

Cost-effectiveness Analysis of a Rural Telemedicine Collaborative Care Intervention for Depression

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Context: Collaborative care interventions for depression in primary care settings are clinically beneficial and cost-effective. Most prior studies were conducted in urban settings.

Objective: To examine the cost-effectiveness of a rural telemedicine-based collaborative care depression intervention.

Design: Randomized controlled trial of intervention vs usual care.

Setting: Seven small (serving 1000 to 5000 veterans) Veterans Health Administration community-based outpatient clinics serving rural catchment areas in 3 mid-South states. Each site had interactive televideo dedicated to mental health but no psychiatrist or psychologist on site.

Patients: Among 18 306 primary care patients who were screened, 1260 (6.9%) screened positive for depression; 395 met eligibility criteria and were enrolled from April 2003 to September 2004. Of those enrolled, 360 (91.1%) completed a 6-month follow-up and 335 (84.8%) completed a 12-month follow-up.

Intervention: A stepped-care model for depression treatment was used by an off-site depression care team to make treatment recommendations via electronic medical record. The team included a nurse depression care man-

ager, clinical pharmacist, and psychiatrist. The depression care manager communicated with patients via telephone and was supported by computerized decision support software.

Main Outcome Measures: The base case cost analysis included outpatient, pharmacy, and intervention expenditures. The effectiveness outcomes were depression-free days and quality-adjusted life years (QALYs) calculated using the 12-Item Short Form Health Survey standard gamble conversion formula.

Results: The incremental depression-free days outcome was not significant ($P = .10$); therefore, further cost-effectiveness analyses were not done. The incremental QALY outcome was significant ($P = .04$) and the mean base case incremental cost-effectiveness ratio was \$85 634/QALY. Results adding inpatient costs were \$111 999/QALY to \$132 175/QALY.

Conclusions: In rural settings, a telemedicine-based collaborative care intervention for depression is effective and expensive. The mean base case result was \$85 634/QALY, which is greater than cost per QALY ratios reported for other, mostly urban, depression collaborative care interventions.

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ACCORDING TO THE MOST RECENT US census in 2000, 19.7% of the population resides in rural areas and there is substantial variation by state. More than 85% of the federally designated mental health professional shortage areas are in rural counties.^{1,2} In the National Comorbidity Study Replication, individuals with a mental health disorder who lived in rural areas were significantly less likely to receive treatment (formal or informal) for their disorder.³ In addition, individuals with a mental health disorder who received formal treatment were sig-

nificantly less likely to receive specialty mental health treatment if they lived in a rural area.³ This is important because those receiving specialty mental health care in the National Comorbidity Study Replication were significantly more likely to receive minimally adequate treatment.⁴ Further, longer travel distance for depression care is associated with lower odds of receiving guideline-concordant care.⁵

Possible explanations for this urban/rural disparity include lack of mental health specialists co-located in primary care settings, weak links to off-site mental health specialists, limited mental health insur-

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ance coverage, and cultural issues (such as greater social stigma for seeking mental health treatment in rural areas).^{2,6-9} Compared with their urban counterparts, rural patients with mental health care needs tend to have fewer visits, enter care later in the disease progression, have more serious symptoms at entry, receive lower-quality care, and need more expensive treatment.^{2,10,11} Therefore, it is critical to adapt collaborative care models for rural primary care practices and to assess the effectiveness and cost-effectiveness (CE) of the adapted model.

While telemedicine promises to bridge some of these gaps, recent reviews of telemedicine interventions conclude that there are very few telemedicine economic evaluations that use methods consistent with current recommendations for policy-relevant CE analyses.¹²⁻¹⁴ For example, there are no "reference case" CE analyses of mental health telemedicine interventions, and reference case analyses are recommended to facilitate comparisons between studies and inform health care resource allocation decisions.^{15,16}

Collaborative care interventions for depression in non-Veterans Affairs (VA), largely urban primary care settings have been shown to be both clinically beneficial¹⁷⁻²⁸ and cost-effective.²⁹⁻³⁶ One of these studies included urban and rural practice settings and demonstrated improved mental health status in urban but not rural patients.³⁷ Therefore, it appears that evidence-based interventions designed for large urban practices may be inappropriate for smaller rural practices. To our knowledge, this is the first CE analysis of a rural telemedicine-based depression collaborative care intervention using reference case CE analysis methods.

METHODS

STUDY SETTING AND ENROLLMENT PROCEDURES

The intervention and evaluation methods are described in detail elsewhere.³⁸ In brief, the study was conducted from April 2003 to September 2004 in Veterans Health Administration community-based outpatient clinics (CBOCs), which are satellite facilities of parent VA medical centers (VAMCs), serving largely rural catchment areas. Eligible CBOCs had interactive video equipment dedicated to mental health but no on-site psychiatrists or psychologists. There were 7 eligible CBOCs in the South Central Veterans Healthcare Network, where at least 2 CBOCs were associated with the same parent VAMC. The CBOCs associated with each parent VAMC were of similar size except for the parent facility with 3 eligible CBOCs, where 2 were combined to approximate the size of the third. Randomization of the CBOCs was stratified by parent VAMC. Five of the CBOCs had on-site midlevel mental health specialists (eg, social workers).

