social networks and less social support increase the presence of depressive symptoms. [6] Additionally, those facing social inequalities are at higher risk of worse health outcomes and less likely to engage with care at the same rates as patients with

higher social supports and assets. Additionally, research suggests that mental health and social asset status have a reciprocal relationship. In 2014, the World Health Organization detailed the effect of poor mental health can be detrimental to various aspects of one's social health and economic stability and demonstrated that these effects can be cumulative through the life course [14]. A variety of studies have demonstrated evidence that one's mental health can affect education performance and completion, romantic relationship stability, criminal justice involvement, workforce capacity, economic status and housing status. [15-20] Patients with MDD are more likely to report negative social interactions and decreased feelings of social belonging, with these reports worsening with a patient's symptom severity. [10] This is further concerning given the longstanding observation that social support not only acts to improve depressive symptoms, but additionally a lack of this support has been shown to contribute to the development of MDD. [31]

Unfortunately, consistently clinically effective treatment for MDD is not a guarantee for patients. Data from a large, prospective study performed by Trivedi et. al. in the STAR*D Trial estimated that the remission rate for patients with MDD was close to one-third after their first antidepressant medication trial. [7] In this context of frequent treatment resistance, Transcranial Magnetic Stimulation (TMS) emerged as an additional treatment modality for MDD [23]. TMS is a non-invasive procedure to treat depression using magnetic fields to stimulate the left frontal cerebral cortex. TMS is approved for those with treatment resistant depression who have not benefited from one

or more different medication trials; typically, TMS patients have had decades of recurrent or chronic episodes of MDD. [5]

Very little research exists into the impact of a patient's social wealth profile on their access to, adherence to, and benefit from TMS therapy. Given the effective treatment modality that TMS represents for a subset of patients with MDD and the particular vulnerability of the patients that may benefit from this treatment, we believe it is important to understand the social dynamics surrounding this therapy. An analysis of this cohort's social needs and assets could better inform holistic mental health care and aid in the identification of barriers to TMS therapy. Additionally, in this pursuit of comprehensive psychiatric care, it is important to understand the effect of a patient's health related social needs on their response to TMS treatment. Not only might this identify opportunities to provide additional patient support and social interventions, but it could add to the growing evidence of the effects of social determinants on the health of patients. It is our hope that if significant disparities are identified, this information can be used to inspire policies to provide more accessible, equitable, and effective care.

This study was therefore undertaken to characterize the social determinants in a TMS patient population and their change following TMS treatment. Additionally, the goal was to evaluate whether social needs are related to clinical outcome 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 was collected at the beginning of their course of TMS and again after the last treatment session as a routine part of clinical care. Treatment was naturalistic and determined by standard-of-care TMS clinical practice.

Sample Characteristics

We included data from all consecutively admitted adult patients (≥18 years of age) who received an acute series of TMS at the Butler Hospital TMS Clinic and completed the modified Social Determinants of Health questionnaire; the patients were either self-referred or referred by care providers in the community. Patients who met their health insurance coverage criteria for TMS therapy were required to have a primary diagnosis of MDD (single or recurrent episode, without psychotic features, consistent with DSM-IV criteria). They did not have medical conditions (seizure disorder) or other conditions (intracranial metal) that would preclude the safe use of TMS therapy. They were

required to have MDD symptoms at a moderate or severe level and be sufficiently stable to engage in outpatient care.

TMS Device and Treatment Protocol

Data was collected from Butler TMS Clinic patients as a routine part of screening and patient care. Butler Hospital is a private, non-profit, psychiatric and substance abuse hospital that also serves as a teaching and research facility for Rhode Island and Southeastern Massachusetts.

TMS treatments sessions were given once per day as an adjunct to ongoing psychiatric medications. Patients typically received five daily treatment sessions per week, for a total of 30 total sessions over 6 weeks, followed by a taper phase comprised of 6 final sessions over 3 weeks. In some cases when a patient was improving but had not yet achieved remission, the course was extended by an additional 10 sessions; it is notable that this option for a treatment course extension was not available to patients with Medicare or Medicaid. Given the retrospective design of this study and the naturalistic nature of TMS care, patients were able to continue other aspects of their mental health care, including ongoing 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 hemisphere primary motor cortex at the initial treatment session and used for determination of

treatment intensity. An iterative, automatic software-based mathematical algorithm (MT Assist, Neuronetics) is integrated with this system for use in MT determination. Head measurements were used to identify a scalp location corresponding with the left dorsolateral prefrontal cortex (DLPFC), over which the coil was placed at each treatment session. The standard treatment protocol described in the product user manual specifies stimulation at 120% intensity relative to the MT value. The standard on-label stimulation protocol was comprised of a frequency of 10 pulses per second; and a cycle of 4 seconds active stimulation followed by up to 26 seconds of rest (no stimulation) for a total of 3000 pulses per session. Although all patients initiated their course of TMS therapy with left-sided 10 Hz stimulation, modifications to the stimulation protocol were made according to standard clinical routine to manage side effects or to optimize treatment outcome.

