Research Article

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Resource utilization and economic outcomes following repetitive transcranial magnetic stimulation for treatment-resistant depression: a retrospective observational analysis

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Aim: We investigated the impact of repetitive transcranial magnetic stimulation (rTMS) for treatment-resistant depression on healthcare resource utilization as well as commercial and Medicare Fee-for-Service payer costs. **Materials & methods:** We conducted a retrospective observational analysis of claims data using Medicare Fee-for-Service datasets and commercial (Merative MarketScan Research Databases) datasets from 1 January 2021 to 30 September 2023. We identified two cohorts, a cohort that received rTMS and a cohort not treated with rTMS over an 18-month period. We used propensity score matching to balance the baseline characteristics of the cohorts, and we calculated the total cost of care based on payer allowed amounts from Merative MarketScan Research Databases and Standard Analytical Files. **Results:** Relative to the non-TMS cohort, the rTMS cohort incurred 37% more hospital outpatient visits (14.00 vs 10.21; $p \leq 0.0001$) with 7% higher outpatient cost ($8946 vs $8363; $p = 0.3400$). Simultaneously, the rTMS cohort incurred 24% fewer inpatient admissions (0.25 vs 0.33; $p = 0.0003$) with 19% lower inpatient admission costs ($5666 vs $6978; $p = 0.0392$), 48% fewer emergency room visits (0.27 vs 0.53; $p \leq 0.0001$) with 34% lower emergency room costs ($322 vs $487; $p \leq 0.0001$), and $893 less in episode of care costs. **Conclusion:** This study suggests that patients who receive rTMS for treatment-resistant depression required fewer high acuity hospital visits and incurred less expensive episode-of-care costs compared with patients who do not receive rTMS. From this perspective, rTMS is an investment that returns health and economic dividends through fewer high acuity hospital visits.

Plain language summary

What was the aim of this research? To assess whether repetitive transcranial magnetic stimulation (rTMS) for treatment-resistant depression (TRD) reduces healthcare system utilization and insurance costs over an 18-month timeframe. We tracked inpatient admissions, emergency room usage and hospital outpatient visits.

What methodology is used in this study? We identified patients with TRD from a Medicare and commercial administrative claims database. We used statistical processes to ensure that the rTMS and non-TMS cohort were comparable.

What were the results? Patients treated with rTMS cost payers less money relative to those who were not treated with rTMS.

What do the results of the study mean? rTMS for TRD reduces high acuity medical system utilization and overall payer costs.

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Depression is a common psychiatric disorder estimated to impact at least 300 million people worldwide [1]. In 2021, at least 21 million adults within the USA experienced at least one major depressive episode [2]. Untreated depression can affect physical and emotional well-being [1], leading to poorer health outcomes and lost productivity. Moderate and severe major depressive disorder (MDD) can lead to a high rate of emergency department visits and inpatient admissions [3]. Approximately half of patients with MDD have 'difficult to treat' or treatment-resistant depression (TRD) [4], defined by the Agency for Healthcare Research and Quality as depression that has not improved with two or more antidepressant medications at adequate dosages for adequate durations [5]. The number of antidepressant trials during a depressive episode correlates with the odds of future depressive relapse [6]. Individuals with TRD often incur up to 40% higher medical costs compared with individuals without TRD because of higher system utilization [7].

Repetitive transcranial magnetic stimulation (rTMS) is US FDA cleared for TRD [8]. This treatment involves the application of a strong magnetic field to the cerebral cortex. The most common treatment target is the left dorsolateral prefrontal cortex. The precise mechanism of action of rTMS for MDD remains unclear, but a leading hypothesis is that stimulating the left left dorsolateral prefrontal cortex corrects abnormalities in the brain circuit that regulates mood [9]. Treatments are typically performed in an outpatient clinical setting. Each treatment session typically takes 3–37 min to administer, depending on the particular treatment protocol being used. In a full course of conventional rTMS for MDD, patients typically receive daily weekday treatments until they accumulate 30–36 treatment sessions. The average age of patients receiving TMS typically ranges between 40 and 50 years old, although TMS also has FDA clearances for adolescent and late life depression.