We sought to enroll all patients' primary care physicians (PCPs) who would be comfortable treating the patients for depression, and we excluded patients with serious mental illness (**Figure 1**). Administrative data identified 24 882 patients due for annual depression screening, and 18 306 (73.6%) completed the annual depression screening by telephone using the 9-item Patient Health Questionnaire (PHQ-9) for depression.³⁹ Of these patients, 1260 (6.9%) screened positive for depression (PHQ-9 score ≥ 12). This definition has a 96% specificity and 97% sensitivity for detecting depression.³⁹ Exclusion criteria included diagnosis of schizophrenia, current suicidal

ideation, recent bereavement, pregnancy, court-appointed guardian, substance dependence, bipolar disorder, cognitive impairment, or receiving specialty mental health treatment.

Among eligible patients, 430 (91.3%) agreed to participate and were administered the baseline interview. Of these, 395 (91.9%) attended their baseline appointment and provided written consent. We enrolled 395 participants between April 2003 and September 2004. The Research and Development Committees of the Central Arkansas Veterans Healthcare System in Little Rock, the Overton Brooks VAMC in Shreveport, Louisiana, and the G. V. (Sonny) Montgomery VAMC in Jackson, Mississippi, and their affiliated institutional review boards at the University of Arkansas for Medical Sciences and the University of Louisiana Health Sciences Center at Shreveport approved the study.

USUAL CARE DESCRIPTION

Both intervention and usual care sites received care provider education (via interactive video and Web site) and patient education (via mail and Web site). Depression screening results were entered into the electronic medical record by research personnel at both intervention and usual care sites. Interactive tele-video equipment was installed at all study sites prior to participant recruitment to facilitate specialty mental health consultation and treatment for all patients, not only study participants. In short, the only difference between the usual care and intervention groups was the Telemedicine Enhanced Antidepressant Management (TEAM) intervention.

TEAM INTERVENTION DESCRIPTION

A more detailed description of the intervention has been published elsewhere.³⁸ A brief description follows. The TEAM intervention involved collaboration among 5 types of care providers: (1) PCPs located at CBOCs; (2) consult telepsychiatrists located at parent VAMCs; (3) an off-site depression care manager (DCM) (registered nurse); (4) an off-site clinical pharmacist (with a PharmD degree); and (5) an off-site supervising psychiatrist. The consult telepsychiatrist accepted consultations or referrals from PCPs. The supervising psychiatrist provided clinical supervision to the DCM and clinical pharmacist in weekly face-to-face meetings.

The depression care team made treatment recommendations following a stepped-care model of depression treatment for up to 12 months. The model consisted of 4 steps that increased in treatment intensity and greater involvement of intervention personnel with more mental health expertise when participants' responses to lower steps of care proved unsuccessful. The first step was either watchful waiting (ie, symptom monitoring without active treatment) or antidepressant therapy and monitoring. The second step occurred if the participant did not respond to the initial antidepressant and involved a clinical pharmacist conducting a detailed medication history and providing pharmacotherapy recommendations to PCPs in consultation with the supervising psychiatrist. The third step took place if the participant did not respond to the 2 antidepressant trials and involved a recommendation for a telepsychiatry consultation. The fourth step consisted of referring the participant to specialty mental health care at the parent VAMC.

During each step, the DCM conducted interviews via telephone with prepared scripts to enhance standardization and reproducibility using WinCati-based decision support software (Sawtooth Technologies, Inc, Northbrook, Illinois). During the initial encounter, the DCM performed the following tasks: (1) administered the PHQ-9 symptom monitoring tool; (2) educated the participant with a semistructured script²⁰; and (3) as-