Data

Inventory of Depressive Symptomatology-Self Report (IDS-SR) and Patient Health Questionnaire, 9-item (PHQ-9) total scores were utilized to measure depressive symptom severity, and to define response and remission. [41-42] Consistent with the definitions used in large clinical trials of TMS, response was defined by a reduction of 50% or greater from pre-treatment to post-treatment IDS-SR score, and remission was defined by an endpoint score of 14 or less. Percent change was calculated as ((endpoint - baseline score)/(baseline score) x 100%). The PHQ-9 total scores were

also utilized to measure depressive symptom severity, and to define response (≦50% reduction from baseline) and remission (endpoint score of 5 or less). Patients were grouped for analyses based whether they met criteria for categorical response or remission to TMS treatment at the end of their series of sessions.

Data abstracted from patients' charts included patient age, gender, race, primary language, ethnicity, education attainment, employment status, marital status, insurance type, comorbid psychiatric conditions, use of antidepressant medications and home address. Patient home address used ArcGIS (Esri, Redlands, Calif) to identify the United States Census block group (BG).

To assess patients' levels of social assets, we implemented a modified version of The Accountable Health Communities Health-Related Social Needs (AHC-HRSN) Screening Tool as a self-report measure, with questions added to explore level of community engagement. [41] Specific social need variables were created from items on the questionnaire and coded for hypothesis testing as described below.

Statistical Analysis

Descriptive statistics were performed to characterize the sample at baseline. Continuous parametric data are reported as a mean and SD, continuous non-parametric data as a median and interquartile range (IQR), and categorical data as a proportion.

A total basic needs score was created to summarize baseline level of need, referred to as “AHC-HRSN Screening Tool Total Score”. This was defined by the sum of responses to items 1 through 26, resulting in a score with a range of 0-79. See **Table 1** for description of individual items. To analyze the differences between two treatment outcome groups (remitters vs. non-remitters), chi-square tests were used for categorical variables and a series of Independent-samples t-tests were performed to compare the mean AHC-HRSN screening tool total score between two outcome groups (responders vs non-responders and remitters vs. non-remitters).

Paired t-test analyses were performed to examine changes in over time (pre- versus post-TMS treatment) on domains, some of which were measured by individual items and others by summation of several items (see below).

Regression models were used to identify predictors of IDS-SR treatment outcomes with selected candidate predictors and covariate variables entered in the model. Covariates included Age, Gender (Male = 0, Female=1), Race (unavailable/other = 0, white = 1, black = 2), Ethnicity (Not Hispanic, Spanish or Latino = 0, Hispanic, Spanish or Latino = 1), State of Residence (Rhode Island = 0, Massachusetts = 1) Total Number of TMS Treatments, History of Psychiatric Hospitalization or ECT Treatment (yes/no), Insurance Type (Private = 1, Medicare = 2, Medicaid =3, Dual Eligible =4), Education Level (High School = 0, Some college = 1, Technical college/Associate's Degree= 2, Bachelor's Degree = 3, Graduate School=4) and SSDI Enrollment (yes/no). Scores for specific

domains of social needs were created for analysis of candidate predictors in the regression models. “Housing Insecurity” was defined by response to item 1 (range of 0-2); “Unsafe Housing” was defined by number of problems endorsed in response to item 10 (range of 0-7); “Food Insecurity” was defined by response to item 3 (range of 0-2); “Financial Strain” due to cost of living was defined by response to Item 5 (range of 0-2); “Needing Assistance” with activities of daily living (ADLs) was defined by response to Item 8 (range of 0-3); “Interpersonal Violence Exposure” was defined as the sum of responses to items 11, 12, 13, and 14 (range of 0-16) [43-44]; “Isolation” was defined by response to item 15 (range of 0-4); “Stress” was defined by response to item 16 (range of 0-4); “Lack of Community Connection” was defined by response to Item 17, (range of 0-2); “Lack of Community Engagement” was defined by response to item 21, (range of 0-1); “Lack of Political Engagement” was defined by response to item 22 (range of 0-3); “Days without Moderate Exercise” (per week) was defined by answer to item 20 (range of 0-7); and “Substance Use” was defined by the sum of response to items 23 through 26 (range of 0-16).

A linear regression with backward elimination was chosen to select the most important variables predicting percent change in IDS-SR, and a binary logistic regression model with forward stepwise entry was used for evaluating predictors of IDS-SR response and remitter status. For the backwards elimination models, All variables (the full model) were loaded in the first step, then at each subsequent step, the least significant variables were excluded based on highest p-value, and the p-value > 0.10 was used to set a limit

on the total number of variables included in the final model. For the forward stepwise models, variables were added to the model with the entry criteria of $p < .05$. r values were interpreted based on the magnitude and direction of the relationship between variables, according to widely used criteria: r values <0.3 weak, 0.3-0.7 moderate, >0.7 strong. [16] All p-values were from 2-sided tests and results were deemed statistically significant when $p < .05$. All statistical analyses were performed using SPSS, version 24 (IBM Inc).

While correction of p-value significance thresholds (i.e., with a bonferroni factor) was considered for avoiding type I errors, we wanted this analysis to be exploratory in nature and detect potential signals that could be further explored in a larger and more representative sample. We therefore chose to report uncorrected p-values here.