TMS is prescribed when antidepressant medications and therapy do not work. A large US patient registry analysis performed by Sackeim *et al.* (n = 5010) calculated the open-label response rate of rTMS to be 58–83% [10]. Additionally, the multisite ASCERTAIN-TRD study (n = 278) found that TMS augmentation was superior to antidepressant augmentation or switch for TRD [11]. TMS has no metabolic and systemic side effects. Unlike electroconvulsive therapy (ECT) and rapid-acting pharmacotherapies like esketamine, TMS does not require anesthesia or supervised transportation to and from treatments [12].

Several past and recent studies have assessed the cost–effectiveness of rTMS for TRD. An incremental cost–effectiveness ratio, calculated as the difference in costs divided by the difference in outcomes, conducted in 2009 comparing rTMS to sham treatment as well as the current standard of care. This resulted in rTMS providing a cost of $300 per treatment session, with a value of $34,999 per quality-adjusted life year (QALY) compared with sham treatment. When compared with the current standard of care, rTMS provided a net cost saving of $1123 per QALY. Notably, the overall cost savings were greater for patients at earlier levels of treatment resistance in the overall sample [13]. Similar results were found when TMS was compared with alternative depression treatments. In multiple studies, TMS has been shown to be more effective and less costly than serial pharmacotherapy trials or ECT [14–17]. TMS also demonstrates better patient outcomes, including remission rates, when compared with sham treatments [18].

Despite these positive signals, most of the analyses supporting the cost–effectiveness of TMS rely on economic modeling or clinical trials data rather than real-world claims data. Here, we addressed this gap in the literature by tracking actual healthcare utilization and costs over 18 months to compare resource utilization and cost between rTMS and non-rTMS patients using commercial (Merative Marketscan) and Medicare claims data.

Materials & methods

This study was a retrospective observational claims data analysis of rTMS and non-rTMS cohorts using Medicare Fee-for-Service (MCFFS) dataset, representing all MCFFS enrollees, and Merative MarketScan Research Databases, a commercial administrative claims dataset, identified from 1 January 2021 to 31 December 2021. Patients identified within the index period were tracked for 18 months ending 30 September 2023. To be enrolled in a MCFFS program generally patients need to be US citizens and 65 years or older or having a disability such as end-stage renal disease. Medicare considers TMS medically necessary for up to 6 weeks for severe MDD, single or recurrent episode [19]. The patient requires a confirmed diagnosis of severe MDD as defined by the current Diagnostic and Statistical

Manual of Mental Disorders, and demonstrated failure of one or more trials of a pharmacological medication and/or demonstrates an intolerance to psychopharmacologic medications and the TMS procedure is written by a psychiatrist, who has examined the patient [19].

A patient selection flowchart for both cohorts is presented in Figure 1. To be included in the study, patients needed to meet all of the following inclusion criteria: 18 years of age or older, currently experiencing a major depressive episode, currently experiencing treatment resistant depression and continuously enrolled on an insurance plan during the tracking period. Patients were excluded if they were treated for any of the following conditions in the 180 days prior to the index event: autism spectrum disorder, severe cognitive impairment, epilepsy, mania, psychosis, active suicidal behavior and structural neurological lesion. These conditions are commonly included in insurance policies for TMS coverage as exclusionary. Coding for these conditions is provided as Appendix Table 1. To ensure the logistic regression model was effective for propensity score matching, we undersampled our non-rTMS cohort at 20-times the size of our rTMS cohort, decreasing the size of our non-rTMS cohort to 45,820 patients with similar characteristics prior to undersampling.

Patients were classified as having TRD by meeting one of the following scenarios: Initiation of a new antidepressant treatment course (i.e., either a claim for a new antidepressant or a claim for a new nonantidepressant augmentation medication overlapping with a claim for an antidepressant) after the absence of a response to two antidepressant treatment courses of adequate duration, initiation of at least one antipsychotic alongside one antidepressant within 6 months of the index drug (antipsychotic or antidepressant) or initiation or continuation of rTMS treatment 6 months post index MDD event. The inclusion of antipsychotic augmentation is consistent with FDA labeling for medications such as aripiprazole, brexpiprazole, quetiapine and cariprazine [20]. The absence of response is defined as a change of a treatment course including the switch of an antidepressant or an initiation of augmentation therapy (i.e., an addition of a new antidepressant, or an addition of a new non-antidepressant augmentation medication). Medication coding can be found in Appendix Table 1. Adequate duration is defined as at least 6 weeks of continuous therapy with no gaps longer than 14 days. Due to the lack of medication data, treatment resistance prevalence for Medicare patients was identified based on utilization across inpatient and outpatient service settings 6 months prior to the index MDD event. The percentage of commercial patients identified as having TRD was applied to the top healthcare utilizers in the Medicare arm and all associated outcomes for the Medicare group were derived from MCFFS administrative claims data. This led to us having the same percentage of TRD patients across both our commercial and Medicare cohorts. The timeframe for the commercial and Medicare patient inclusion spans from 1 January 2021 to 31 December 2021. Any patient that had an index event during this time period was tracked for 18 months, with the last tracking event ending in August 2023. We divided the study population into two cohorts to address the study objectives. cohort 1 consisted of patients with MDD and were treated with rTMS, while cohort 2 consisted of patients with MDD who did not receive rTMS.