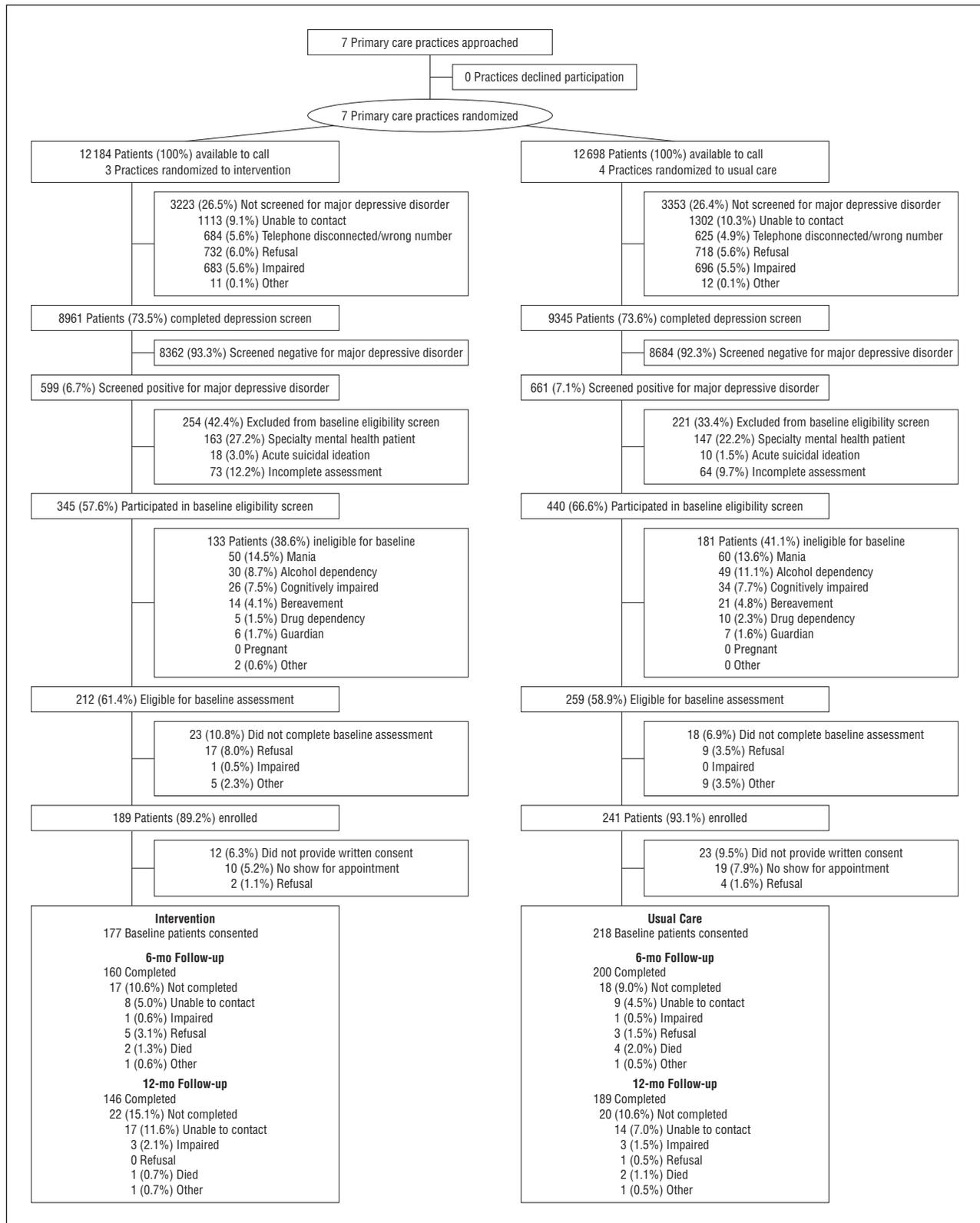


Figure 1. Flowchart of participants in the trial.

essed for treatment barriers using semistructured scripts for adverse effects and other endorsed barriers.^{19,20} The mean (SD) initial encounter duration was 37.2 (13.0) minutes.

The DCM scheduled follow-up encounters to monitor symptoms, medication adherence, and adverse effects every 2 weeks

during acute treatment and every 4 weeks during watchful waiting or continuation treatment. During follow-up interviews, the DCM followed a semistructured script to assess depression treatment response, antidepressant adherence, and adverse effect severity and to address common adherence or adverse effect prob-

Table 1. Fixed Intervention Training Cost Estimates

DCM Intervention Training	Hours	Hourly Cost, \$ ^a	Subtotal Cost, \$	Total Cost, \$
DCM ^b	64	34.2	2189	3017
Psychiatrist ^c	4	89.9	720	
Computer programmer ^c	4	27.0	108	

Abbreviation: DCM, depression care manager.

^aBased on salary plus 25% fringe in 2005 dollars.

^bThe DCM time includes 16 hours for intervention protocol training, 16 hours of WinCati training, and 32 hours of practice interviews.

^cThe psychiatrist and computer programmer times facilitate DCM training.

lems.¹⁹ The mean (SD) number of follow-up DCM encounters during the acute treatment phase (prior to 50% decrease in depression severity) was 7.3 (4.9) and the mean (SD) follow-up encounter duration was 23.0 (7.4) minutes. A trial failed in the acute phase if the participant (1) was nonadherent to the medication, (2) experienced severe adverse effects, (3) scored a 5-point increase or higher on the PHQ-9, or (4) did not respond (50% decrease in PHQ-9 score) after 8 weeks of antidepressant therapy. The DCM provided all feedback to PCPs using the electronic medical record. Progress notes reporting failed trials required an electronic cosignature from the PCP.