RESULTS

Patient Sample

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

The average age of the cohort was 42.82 ± 15.71 years. A total of 67.6% of the patients in the sample were female; 1.4% were black, and 4.1% were Hispanic; 69 (93.2%) were adults aged 18 to 65 years, and 5 (6.8%) were older adults (>65 years of age). The summarized demographic and clinical characteristics of the study population can be found in **Table 2.**

Reported Social Needs at Pre-Treatment Baseline

Patients' pretreatment responses to the modified AHC-HRSN Screening Tool are summarized in **Table 3**, where the number and percent endorsing each social need are reported for the patient sample (n=74). Less than a quarter of patients endorsed worrying about their housing security, with just one patient in the entire sample endorsing active *Housing Instability*. Similarly, less than a quarter of patients endorsed *Food Insecurity*. Only one patient *Lacked Reliable Transportation*, and only one patient endorsed *Difficulty Affording Utilities*. However, just over a third of patients endorsed some level of *Financial Strain due to Cost of Living* from affording necessities such as medical, food, housing, or heating bills. The domains most often reported by the patients were *Feeling Isolated or Lonely* and *Feeling Stressed Lately* – both endorsed by 94.6% of the sample. Similarly, 90.8% of the cohort reported low or no *Community Connection* and 86.2% reported little or no Political Engagement in the last 3 months prior to their first TMS treatment.

TMS Treatment Outcomes

Treatment outcomes for the sample are summarized in **Table 4.** After completion of their last TMS treatment session, the mean (SD) percent change in IDS-SR scores from baseline pretreatment scores was 53.1% (31.3%). The mean percent change in PHQ-9 scores from baseline pretreatment scores was 59.6% (36.1%). A total of 41 (55.4%) patients met IDS-SR response criteria and 50 (67.6%) met PHQ-9 response criteria after their last TMS treatment; 32 (43.2%) met IDS-SR remission criteria and 33 (44.6%) met PHQ-9 remission criteria after their last TMS treatment.

Changes in Social Needs Associated following TMS Treatment

Results of a series of paired t-tests evaluating change in social needs over time (from pre- to post-TMS treatment) are summarized in **Table 5** below. There was a nonsignificant trend showing decrease in *Housing Insecurity* following TMS treatment (baseline 0.2±0.46 vs. endpoint 0.08±0.27; $t(39)=1.96$, $p = 0.06$). There was not a significant change in *Exposure to Physical Violence* (0.05±0.32 vs. 0.00±0.00; $t(39)=1.00$, $p = 0.32$) however this was only reported by 2 patients at baseline and by none at the post-treatment endpoint. While *Exposure to Insults or Verbal Demeaning* showed a significant decrease from baseline (0.97±1.0) to endpoint (0.56±0.85; $t(38)=2.82$, $p =0.008$), there was not a significant change over time in the scores on

Threats of Physical Harm (0.05±0.22 vs. 0.05±0.22; t(39)=0.00, p =1.00) or on *Exposure to Verbal Abuse* (0.43±75 vs. 0.40±0.71; t(39)=0.37, p = 0.74). *Difficulty Paying for Basic Needs* decreased significantly after TMS treatment (0=.63±0.77 vs. 0.43 ±0.59; t(39)=2.24, p = 0.031). There were also significant drops in patients reporting *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 Activities of Daily Living* (0.62±0.85; t(38)=2.77, p = 0.009). There was a significant reduction in reported *Isolation and Loneliness* after TMS (2.9±0.73 vs. 1.73±1.1; t(39)=7.86, p <0.001) as well as ratings of *Stress* (3.23±0.81 vs. 1.54±1.06; t(38)=8.25, p <0.001). There was not a significant difference in the scores for reported *Community Connection* (1.25 ± 0.62 vs. 1.09 ± 0.70; t(31)=1.54, p =0.134). There was a significant decrease in self-reported *Difficulties with Concentration, Memory and Decision Making* (0.79 ± 0.41 vs. 0.47 ±0.51; t(37)=3.39, p =0.002) reflecting improved cognition after treatment. Similarly, there was a significant difference in *Inability to Complete Errands Alone* (0.56 ±0.50 vs. 0.18 ± .39; t(38)=4.42, p = <0.001) reflecting functional improvements after TMS. There was a significant decrease in *Days each week Without Moderate Exercise* (4.95 ± 2.10 vs. 3.97±2.14; t(37)=2.48, p = 0.018) reflecting increased physical activity after TMS. There was no significant change in *Community Engagement* (0.31± 0.90 vs. 0.34±0.87; t(31)=-2.73, p = 0.79) and no significant change in *Political Engagement* as measured by likelihood of voting in elections (0.88± 0.34 vs. .8438, ±37; t(31)=.571, p = 0.572).

Comparison of Response Groups

Independent-samples t-tests compared TMS responders versus non-responders on the AHC-HRSN Screening tool total score; this was done with response groups defined by both depression scales. There was not a significant difference between the groups in the baseline social needs scores (Responders $_{IDS\text{-}SR}$ 16.21± 5.72 vs. Non-Responders $_{IDS\text{-}SR}$ 15.14±7.55; t(59)= -6.29, p =.532). Similarly, the response groups defined by PHQ-9 criteria were equivalent with regard to baseline social needs (Responders $_{PHQ\text{-}9}$ 15.88±5.69 versus Non-Responders $_{PHQ\text{-}9}$ 15.43±8.17; t(59)= -2.50, p =.804).