We analyzed resource utilization and economic outcomes up to 18 months following the initial invention. Resource utilization included the number of visits post-index inclusive of hospital inpatient, outpatient, and emergency department. The economic outcomes included episode of care (EOC) costs from inpatient, outpatient, and emergency room settings. Primary care data was not available for all patients within the study and was omitted from the analysis. Allowed amounts captured in the post-index tracking period are inclusive of all payments for services rendered, including patient responsibility such as copays, coinsurance and deductibles.

Statistical analysis

We summarized patient demographics using descriptive statistics for each cohort. We used frequency (%), dosage, type of treatment, and treatment setting (if applicable) post index visit, and we compared demographic categorical data between groups using Pearson's chi-squared or Fisher's exact test. We used independent sample *t*-tests to compare post-index costs across cohorts. Utilization outcome events were analyzed with Pearson's chi-squared and Fisher's exact tests when appropriate. The threshold for statistical significance was set a priori at $\alpha < 0.05$.

We used propensity score matching to balance the baseline characteristics of the cohorts to ensure the outcomes could be analyzed by controlling for differences in patient characteristics. We used a traditional logistic regression model for the propensity score calculation and chose the nearest neighbor for matching. Standardized mean differences (SMDs) were used to measure the difference between two group means. The primary tool used for this analysis was R version 4.4.0 (R Studio version 1.4.1106).