TEAM INTERVENTION CLINICAL OUTCOMES

Clinical outcomes from the TEAM study have been published elsewhere.⁴⁰ In general, the TEAM study demonstrated that telemedicine technologies could be used to successfully adapt the collaborative care model for implementation in small, rural primary care clinics lacking on-site psychiatrists or psychologists. For example, patients in the intervention group had significantly greater odds of being adherent to antidepressant medications than those in the usual care group at both a 6-month follow-up (odds ratio=2.1; $P=.04$) and a 12-month follow-up (odds ratio=2.7; $P=.01$). At 6 months, patients in the intervention group were significantly more likely to demonstrate depression treatment response (odds ratio=1.9; $P=.02$), and by 12 months, the intervention group had significantly greater odds of depression remission (odds ratio=2.4; $P=.02$). Mental health status measured by the 12-item Short Form for Veterans (SF-12V) improved more in the intervention group than in the usual care group at 6 months ($P=.07$) and at 12 months ($P=.009$). Health-related quality of life as measured by the Quality of Well-being (QWB) scale improved significantly more in the intervention group at 6 months ($P=.003$), but not at 12 months ($P=.70$), compared with the usual care group.

DATA COLLECTION

Research data were collected during telephone interviews by research assistants blinded to the intervention condition. At baseline, demographic characteristics and depression history were measured using the Depression Outcomes Module.^{41,42} Race data were collected using categories defined by the study to examine intervention effects by race. The Depression Health Beliefs Inventory was used to measure perceptions about depression treatment including barriers, need, and effectiveness.⁴³ Psychiatric comorbidity was measured using the Mini International Neuropsychiatric Interview.^{44,45} Follow-up telephone interviews were completed for 360 participants (91.1%) at 6 months and 335 participants (84.8%) at 12 months (Figure 1).

Primary outcomes were depression-free days (DFDs) derived from the 20-item Symptom Checklist⁴⁶ and quality-adjusted life years (QALYs) calculated using the SF-12 standard gamble to QALY conversion formula,⁴⁷ the QWB scale,^{48,49}

and health care expenditures. The DFDs are reported because they are a common effectiveness outcome in recent depression collaborative care studies. The QALYs are reported because they are the recommended unit of effectiveness for the reference case CE analysis.^{15,16} There is no gold-standard QALY measure, so we included a shorter measure (standard gamble preference-weighted SF-12V) and a longer measure (QWB scale). The DFDs and QALYs were calculated using analyses of area under the curve of the baseline, 6-month, and 12-month data.^{50,51}

The DFDs were calculated using the formulas originally developed by Lave et al⁵¹ and adapted for the 20-item Symptom Checklist.⁴⁶ For each assessment, a 20-item Symptom Checklist score of 0.5 or less was considered depression free, a score of 2.0 or higher was considered fully symptomatic, and scores in between were assigned a linear proportional value. Sensitivity analyses using alternative depression severity thresholds resulted in only minimal difference for the intervention effect.

Brazier et al⁵² and Brazier and Roberts⁵³ used 3 steps to derive the SF-12 standard gamble preference-weighted conversion formula: (1) simplify the SF-12's health state classification system into 6 dimensions (SF-6D); (2) obtain preferences for SF-6D health states; and (3) estimate the preference weights for each level of impairment within the 6 dimensions of the SF-6D using regression models. The 6 SF-12 dimensions included physical functioning, role limitations due to physical health or emotional problems, social functioning, pain, mental health, and vitality. Standard gamble preference weights included elements of choice and risk and are consistent with expected utility theory.⁵⁴ The SF-6D standard gamble preference weights were derived from a general population sample of 611 subjects. The standard gamble preference-weighted conversion formula transforms SF-12 data into a preference-weighted index score that varies from 0.0 (death) to 1.0 (perfect health).

The QWB scale was designed for cost per QALY analyses and comprises 4 subscales: a symptom and problem complex subscale, physical activity, social activity, and mobility.^{49,55} Each subscale score is determined by preference weights derived from a representative community sample using a categorical rating scale method and a multiattribute utility model. Subscale scores are subtracted from 1.0 (perfect health) to determine the QWB scale index score, with a range from 0.0 (death) to 1.0 (perfect health).

Intervention costs and health care expenditures were collected to assess the CE of the intervention from a payer's perspective (Veterans Health Administration). Intervention costs included both fixed and variable costs (**Table 1** and **Table 2**). Fixed intervention costs included the cost of patient education pamphlets, care provider education, development of participant and care provider sections of the TEAM Web site, interactive video equipment, and DCM intervention training. We included only DCM training as a net fixed intervention cost because the other fixed intervention costs were attributed to participants in both the intervention and usual care groups. Variable intervention costs included the time spent by intervention personnel delivering the intervention, eg, time spent prepar-

Table 2. Variable Intervention Delivery Cost Estimates

Quarter	Active Patients in Panel, No. (% Time) ^a	DCM Cost, \$ ^b	Clinical Pharmacist Cost, \$ ^c	Psychiatrist Cost, \$ ^d
2003 Quarter				
2	0 (0)	0	0	0
3	44 (30.8)	5480	1654	1169
4	107 (74.8)	13 307	4016	1169
2004 Quarter				
1	138 (96.5)	17 168	5181	1169
2	143 (100)	17 791	5369	1169
3	132 (92.3)	16 421	4955	1169
4	99 (69.2)	12 660	3715	1169
2005 Quarter				
1	59 (41.3)	7347	2217	1169
2	28 (19.6)	3487	1052	1169
3	15 (10.5)	1868	564	1169
4	10 (7.0)	1245	376	1169
2006 Quarter				
1	0 (0)	0	0	0
Subtotal ^e		96 774	29 099	11 687

Abbreviation: DCM, depression care manager.