When AHC-HRSN Screening tool total score were compared in Remitters and Non-Remitters, again there were no significant differences between groups at baseline using remission criteria defined by either scale. 15.46±5.49 versus 15.91±SD=7.37 t(59)=.264, p =0.793 for IDS-SR, and 15.44±7.18 versus 15.92 ±5.75; t(59)=.276, p =0.784 for PHQ-9.

The difference in the percentage of the patients endorsing specific domains of social needs between IDS-SR remitters and non-remitters were analyzed using a series of chi-square tests. Our analysis did not find significant differences between these two groups in the examined domains which can be found in **Table 6,** below. However there were some nonsignificant trends in higher needs for non-remitters in the following variables. *Worried about Housing Security* (6% of remitters, 19% of non-remitters, p = 0.156), *Food Insecurity* (6% of remitters, 17% of non-remitters, p = 0.174), *Food Security Worry*

(10% of remitters, 17% of non-remitters, p = 0.291), *Threats of Harm* (0% of remitters, 10% of non-remitters, p = 0.200), *Tobacco Use* (9% of remitters, 14% of non-remitters, p = 0.260), *Recreational Prescription Drug Use* (6% of remitters, 12% of non-remitters, p = 0.075).

Social Determinants as Predictors of TMS Outcomes

A significant regression model predicting percent change in IDS-SR (Adjusted R^2= .382, F(9, 51)= 5.12, p = < 0.001) retained nine variables. It was found that *Age* significantly predicted percent change in IDS-SR (β = 0.327, t(51) = 3.03, p = 0.004). Additionally, *Lack of Moderate Exercise Days Each Week* (β = 0.34, t(51) = 3.05, p = 0.004), *Lack of Political Engagement* (β = 0.32, t(51) = 2.62, p = 0.011), *Financial Strain Due to Cost Of Living (*β = 0.33, t(51) = .47, p = 0.017) were significant positive predictors of percent change in IDS-SR. Significant negative predictors of percent change in IDS-SR (i.e., associated with worse clinical outcome) were *Lacking Community Connection* (β = -0.34, t(51) = -2.99, p = 0.004), *Housing Insecurity* (β = -0.26, t(51) = -2.09, p = 0.042), and *Food Insecurity* (β = -0.29*,* t(51) = -2.25, p = .029) and *History of Psychiatric Hospitalization or ECT Treatment* (β = -0.25, t(51)=-2.36, p = 0.022),. *Interpersonal Violence (*β = *-0.18*, t(51) = -1.69, p = 0.097) was a trend level negative predictor of IDS-SR percent change.

A significant regression model predicting percent change in PHQ-9 Scores (Adjusted R^2= .391, F(7, 53)= 6.51, p = < 0.001) retained seven variables. It was found that *Age*

significantly predicted percent change in IDS-SR (β = 0.22, t(53) = 2.06, p = 0.044). Additionally, *Insurance Type* (β = 0.34, t(53) = 3.29, p = 0.002) and *Lack of Moderate Exercise Days Each Week* (β = 0.40, t(53) = 3.67, p = 0.001) were significant positive predictors of percent change in IDS-SR. *Total Number of Treatments (*β = 0.19, t(53) = 1.79, p = 0.079) was a trend level positive predictor of greater symptom improvement. Significant negative predictors of PHQ-9 percent change (i.e., associated with worse clinical outcome) were *History of Psychiatric Hospitalization or ECT Treatment* (β = -0.29, t(53) = -2.70, p = 0.009), *Lacking Community Connection (*β = *-0.25*, t(53) = -2.29, p = 0.097) and *Food Insecurity* (β = -0.22*,* t(53) = -2.00, p = .026).

A significant binary logistic forward stepwise regression model predicting IDS-SR Responder Status (Cox & Snell R^2= .280, Nagelkerke R^2 = .374, overall percent correct =74.2%, p = < 0.001) retained four variables. Significant positive predictors of response status were *Total Number of Treatments* (B = .12, $\chi^2(1) = 5.35$, p = 0.021), and *Days without Moderate Exercise per Week* (B = .474, $\chi^2(1) = 7.068$, p = 0.008). *Lacking Community Connection* (B = -1.36, $\chi^2(1) = 4.97$, p = 0.026) was a significant predictor of nonresponse. *Housing Insecurity* (B = -1.80, $\chi^2(1) = 3.77$, p = 0.052) was a trend level predictor of IDS-SR nonresponse.

A significant binary logistic forward stepwise regression model predicting PHQ-9 Responder Status (Cox & Snell R^2= .338, Nagelkerke R^2 = .464, overall percent correct

=74.2%, p = < 0.001) included four variables. Significant positive predictors of response status were *Total Number of Treatments* (B = .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). *Housing Insecurity* (B = -2.64, $\chi^2(1) = 5.20$, p = 0.023) was a significant predictors of PHQ-9 nonresponse status.

A significant binary logistic forward stepwise regression model predicting IDS-SR Remission Status (Cox & Snell R^2= .315, Nagelkerke R^2 = .424, overall percent correct =75.8%, p = < 0.001) included five variables. *Needing Help with ADLs* (B = 1.05, $\chi^2(1) = 3.60$, p = 0.058) was a trend level positive predictor of remission status. Significant predictors of non-remission were *Housing Insecurity* (B = -2.39, $\chi^2(1) = 5.12$, p = 0.024), *Lacking 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).