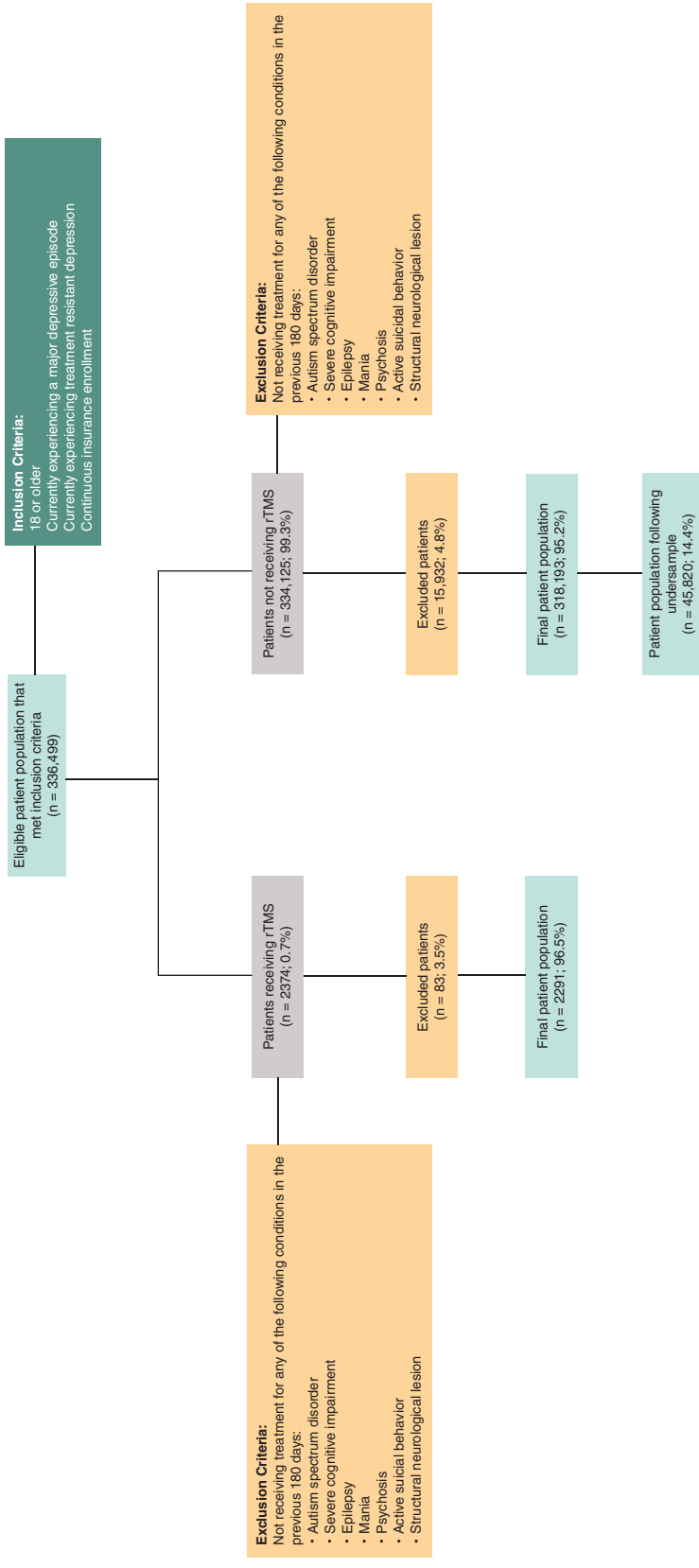

Figure 1. Patient selection.

Results

Patient flowchart

Unadjusted baseline characteristics and comorbidities are presented in Table 1, for the undersampled patient population and propensity matched population. After undersampling the non-rTMS cohort, the rTMS cohort contained a greater percentage of commercial patients (80.7 vs 40.4%; SMD: -1.02) who also had a larger proportion of patients in the 26–35 age range compared with the non-rTMS cohort (12.2 vs 6.9%; SMD: 0.16). The rTMS cohort also experienced significantly higher rates of anxiety disorder (58.4 vs 28.6%; SMD: 0.60), substance abuse disorder associated with alcohol, opiates, and/or sedatives (6.2 vs 4.1%; SMD: 0.087), and other substance abuse disorder types (3.9 vs 1.9%; SMD: 0.11), while experiencing significantly lower rates of cardiovascular disease (0.7 vs 5.6%; SMD: -0.56), cancer (1.0 vs 1.5%; SMD: -0.05) and obesity (9.7 vs 10.7%; SMD: -0.03). The propensity score matching model was successful in balancing baseline differences between the two cohorts and any significant differences were no longer present in the final patient population for analysis. A total of 9164 patients were included in the analysis: 2291 patients in the rTMS cohort and 6873 patients in the non-rTMS cohort.

Eighteen-month utilization outcomes

Propensity score matched utilization outcomes are shown in Table 2. Adjusted 18-month post-index data shows that on average, the rTMS cohort incurred 37% more hospital outpatient department visits (14.00 vs 10.21; $p \leq 0.0001$), 24% fewer inpatient admissions (0.25 vs 0.33; $p = 0.0003$) and 48% fewer emergency room visits (0.27 vs 0.53; $p \leq 0.0001$) compared with the non-rTMS cohort.

The rTMS cohort utilized more outpatient psychiatric treatments compared with the non-rTMS cohort (0.87 vs 0.21). The rTMS cohort utilized more group psychotherapy compared with non-rTMS (0.52 vs 0.24). Psychotherapy services were utilized at a higher rate among rTMS patients compared with non-rTMS patients, 47% higher for 45 min psychotherapy sessions (0.32 vs 0.22); 45% higher for 60 min psychotherapy sessions (0.44 vs 0.08).

Eighteen-month economic outcomes

Propensity score matched EOCs are shown in Table 3. On average, the rTMS cohort incurred $893 less in EOC costs compared with the non-rTMS cohort ($14,934 vs $15,828; $p = 0.3499$). This difference can be attributed to 19% lower inpatient admission costs for the rTMS cohort ($5666 vs $6978; $p = 0.0392$), as well as 34% lower emergency room costs ($322 vs $487; $p \leq 0.0001$). Costs for hospital outpatient department visits were 7% higher for the rTMS cohort ($8946 vs $8363; $p = 0.3400$). Additional cost values (minimum, maximum and median) are available within Supplementary Table 1.