^aPercentage of time is based on 143 participants being a full panel for the DCM.

^bDCM cost is the percentage of time multiplied by 100% of the DCM salary plus fringe.

^cClinical pharmacist cost is the percentage of time multiplied by 20% of the clinical pharmacist salary plus fringe.

^dThe psychiatrist cost is based on weekly 1-hour depression care team meetings.

^eThe total for the variable intervention delivery costs is \$137 560, and the combined fixed (Table 1) and variable intervention cost is \$140 577.

ing and delivering the intervention, entering progress notes into the medical record, and attending intervention team meetings. These costs were calculated separately for the DCM, clinical pharmacist, and psychiatrist on the depression care team based on their respective VA salaries and fringe costs. Total intervention costs were estimated at \$794 per consented intervention participant (\$140 577 fixed plus variable costs per 177 consented intervention participants or per capita \$17 for training plus \$777 for intervention delivery).⁵⁶ All costs were adjusted to reflect year 2005 dollars.

The VA expenditures in fiscal years 2002 to 2005 were assessed using VA Decision Support System data, which use an activity-based costing allocation method and include fixed direct, variable direct, and fixed indirect costs. Outpatient expenditures for the base case analysis were organized in the following groups by primary stop code field: primary care, mental health specialty care, ancillary, physical health specialty, and other. All outpatient and inpatient encounters were examined for primary or secondary depression-related diagnoses to classify encounters as related or unrelated to depression. Outpatient medication expenditures were assessed using the Pharmacy Benefits Management/Strategic Healthcare Group database. Inpatient medication expenditures were not available from the Pharmacy Benefits Management/Strategic Healthcare Group database. Inpatient encounter data were used for secondary cost per QALY analyses.

Patient travel and time expenditures for secondary analyses were derived from patient self-report at 6- and 12-month follow-up interviews. Patients reported round trip travel distance to and from the VAMC where they received inpatient or emergency department care and the VA facility where they typically received physical health and mental health outpatient care. The number of miles traveled was multiplied by 0.29 to calculate travel expenditures. Patients also reported time estimates for traveling to and from and during visits to the emergency department and typical physical health and mental health outpatient visits. The number of patient hours was multiplied by their wage rate to calculate patient time expenditures. Wage rates for patients were computed using their employment status and income category. The minimum wage was \$5.15 per hour.

Incremental CE ratios (CERs) are reported from the Veterans Health Administration perspective. The numerator is the incremental difference in total expenditures between the intervention and usual care. The denominator is the incremental difference in QALYs between the intervention and usual care. Expenditures and effectiveness were not discounted because of the relatively short 12-month time horizon of the study.¹⁵ The base case expenditure analysis included outpatient, emergency department, pharmacy, and intervention costs. Secondary analyses included adding the following expenditure categories to base case expenditures: depression-related inpatient expenditures, all inpatient expenditures, and a lower intervention expenditure equivalent to the depression care team without the clinical pharmacist because most depression collaborative care interventions do not include a clinical pharmacist.

STATISTICAL ANALYSIS

Patients were the unit of the intent-to-treat analysis. We did not adjust standard errors for potential nesting of patients within CBOCs or parent VAMCs because the intraclass coefficients for expenditures and QALYs were close to 0 at the CBOC level (0.007 and 0.008, respectively) and VAMC level (0.0002 and 0.0015, respectively) and were nonsignificant. Independent variables with missing values were imputed using multiple imputation methods.⁵⁷ Sampling and attrition weights were calculated from administrative and baseline data, respectively, to adjust for the potential bias associated with nonparticipation, loss to follow-up, or both. Owing to the large number of available covariates and the use of multiple imputation methods, only those covariates found to significantly predict dependent variables at $P < .10$ in bivariate analyses were included in multivariate analyses. After model specification was finalized, pre-intervention expenditures were added as a covariate to expenditure models to control for baseline expenditure differences.

The expenditure outcomes were nonnormally distributed due to skewness from several high cost outliers, so generalized linear models (GLMs) were considered because ordinary least

squares regression was likely to generate biased estimates given the relatively small sample.⁵⁸ We ran 7 GLMs with normal, γ , or inverse normal distributions with identity, logarithm, or square root link functions using a consistent specification of independent variables. The GLM regression with a γ distribution and identity link function fit the expenditure data most appropriately. Using a similar procedure, the GLM regression with a normal distribution and identity link fit the QALY data best.