A significant binary logistic forward stepwise regression model predicting PHQ-9 Remission Status (Cox & Snell R^2= .117, Nagelkerke R^2 = .158, overall percent correct =69.4%, p = < 0.006) included only one variable. *Age* (B = 0.05, $\chi^2(1) = 6.758$, p = 0.009) was a significant positive predictor of remission status.

DISCUSSION

The purpose of this study was to define a TMS treatment cohort's social needs, evaluate the impact of a patient's social wealth profile on their response to TMS therapy, and to examine the change in self-reported social determinants data before and after a course of TMS treatment for major depressive disorder. We performed a retrospective analysis of data obtained from patients who underwent an acute series of TMS therapy, including IDS-SR, PHQ-9 and modified AHC-HRSN results before and after treatment. We anticipated that this patient cohort would more likely represent patients with higher levels of social assets since they were able to connect with a specialty clinic offer TMS therapy and engage in a treatment that required they travel to the TMS clinic for one-hour sessions (during regular business hours) every weekday, for at least 6 consecutive weeks. Within this patient sample, we hypothesized that patients with higher baseline social assets would have higher rates of response and remission after a TMS treatment series.

Notably, the cohort was categorized by a disproportionate percentage of patients that racially identified as white, at 93.2%. In 2019, when recruitment for the study began, the percentages of the population in Massachusetts and Rhode Island that self-identified as solely white were 78.5% and 80.9%, respectively. Similarly, the percentage of the TMS cohort identified as being of Latino, Hispanic, or Spanish ethnicity was only 4% - considerably less than the 11.6% or 15% of the population identifying with this ethnicity in Massachusetts or Rhode Island. 90.5% of TMS patients reported English as the only

language spoken at home; in Massachusetts and Rhode Island English is primary for 76.4% and 77.9%, respectively. [32] The TMS patient sample is clearly not representative of the greater population with regard to race and ethnicity, reflecting structural barriers that lead to disparity in access to TMS treatment. However, this trend in under-representation of minority group patients in mental health care is not unique to TMS care. Individuals identifying as members of racial and/or ethnic minorities have less access to care for mental illness and have reduced rates of getting necessary mental health care. Research shows that the care these patients receive is of worse quality with higher rates of care discontinuation and lower satisfaction reports. [33-37] The data from this study may serve as additional evidence of the need for continued outreach and support for historically underserved patient populations.

Across many of the social determinants of health examined in these patients receiving a course of TMS therapy, we found the majority of patients reporting that had at least basic assets and minimal needs. Notably, only one patient out of 74 endorsed having needs on questions regarding housing insecurity, lack of reliable transportation, and difficulty affording utilities.

However, there were several notable categories where the cohort was defined by a majority of patients reporting social needs. These included: *Feeling Isolated or Lonely*, *Feeling Stressed Lately*, Serious *Difficulty with Concentration/Memory/Decision-Making*, *Moderate Exercise (outside of work) Less Than 3 Days per Week*, *Difficulty Completing*

Errands Alone (due to mental/physical conditions), *No Volunteer Activity* (past 3 months), and *Low or No Connection with Community*. It is possible that some of these reported areas of deficits may be explained by the cohort's shared diagnosis of MDD. Depression can manifest including difficulty with concentration and psychomotor retardation presenting as lack of appropriate exercise. Symptoms may be disabling and promote isolation and disengagement with others and the community. [10]

Contrary to our hypothesis, in this cohort, baseline social needs (represented as a total score) measured by our modified AHC-HRSN Screening Tool did not differ between patients whose illness responds to TMS therapy and those whose illness persists despite TMS. This may be for several reasons. It is possible our study has a treatment access selection bias, and this cohort is not representative of all patients eligible for TMS therapy. As previously mentioned, the sample of patients receiving TMS does not seem representative of the larger community of depressed patients in Rhode Island and surrounding areas. It is also possible that our sample size was too small for sufficient power and suffers from a type II error. Finally, it is possible that this scale, which was subjected to several modifications, was not psychometrically sufficient to produce a valid total score for comparisons across patient groups.

Interestingly, patients in our cohort show some areas of significant improvement and non-significant trends toward improvement in self-reported social needs after a series of TMS treatments. It is possible that this effect is seen because patients reevaluate their

social circumstance over their treatment course or there is overlap between certain social need domains and manifestation of depressive symptoms. Another hypothesis is that being in contact with healthcare providers for this extended period has a positive effect on patients' reevaluation of perceived social assets. This effect will need to be recreated and explored in future research.

In our series of regression models thirteen possible predictors of response were identified. Some of these variables such as Insurance type, State of Residence, and total numbers of treatments were expected positive predictors of response. It has been previously documented that patients with Medicaid and who have Dual Eligibility are subjected to mental health disparities when compared to similar patients with private insurance. [45] This data may represent another example of this effect. One of our models showed higher prediction of response for out of state patients. This may represent that a person able to achieve daily TMS session while commuting across state lines has access to more resources and a stronger support network. Other variables, such as *Lack of Community Connection, Housing Insecurity, Food Insecurity, Interpersonal Violence, History of Psychiatric Hospitalizations or ECT Treatments* were expected negative predictors of response. The first four of these variables represent increased social needs and support our overarching hypothesis. The remaining factors predicted outcomes in a direction contrary to our hypothesis. *Lack Of Moderate Exercise Days Per Week, Lack of Political Engagement, Needing Help With ADLs,* and *Financial Strain Due To Cost Of Living* all present as positive predictors of good

outcomes, despite representing higher burden of social need. Similarly, Age which has been previously shown to not have a significant relationship with TMS outcomes was calculated as a positive predictor for our cohort. [46]

Consistent with published response rates for cohorts receiving TMS in naturalistic treatment settings of 45%-60%, our cohort was characterized by expected response rates of 55.4% and 67.6% when measured using IDS-SR and PHQ-9 scores, respectively. Similarly, the cohort had an expected remission rate of 43.2% and 44.6% when measured using IDS-SR and PHQ-9 scores, respectively; reported remission rates for depressed patients receiving TMS are typically between 30%-40%. [38,39].