Discussion

This study suggests that rTMS for TRD may diminish high acuity encounters and reduce EOC costs for at least 18 months after the index treatment. This naturalistic outcome, based on real-world claims data, aligns with earlier reports from clinical trials and modeling approaches [10,11,13], providing strong converging support for lower EOC costs with rTMS treatment. Reductions in inpatient and emergency room services likely reflect the successful management of illness with outpatient visits. Indeed, we found increased outpatient visits in the rTMS cohort (14.00 vs 10.21; $p \leq 0.0001$), driven by the rTMS course [21], any rTMS course treatment extension [22], outpatient follow-up after rTMS along with additional psychiatric treatments for group therapy and psychotherapy for the rTMS cohort compared with non-rTMS. Our review of allowed amounts in this analysis suggests that the cost savings for payers would also translate into cost savings for patients. Treating depression can also have downstream improvements on a patient's adherence and prognosis for other medical conditions [23].

This study adds important context to the existing literature on cost–effectiveness of TMS. Most of the existing studies have focused on economic modeling or clinical trials data. For example, Dalhusien *et al.* conducted a randomized trial comparing rTMS to the next pharmacological step in MDD patients unresponsive to at least two treatments [15]. rTMS led to a significantly greater reduction in symptoms than medication switch, supporting its earlier use and potential cost–effectiveness in depression treatment [15]. Voigt *et al.* used a Markov model to assess the lifetime cost–effectiveness of rTMS versus pharmacotherapy after one failed medication trial [16]. Using published data and Medicare costs, rTMS was found to be more effective and less costly across all age groups. Sensitivity analyses confirmed its cost–effectiveness, supporting earlier use in depression treatment [16]. These cost–effectiveness results are also found in various healthcare settings. For example, Dalhuisen *et al.* conducted a 12-month RCT in

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Table 1. Patient characteristics before and after propensity score matching.

	Before propensity score matching				After propensity score matching			
	rTMS	non-rTMS	% difference	Standardized mean difference	rTMS	non-rTMS	% difference	SMD
	(n = 2291)	(n = 45,820)	–	–	(n = 2291)	(n = 6873)	–	
	n (%)	n (%)	–		n (%)	n (%)		
Payer makeup								
Commercial	1849 (80.7%)	18,502 (40.4%)	99.9%	-1.0220	1849 (80.7%)	5507 (80.1%)	1%	-0.0113
Medicare	442 (19.3%)	27,318 (59.6%)	-67.6%		442 (19.3%)	1366 (19.9%)	-3%	
Age (years)								
18–25†	328 (14.3%)	3058 (6.7%)	114.7%	–	328 (14.3%)	952 (13.9%)	3.4%	–
26–35	279 (12.2%)	3147 (6.9%)	77.3%	0.1624	279 (12.2%)	858 (12.5%)	-2.4%	0.0052
36–45	464 (20.3%)	5319 (11.6%)	74.4%	0.2151	464 (20.3%)	1457 (21.2%)	-4.5%	-0.0111
46–55	512 (22.4%)	7031 (15.3%)	45.7%	0.1681	512 (22.4%)	1454 (21.2%)	5.6%	0.0008
56–65	422 (18.4%)	8772 (19.1%)	-3.8%	-0.0187	422 (18.4%)	1273 (18.5%)	-0.5%	0.0009
66–75	220 (9.6%)	10,932 (23.9%)	-59.8%	-0.4839	220 (9.6%)	680 (9.9%)	-2.9%	-0.0016
76–99	66 (2.9%)	7561 (16.5%)	-82.5%	-0.8143	66 (2.9%)	199 (2.9%)	-0.7%	-0.0027
Gender								
Female†	1551 (67.7%)	32,711 (71.4%)	-5.2%	–	1,551 (67.7%)	4559 (66.3%)	2.1%	–
Male	740 (32.3%)	13,109 (28.6%)	12.9%	0.0789	740 (32.3%)	2314 (33.7%)	-4.1%	-0.0106
Hospital region								
South	920 (40.2%)	15,900 (34.7%)	15.7%	0.1113	920 (40.2%)	2776 (40.4%)	-0.6%	-0.0057
Northeast	343 (15.0%)	7717 (16.8%)	-11.1%	-0.0524	343 (15.0%)	1075 (15.6%)	-4.3%	-0.0063
Midwest†	392 (17.1%)	14,127 (30.8%)	-44.5%	–	392 (17.1%)	1169 (17.0%)	0.6%	–
West	636 (27.8%)	8076 (17.6%)	57.5%	0.2263	636 (27.8%)	1853 (27.0%)	3.0%	0.0066
Additional risk factors								
Anxiety disorder	1337 (58.4%)	13,093 (28.6%)	104.3%	0.6042	1,337 (58.4%)	4000 (58.2%)	0.3%	0.0021
Substance abuse (alcohol, opiates, sedatives)	141 (6.2%)	1865 (4.1%)	51.1%	0.0867	141 (6.2%)	378 (5.5%)	11.8%	0.0181
Substance abuse (other)	90 (3.9%)	851 (1.9%)	111.3%	0.1066	90 (3.9%)	241 (3.5%)	12.0%	0.0067
Pain	170 (7.4%)	3597 (7.9%)	-5.5%	-0.0164	170 (7.4%)	442 (6.4%)	15.4%	0.0149
Cardiovascular disease	17 (0.7%)	2561 (5.6%)	-86.8%	-0.5648	17 (0.7%)	25 (0.4%)	105.6%	0.0458
Cancer	22 (1.0%)	672 (1.5%)	-34.7%	-0.0519	22 (1.0%)	40 (0.6%)	65.5%	0.0268
Obesity	221 (9.7%)	4886 (10.7%)	-9.5%	-0.0344	221 (9.7%)	626 (9.1%)	5.9%	0.0013