To determine the incremental treatment effect on costs, we calculated 2 predicted expenditures for each participant based on the coefficients from the GLM regressions and the covariate values for each participant. The first expenditure predic-

tion was for expenditures as if the participant had been randomized to the intervention, and the second expenditure prediction was for expenditures as if the participant had been randomized to usual care. The difference between these 2 expenditure predictions represented the incremental effect of the intervention on expenditures for a particular participant because all covariate effects were identical for the 2 estimates in a given patient. We then averaged the difference between the 2 predicted values for each participant across all participants to generate an incremental effect in the entire sample.

Typical standard error estimation methods do not apply to CERs because the possibility of having a 0 or near 0 denominator is nonnegligible and expenditure and effectiveness estimates are rarely independent.⁵⁹ Therefore, we used a nonparametric bootstrap with replacement method and 1000 replications to generate an empirical joint distribution of incremental expenditures and QALYs^{59,60} and acceptability curves representing the probability of falling below CER thresholds ranging from \$0 to \$150 000 per QALY.⁶¹

Table 3. Bivariate Baseline Comparisons of the Intervention vs Usual Care

Variable	Usual Care (n=179)	Intervention (n=141)	P Value
Age, mean (SD), y	60.0 (11.7)	58.8 (11.4)	.36
Male, %	89	95	.047
White, %	74	78	.44
Married, %	61	65	.42
High school graduate, %	78	76	.62
Employed, %	20	21	.80
Household income, \$, %			.28
<10 000	16	22	
10 000-20 000	34	28	
>20 000	50	50	
SCL-20 score, mean (SD)	1.8 (0.7)	1.9 (0.7)	.74
MCS-12 scale score, mean (SD)	37.2 (12.3)	36.0 (12.4)	.40
PCS-12 scale score, mean (SD)	29.6 (12.6)	30.5 (13.5)	.57
Chronic physical illnesses, mean (SD), No.	5.7 (2.8)	5.2 (2.7)	.11
Baseline current depression treatment, %	44	38	.34
Family history of depression, %	43	47	.45
Prior depression episodes, mean (SD), No.	3.7 (1.8)	3.7 (1.8)	.94
Baseline PTSD, %	22	26	.35
Baseline MINI alcohol misuse, %	12	12	.93
Baseline standard gamble preference-weighted SF-12 score, mean (SD)	0.53 (0.12)	0.54 (0.14)	.62
Baseline QWB scale score, mean (SD)	0.42 (0.11)	0.43 (0.13)	.33

Abbreviations: MCS-12, 12-item Mental Component Summary; MINI, Mini International Neuropsychiatric Interview; PCS-12, 12-item Physical Component Summary; PTSD, posttraumatic stress disorder; QWB, Quality of Well-being; SCL-20, 20-item Symptom Checklist; SF-12, 12-item Short Form.

RESULTS

Table 3 shows the baseline demographic and clinical characteristics of the sample by intervention group. In general, TEAM patients were middle-aged, white men with moderate to severe depression and high levels of physical and mental health comorbidity. The only statistically significant differences between the intervention and usual care groups was a higher percentage of male subjects in the intervention group (134 of 141 [95%]) than in the usual care group (159 of 179 [89%]) ($P=.047$). The unadjusted mean 12-month health care utilization expenditures by category were all greater for participants in the intervention group than for those in the usual care group (**Table 4**). Two expenditure categories were statistically different: outpatient expenditures and outpatient plus all inpatient expenditures.

The effect of the intervention on DFDs was not significant ($\beta=14.6$; $SE=8.9$; $P=.10$); therefore, we did not conduct an incremental cost per DFD analysis. Of the 2 generic, preference-weighted, health-related quality-of-life measures (standard gamble preference-weighted SF-12 and QWB scale), the intervention effect was only significant for the SF-12 QALY and therefore only the SF-12 QALY results are presented. Although the intervention significantly improved QWB scale scores and response rates (measured by the 20-item Symptom Checklist) at

Table 4. Unadjusted Mean 12-Month Healthcare Utilization, Patient Travel, and Patient Time Expenditures for the Intervention vs Usual Care in 2005 Dollars

Expenditure Category	Cost, Mean (SE), \$		Z Score	P Value ^a
	Usual Care	Intervention		
All outpatient encounters	3117 (244)	3704 (263)	-2.991	.003
Total outpatient prescriptions	927 (79)	997 (102)	-0.568	.57
Depression-related, inpatient	93 (65)	150 (75)	-1.103	.27
Inpatient total	939 (312)	2235 (1387)	-1.242	.21
All health care expenditures	4982 (488)	7730 (1485) ^b	-4.821	<.0001
Patient travel	316.20 (37.24)	233.0 (26.04)	-0.91	.36
Patient time	301 (37.0)	294 (48.3)	-0.24	.81

^aNonparametric Wilcoxon t test.

^bIncludes \$794 for intervention cost.