Strengths of this study include its longitudinal design. A common pitfall of studies with the goal of examining social determinants is that their designs do not capture changes over time. [21] by examining changes in self-report data before and after treatment, we were able to identify multiple statistically significant changes including number of exercise days, ratings of isolation, and need for help in completing ADLs. Further study is warranted to verify our findings in large-scale trials. Additionally, by allowing patients to receive medication therapy during the study, our results are more practically applicable to the average patient receiving TMS.

There were several limitations in this study. All participants in this study received treatment at a single care site. This may lower the external validity of our results. Additionally, we were unable to collect survey results at the end of treatment for a

proportion of the cohort by the end of the study period. Given that our cohort was generally defined by high social assets, this may lessen the effect seen in our regression. Lastly, while the AHC-HRSN Screening Tool provides a model for collecting social determinants data from patients, certain details such as time frames and score scales may be adjusted for future ease and clarity in future studies.

Future directions for this research include further examination of the results and increased definition of the cohort. Data surrounding the social determinants of health in this cohort including household income, housing value, homeowner status, neighborhood safety and walkability, and level of debt could be further characterized in future studies. Similarly, further qualitative data collection may provide insights into barriers to TMS access and the effect of social determinants on outcomes. Structured patient interviewing regarding perceptions of hurdles in obtaining treatment and the use of own social assets may be conducted. Questions could also be included to elicit qualitative data on patients' views regarding changes to the modified AHC-HRSN screening tool over the course of TMS treatment. Interviewing referring providers may be particularly important in understanding which eligible patients are connected to TMS clinics and ways to increase access equity.

Table 1: Items in The Modified Version Of The Accountable Health Communities Health-Related Social Needs (AHC-HRSN) Screening Tool Used For Data Collection With Item Scoring.

Item #	Item as it appears on Questionnaire	Social Need Domain
1)	What is your living situation today?	Housing Insecurity
	0. I have a steady place to live. 1. I have a place to live today, but I am worried about losing it in the future. 2. I do not have a steady place to live (I am temporarily staying with others, in a hotel, in a shelter, living outside on the street, on a beach, in a car, abandoned building, bus or train station, or in a park)	
2)	Within the past 12 months, you worried that your food would run out before you got money to buy more:	Food Security Worry
	0. Never true 1. Sometimes true 2. Often true	
3)	Within the past 12 months, the food you bought just didn't last and you didn't have money to get more:	Food Insecurity
	0. Never true 1. Sometimes true 2. Often true	
4)	In the past 12 months has the electric, gas, oil, or water company threatened to shut off services in your home?	Utilities
	0. No 1. Yes 2. Already shut off	
5)	How hard is it for you to pay for the very basics like food, housing, medical care, and heating?	Financial Strain Due to Cost of Living
	0. Not hard at all 1. Somewhat hard 2. Very Hard	
6)	Do you want help finding or keeping work or a job?	Needs Employment Help
	0. I do not need or want help. 1. Yes, help keeping work.	

	2. Yes, help finding work	
7)	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?	Lack Of Transport
	0. No 1. Yes	
8)	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?	Needing Assistance with ADLs
	0. I don't need any help. 1. I get all the help I need. 2. I could use a little more help. 3. I need a lot more help	
9)	Do you want help with school or training? For example, starting or completing job training or getting a high school diploma, GED or equivalent.	School Help
	0. No 1. Yes	
10)	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	Unsafe Housing
	1 point for each problem (1-7) selected; 0 points if option 8 was selected	
11)	How often does anyone, including family and friends, physically hurt you?	Exposure To Physical Violence
	0. Never 1. Rarely 2. Sometimes 3. Fairly often 4. Frequently	
12)	How often does anyone, including family and friends, insult or talk down to you?	Insults And Verbal Demeaning
	0. Never 1. Rarely 2. Sometimes	

	3. Fairly often 4. Frequently	
13)	How often does anyone, including family and friends, threaten you with harm?	Threats of Harm
	0. Never 1. Rarely 2. Sometimes 3. Fairly often 4. Frequently	
14)	How often does anyone, including family and friends, scream or curse at you?	Exposure to Verbal Abuse
	0. Never 1. Rarely 2. Sometimes 3. Fairly often 4. Frequently	
15)	How often do you feel lonely or isolated from those around you?	Isolation
	0. Never 1. Rarely 2. Sometimes 3. Often 4. Always	
16)	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?	Stress
	0. Not at all 1. A little bit 2. Somewhat 3. Quite a bit 4. Very much	
17)	How connected do you feel to your community?	Lack of Community Connection
	0. High Connection 1. Low Connection 2. No Connection	
18)	Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions	Difficulty Concentrating, Remembering, Or Making Decisions