†Reference categories used in logistic regression model; no SMD was calculated for these categories.
rTMS: Repetitive transcranial magnetic stimulation; SMD: Standardized mean difference.

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Table 2. Total medical utilization for patient cohorts.

	rTMS	non-rTMS	% difference	p-value
Patient volume	2291	6873	–	–
Admissions (n)	0.25	0.33	-24%	0.0003
Hospital outpatient department visits (n)	14.00	10.21	37%	<.0001
Emergency room visits (n)	0.27	0.53	-48%	<.0001

rTMS: Repetitive transcranial magnetic stimulation.

Table 3. Total healthcare costs for patient cohorts.

	rTMS	non-rTMS	% difference	p-value
Patient volume	2291	6873	–	–
All cause costs	$14,934	$15,828	-6%	0.3499
Admission costs	$5666	$6978	-19%	0.0392
Hospital outpatient department costs	$8946	$8363	7%	0.3400
Emergency room costs	$322	$487	-34%	<.0001

rTMS: Repetitive transcranial magnetic stimulation.

the Dutch healthcare system comparing rTMS to continued pharmacotherapy for TRD patients [17]. Relative to pharmacotherapy, those receiving rTMS showed higher QALYs, better response/remission rates and lower costs. Fitzgibbon *et al.* conducted a cost–utility analysis using a Markov model in Ontario, CA, comparing rTMS and ECT as first-line treatments for TRD [14]. Based on data from randomized trials and meta-analyses, rTMS was found to be less costly and more effective, yielding 0.96 additional QALYs and $46,098 in cost savings compared with ECT [14]. These studies complement our current study, which assessed actual healthcare utilization and costs in the USA.

There are several topics worth emphasizing. First, our findings are generalizable. We analyzed a multipayer dataset that was geographically diverse across the USA. This point underscores the importance of equitable access for outpatient mental health services, which varies by region [24]. Second, rTMS-associated reductions in high acuity visits and costs persist beyond 12 months. It is important to note that our service tracking included all-cause utilization regardless of whether the services rendered were associated with TRD. Thus, treating TRD with rTMS not only reduces high acuity visits related to TRD, but all-cause high acuity visits more broadly. Third, we were able to develop a control cohort that is comparable to our rTMS cohort, which was not available in previous observational rTMS studies [25,26]. Finally, only 0.7% of the total eligible treatment population received rTMS. Our data suggests that greater utilization of rTMS could reduce costs and improve clinical outcomes, especially given the data on rTMS being superior to medication augmentation or switch [27]. This observation is timely in light of the American Psychiatric Association's recent supportive position statement on the use of rTMS for TRD [28].