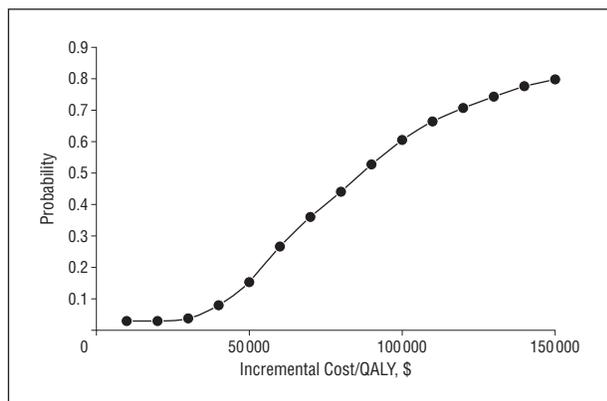


Figure 2. Acceptability curve for base case analysis. QALY indicates quality-adjusted life year.

6 months,⁴⁰ the intervention did not significantly improve 12-month QALYs based on the QWB scale score ($\beta=0.015$; $SE=0.008$; $P=.08$).

In the base case analysis (existing sample, not bootstrapped), the incremental intervention effects on SF-12 QALYs ($\beta=0.018$; $SE=0.009$; $P=.04$) and expenditures ($\beta=\$1528$; $SE=\$298$; $P<.001$) were significant. The mean incremental CER using SF-12 QALYs and expenditures from the bootstrapped-with-replacement sample was \$85 634/QALY (median, \$85 932/QALY; interquartile range, \$48 911/QALY-\$122 952/QALY). The base case acceptability curve is presented in **Figure 2**.

Secondary analyses added inpatient expenditures to the base case and added patient time and travel costs. Adding depression-related inpatient expenditures, the incremental intervention effect on expenditures was significant ($\beta=\$1510$; $SE=\$326$; $P<.001$) and the mean incremental CER using SF-12 QALYs and expenditures from the bootstrapped-with-replacement sample was \$132 175/QALY (median, \$83 174/QALY; interquartile range, \$36 722/QALY-\$119 869/QALY). Adding all inpatient expenditures to the base case analysis expenditures, the incremental intervention effect on expenditures was significant ($\beta=\$1355$; $SE=\$404$; $P=.001$) and the mean incremental CER was \$111 999/QALY (median, \$71 028/QALY; interquartile range, \$32 057/QALY-\$103 085/QALY).

Patient time and travel costs are summarized in Table 4. Adding patient expenditures to the base case expenditures, the incremental intervention effect on expenditures was significant ($\beta=\$1304$; $SE=\$371$; $P<.001$) and the mean incremental CER was \$72 636/QALY (median, \$74 390/QALY). The CERs for adding patient time and travel expenditures to the secondary analyses are summarized in **Table 5**.

COMMENT

To our knowledge, this is the first article to present cost per QALY results from a trial using a rural telemedicine collaborative care intervention for depression. The mean incremental cost per QALY ratios for the TEAM intervention ranged from \$85 932/QALY (base case analysis) to \$72 636 to \$144 990/QALY (secondary analyses). These cost per QALY ratios are greater than the \$50 000/QALY thresh-

Table 5. Summary of Mean Incremental Cost per Quality-Adjusted Life Year Ratios

Base Case or Secondary Analysis	VHA Perspective, \$	VHA Plus Patient Time and Travel Costs, \$	Lower Intervention Cost, \$
Base case			
Outpatient cost only	85 634	72 636	76 056
Secondary			
Base case plus depression-related inpatient costs	132 175	144 990	125 648
Base case plus all inpatient costs	111 999	126 209	109 140

Abbreviation: VHA, Veterans Health Administration.

old, which is commonly cited as the threshold for adoption; however, this threshold has not been adjusted for nearly 3 decades.⁶² More recently, some have suggested adjusting the adoption threshold to the \$100 000/QALY to \$300 000/QALY range.^{63,64} Cost per QALY estimates for non-VA depression collaborative care interventions range from \$2738/QALY to \$55 718/QALY adjusted to 2005 dollars and using only outpatient costs.^{32,33,46,65,66} A VA depression collaborative care study from an urban catchment area reported cost per QALY estimates ranging from \$28 199/QALY to \$56 332/QALY (adjusted to 2005 dollars and using depression treatment costs only).³⁵

The TEAM secondary cost per QALY ratios that included inpatient expenditures resulted in positively skewed CER distributions indicating that inpatient expenditures were greater for patients in the intervention group than for those in the usual care group. A possible explanation for higher expenditures for inpatients in the intervention group is that the DCM identified more health care concerns and encouraged subjects to follow-up with their health care provider, which could have resulted in increased inpatient utilization. The secondary cost per QALY ratios that included patient time and travel expenditures were included because of the assumption that telemedicine interventions will result in significant patient travel and time cost offsets. Adding patient expenditures lowered the cost per QALY estimates for the base case analysis, reflecting a modest cost offset. However, adding patient expenditures slightly increased cost per QALY estimates that included inpatient expenditures, most likely reflecting increased inpatient utilization among patients in the intervention group.