	0. No 1. Yes	
19)	Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?	Difficulty Doing Errands
	0. No 1. Yes	
20)	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?	Days Without Moderate Exercise
	0. 7 1. 6 2. 5 3. 4 4. 3 5. 2 6. 1 7. 0	
21)	In the past 3 months, have you engaged in any volunteering?	Lack of Community Engagement
	0. No 1. Yes	
22)	How likely are you to vote in the upcoming election?	Lack of Political Engagement
	0. Very Likely 1. Somewhat Likely 2. Somewhat Unlikely 3. Not at all	
23)	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.	Binge Drinking
	0. Never 1. Once or Twice 2. Monthly 3. Weekly 4. Daily or Almost Daily	
24)	How many times in the past 12 months have you used tobacco products (like cigarettes, cigars, snuff, chew, electronic cigarettes, vaping)?	Tobacco Use

	0. Never 1. Once or Twice 2. Monthly 3. Weekly 4. Daily or Almost Daily	
25)	How many times in the past year have you used prescription drugs for non-medical reasons?	Recreational Prescription Drug Use
	0. Never 1. Once or Twice 2. Monthly 3. Weekly 4. Daily or Almost Daily	
26	How many times in the past year have you used illegal drugs (e.g., ecstasy, heroin, cocaine, LSD)?	Illicit Substance Use
	0. Never 1. Once or Twice 2. Monthly 3. Weekly 4. Daily or Almost Daily	
27)	Do you speak a language other than English at home?	Primary Language

Table 2. Demographics and clinical characteristics of study population (n=74)

Age, years (mean ± SD)	42.82 ± 15.71
GENDER	
Female (n, %)	50 (67.6%)
Male (n, %)	24 (32.4%)
RACE	
White (n, %)	69 (93.2%)
Black (n, %)	1 (1.4%)
Other/Unavailable (n, %)	4 (5.4%)
ETHNICITY	
Hispanic, Latino, or Spanish	3 (4.1%)
All Other	71 (95.9%)
PRIMARY LANGUAGE	
English (n, %)	72 (97.3%)
French (n, %)	1 (1.4%)
Other (n, %)	1 (1.4%)
Language other than English spoken at home (n, %)	7 (9.5%)
MARITAL STATUS	
Married (n, %)	31 (41.9%)
Single (n, %)	35 (47.3%)
Divorced (n, %)	8 (10.8%)

INSURANCE	
Private Insurance (n, %)	35 (47.3%)
Medicare only (n,%)	17 (23.0%)
Medicaid only (n, %)	16 (21.6%)
Dual Eligible (n, %)	6 (8.1%)
EMPLOYMENT STATUS	
Employed (n, %)	26 (35.1 %)
Unemployed (n, %)	15 (20.3 %)
Disabled (no SSDI) (n, %)	1 (1.4 %)
SSDI recipient (n %)	20 (27%)
Student	2 (2.7 %)
Retired	4 (5.4 %)
Leave of Absence	6 (8.1 %)
EDUCATION	
High School (n, %)	9 (12.2 %)
Some College (n, %)	16 (21.6 %)
Technical College/Associate Degree (n, %)	4 (5.4 %)
Bachelor's (n, %)	30 (40.5 %)
Graduate School (n, %)	15 (20.3 %)
GEOGRAPHY	

Living in RI (n, %)	64 (86.5 %)
Living in MA (n, %)	10 (13.5 %)
Unique Census Tracts (n)	60
Prior Treatment in Psychiatric Day Hospital or Intensive Outpatient Program	23 (35.4 %)
Prior Psychiatric Hospitalization (n, %)	46 (62.2 %)
Prior Electroconvulsive Therapy (n, %)	18 (24.3%)
Baseline IDS-SR score (mean ± SD)	45.81 ± 9.38
Baseline PHQ-9 score (mean ± SD)	18.91 ± 4.75
Concurrent Use of Antidepressant Medications (n, %) *	64 (86.5%)
Any Comorbid Psychiatric Diagnosis (n, %)	32 (43.2%)
Number of Treatments (mean ± SD)	35.20 ± 7.63

* 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 3: N (%) Endorsing Social Needs at Baseline (n=74)

Worried about Housing Stability (n, %)	10 (13.5%)
Unstable Housing (n, %)	1 (1.4%)
Unsafe Housing (n, %)	9 (12.2%)
Food Insecurity (n, %)	9 (12.2%)
Food Security Worry (n, %)	11 (14.9%)
Lack Reliable Transportation (n, %)	1 (1.4%)
Difficulty Affording Utilities (n, %)	1 (1.4%)
Financial Strain due to Cost of Living	
Significant challenges paying for basic needs (medical, food, housing, heating)	8 (10.8%)
Some challenges paying for basic needs (medical, food, housing, heating)	19 (25.7%)
Help Needed Keeping Work	6 (8.1%)
Help Needed Finding Work	17 (23.0%)
School Help	6 (8.1%)
Needing Assistance with ADLs	8 (10.8%)
Physically Harmed by Others [a]	2 (2.7%)
Insulted or Verbally Demeaned by Others [a]	17 (23.0%)
Threatened with Physical Harm by Others [a]	1 (1.4%)