There are several limitations to this study. One of the biggest to mention is the inclusion of data during the peak of COVID-19. Healthcare utilization during this period may not accurately reflect healthcare utilization outside of a pandemic setting, especially in terms of outpatient and elective procedures [29]. Another limitation is inferring lack of treatment response and treatment resistance using prescribing changes. While psychiatric medications may be prescribed prophylactically, we assume that medication changes follow typical clinical practice and are due to an attempt to control uncontrolled symptoms. A third limitation is the lack of data on medications for those with Medicare coverage and the lack of psychometric scales that document illness severity. Both of these factors play a role in the Maudsley Staging Method [30], a metric that estimates degree of treatment resistance. However, we were able to apply a utilization proxy to assess TRD status for Medicare patients and assess treatment resistance with alternative metrics. Additionally, while statistical adjustments were made, the inherent complexity of psychiatric disorders and their treatment can introduce variables not fully accounted for in statistical analyses. This complexity may influence the interpretation of results. The study represents a geographically diverse dataset, but the findings may not apply across different systems both within the US and internationally due to varied access and treatment policies and procedures. Our propensity score matching analysis was built to control for patient population differences, and not

to show differences by payer type. There have been other studies that have also performed similar methodologies to control for baseline characteristics [31].

Future analyses should explore the treatment benefits of new rTMS modalities or compare rTMS to alternative procedural treatments such as esketamine or ECT. For example, accelerated rTMS is a new version of rTMS which includes multiple sessions per day across a shortened treatment schedule, often with improved response rates when compared with standard rTMS treatment [32]. The SAINT neuromodulation system (SAINT) is an FDA cleared form of rTMS which combines MRI-guided selection of targeted brain regions with an accelerated 5-day treatment regimen. Given the condensed nature and high efficacy of accelerated rTMS courses, future studies may show an improved cost–effectiveness versus standard rTMS treatment. Additionally, accelerated protocols have the potential to expand rTMS utilization to psychiatric observation units or inpatient settings, further cutting costs associated with extended high acuity psychiatric hospitalizations.

Conclusion

This study provides evidence that rTMS for TRD is associated with fewer high acuity encounters and lower costs for at least 18 months after the index treatment. Future research should examine resource utilization and economic outcomes in larger sample sizes and across different time intervals, compare rTMS to other procedural TRD treatments, and monitor new rTMS developments.

Summary points

- Depression is one of the most common psychiatric disorders with lasting emotional and physical consequences if left untreated.
- While some patients with major depressive disorders experience benefit from the use of antidepressants and pharmacotherapy, 50% of major depressive disorders patients can be classified as having treatment-resistant depression.
- Patients were identified during January 2021 through December 2021 from a Medicare Fee-for-Service database and a commercial administrative claims dataset, Merative MarketScan Research Database and tracked for 18 months to measure resource utilization and economic outcomes.
- A total of 9164 patients were included within the analysis: 2291 patients in the repetitive transcranial magnetic stimulation (rTMS) cohort and 6873 patients in the non-TMS cohort following inclusion/exclusion criteria.
- Adjusted 18-month post-index data shows that on average, the rTMS cohort incurred 24% fewer inpatient admissions (0.25 vs 0.33; $p = 0.0003$), 37% more hospital outpatient department visits (14.00 vs 10.21; $p \leq 0.0001$) and 48% fewer emergency room visits (0.27 vs 0.53; $p \leq 0.0001$) compared with the non-TMS cohort.
- On average, the rTMS cohort incurred $893 less in EOC costs compared with the non-TMS cohort ($14,934 vs $15,828; $p = 0.3499$), including 19% lower inpatient admission costs for the rTMS cohort ($5666 vs $6978; $p = 0.0392$) and 34% lower emergency room costs ($322 vs $487; $p \leq 0.0001$).
- This study provides evidence that the use of rTMS may lead to lower healthcare utilization and costs over an extended period.
- Future studies should be conducted to evaluate the efficacy of different rTMS therapy types on healthcare utilization and costs.

Supplementary data

To view the supplementary data that accompany this paper please visit the journal website at: https://bpl-prod.literatumonline.com/doi/10.57264/cer-2025-0019

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Competing interests disclosure

The authors have no competing interests or relevant affiliations with any organization or entity with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

Ethical conduct of research

The study received an expedited review and does not require institutional review board approval

Writing disclosure

No writing assistance was utilized in the production of this manuscript.

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Papers of special note have been highlighted as: • of interest; •• of considerable interest

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