Possible explanations for the higher cost per QALY ratio for the TEAM intervention relative to other depression collaborative care interventions and the historical \$50 000/QALY threshold include the following: (1) influence of the DCM on all care received; (2) modest intervention effectiveness; and (3) high cost of the intervention. The VA system is an integrated system of care that creates a "1-stop shopping" health care environment. Therefore, as suggested earlier the DCM intervention may prompt patients to seek additional care, and notes by the DCM in the electronic medical record may have a greater effect on care received than in a less integrated health care system.

The intervention focused on antidepressant medication management and took place in a VA sample of mostly older men with multiple physical health comorbidities. The narrow focus of the intervention (antidepressant medication management) may have limited its effectiveness given that approximately 50% of primary care patients state they would prefer counseling over antidepressant medications.^{67,68} Multiple physical health comorbidities can also limit intervention effectiveness because even if the depression symptoms improve, most comorbid physical health symptoms remain. In addition, there were high baseline levels of depression treatment, indicating at least some degree of treatment resistance. There may also be additional challenges treating male depressed patients using a collaborative care intervention.³⁰ The intervention did not directly address common mental health comorbidities (such as pain, anxiety, and substance abuse), which may have further limited its effectiveness.

The per capita cost of the TEAM intervention was \$794, compared with \$226 to \$640 per capita (adjusted to 2005 dollars) for other interventions referenced earlier. Intervention personnel time was the primary intervention cost. Strategies to decrease intervention personnel time expenditures include decreasing DCM time spent on ancillary activities (precall preparation, call attempts, postcall documentation, and health care provider communication). This could be achieved by streamlining documentation through improved informatics support and decreasing unsuccessful call attempts by scheduling future calls with patients.⁵⁶ Most collaborative care interventions for depression do not include a clinical pharmacist. Sensitivity analyses show that cost per QALY ratios improve by 11% when the intervention team does not include the clinical pharmacist, but it is not known how this change would affect intervention effectiveness.

In a recent review of collaborative care interventions for depression, 28 interventions were reviewed; of these, 5 were VA studies and 2 of the 5 VA study interventions resulted in significant mean symptom improvement as compared with usual care.⁶⁹ One of these VA studies was the TEAM study⁴⁰ reported here, and the other was a telephone disease management program for depression and/or at-risk drinking.⁷⁰ A third VA collaborative care study reported a nonsignificant increase of 14.6 incremental DFDs over 9-month follow-up ($P = .06$),³³ which is very similar to the DFD result reported here from the TEAM study over 12 months (14.6 DFDs; $P = .10$).

Results from non-VA collaborative care interventions for depression tend to report higher incremental DFDs. For example, over a 12-month non-VA sample, results ranged from 20 to 72 adjusted incremental DFDs.^{33,51,65,71} The Improving Mood Promoting Access to Collaborative Treatment study included VA (10.4% of sample) and non-VA subjects and reported 107 adjusted incremental DFDs over 24 months for the combined sample⁶⁵ and similar response patterns for male and female participants.⁷² To our knowledge, a separate analysis of the VA sample in the Improving Mood Promoting Access to Collaborative Treatment study has not been reported. Possible explanations for the lower DFD results in the TEAM study are similar to those outlined earlier to explain the modest intervention effectiveness.

Limitations of this study include the following. Although the VA is the largest managed care organization in the United States, our results may not generalize to non-integrated systems of care that do not use electronic medical records or interactive televideo technology. However, the advantage of conducting this first CE analysis of a telemedicine-based collaborative care intervention for depression in the VA system is that the use of interactive video and electronic medical record technology will most likely be spreading to the private sector. The demographic characteristics of VA patients (eg, older men) are different from private sector patients; therefore, our results may not generalize to private health care settings. Incremental cost per DFD results were not presented because the intervention effect on DFDs was not significant, although some health care economists argue that statistically significant intervention effects are not needed to conduct CE analyses.⁷³ The preference weights used to calculate the QWB scale and SF-12 scores were derived from representative samples from the United States and United Kingdom, respectively. However, others have found no significant differences in preference weights from US and UK subjects.⁷⁴

In conclusion, delivering collaborative care interventions for depression via telemedicine technologies in small rural primary care clinics is challenging. In rural settings, we found that a telemedicine-based collaborative care intervention for depression was effective but expensive. The base case analysis mean cost per QALY ratio was \$85 634/QALY, is greater than cost per QALY ratios reported for other mostly urban collaborative care interventions for depression targeting primarily female patient populations, and is less than cost per QALY thresholds for intervention adoption that have been suggested more recently. Individuals with depression who have poor access to mental health care specialists are deserving of high-quality depression care just like their urban counterparts. The future challenge will be to improve the efficiency of similar interventions to further enhance adoption. The TEAM intervention can stand as a starting point for such efforts.

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