Screamed at or Cursed at by Others [a]	9 (12.2%)
Feeling Isolated or Lonely [b]	70 (94.6%)
Feeling Stressed Lately [c]	70 (94.6%)
Serious Difficulty with Concentration/Memory/Decision-Making	59 (79.7%)
Moderate Exercise (outside of work) Less than 3 days per week	47 (63.5%)
Difficulty Completing Errands Alone due to mental/physical conditions	38 (51.4%)
Lacking Community Engagement (past 3 months) [d]	56 (86.2%)
Not Likely/Somewhat Unlikely to Vote in Elections [d]	11 (16.9%)
Low or No Community Connection [d]	59 (90.8%)
Binge Alcohol Drinking (monthly or more often; past year)	12 (16.2%)
Tobacco Use (daily or almost daily; past year)	9 (12.2%)
Recreational Prescription Drug Use (any in past year)	6 (8.1%)
Illicit Substance Use (any in past year)	4 (5.4%)

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"

[b] counted as present if endorsed as happening "sometimes," "often" or "always"

[c] counted as present if endorsed as happening "somewhat," "quite a bit" or "very much"

[d] Sample size=65 due to missing data

Table 4: 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

Table 5: Comparison of Subscale and Select Item Scores Before and After TMS Therapy in n=40 with pre- and post-treatment data

	Mean	Std. Deviation	T	Df	Sig
Housing Insecurity	.2000	.46410	1.955	39	0.058
	.0750	.26675			
Exposure To Physical Violence	.0500	.31623	1.000	39	0.323
	.0000	.00000			
Insults and Verbal Demeaning	.9744	1.01274	2.817	38	0.008
	.5641	.85208			
Threats of Harm	.0500	.22072	.000	39	1.000
	.0500	.22072			
Verbal Abuse	.4250	.74722	.374	39	0.711

	.4000	.70892			
Financial Strain Due to Cost Of Living	.6250	.77418	2.243	39	0.031
	.4250	.59431			
Needs Employment Help	.6250	.89693	3.009	39	0.005
	.2750	.67889			
Needing Assistance with ADLs	.6154	.84652	2.768	38	0.009
	.3077	.61361			
Isolation	2.9250	.72986	7.856	39	<0.001*
	1.7250	1.06187			
Stress	3.2308	.80986	8.253	38	<0.001*
	1.5385	1.25334			
Community Connection	1.2500	.62217	1.539	31	0.134
	1.0938	.68906			
Difficulty Concentrating, Remembering, Or Making Decisions (n=38)	.7895	.41315	3.389	37	0.002
	.4737	.50601			
Difficulty Doing Errands (n=39)	.5641	.50236	4.418	38	<0.001*
	.1795	.38878			
Days without Moderate Exercise Per Week (n=38)	4.9474	2.10466	2.479	37	0.018
	3.9737	2.13702			
Minutes of exercise (n=39)	1.8718	.95089	2.061	38	0.046
	1.5128	.79046			

Community Engagement (n=32)	.3125	.89578	-.273	31	0.786
	.3438	.86544			
Political Engagement (n=32)	.8750	.33601	.571	31	0.572
	.8438	.36890			

Table 6: Chi square tests of Social Needs by IDS-SR Remission Status

Social Need Domain		**Remitters (n=32)**	**Non-Remitters (n=42)**	**p-Value**
Housing Insecurity				
	Worried about Housing (n, %)	2 (6)	8 (19)	.156
	Unstable Housing (n, %)	1 (3)	0 (0)	
Unsafe Housing (n, %)		3 (9)	6 (14)	.724
Food Insecurity (n, %)				.174
	Sometimes True	2 (6)	7 (17)	
Food Security Worry (n, %)				.291
	Sometimes True	4 (10)	4 (10)	
	Often True	0 (0)	3 (7)	
Unreliable Transportation (n, %)		0 (0)	1 (2)	1.000
Difficulty Affording Utilities (n, %)		1 (3)	0 (0)	.432

Financial Strain due to Cost of Living				.716
	Somewhat Hard	7 (22)	12 (29)	
	Very Hard	3 (9)	5 (12)	
Need Help Keeping Work		3 (7)	3 (9)	.281
Need Help Finding Work		10 (31)	7 (17)	
School Help Needed		2 (6)	4 (10)	.693
Needing Assistance with ADLs				.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)	.502
Insulted or verbally demeaned [a]		17 (55)	20 (48)	.578
Threats of Harm [a]		0 (0)	4 (10)	.200
Verbally abused [a]		7 (22)	12 (28)	.543
Isolated or Lonely				.535
	Rarely	1 (3)	1 (2)	
	Sometimes	10 (31)	12 (29)	
	Often	12 (38)	20 (48)	
	Always	7 (21)	9 (21)	

Stress				.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 (81)	1.000
Days without Moderate exercise each week				
	Two or less	8 (25)	10 (24)	.525
	Seven	13 (41)	11 (26)	
Difficulty Doing Errands		18 (56)	20 (48)	.491
Binge Alcohol Drinking (monthly or more often; past year)		10 (38)	16 (31)	.901
Tobacco Use (daily or almost daily; past year)		3 (9)	6 (14)	.260
Recreational Prescription Drug Use (any in past year)		2 (6)	5 (12)	.075
Illicit Substance Use (any in past year)		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"

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