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TITLE: Does Evidence-Based PTS Treatment Reduce PTS Symptoms and Suicide in Iraq and Afghanistan Veterans Seeking VA Care?

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14. ABSTRACT

To compare effectiveness of evidence-based psychotherapy (EBP) for PTS in Iraq and Afghanistan War Veterans who use Veterans Health Administration (VHA) care (Aim 1), we used an approach that mimics a sequence of randomized trials by implementing propensity score models within each trial to achieve covariate balance, using matching. We found that Veterans who completed EBP for PTS experienced a significant improvement in PTSD Checklist (PCL) scores compared to the non-completers (i.e., 5.4-point improvement on the PCL). We also completed an analysis of factors associated with completing EBP for PTS (Aim 2). Using ordered logistic regression, we identified factors associated with achievement of hierarchal outcome categories (no EBP, EBP dropout, EBP completion) during any 24-week period. Using Cox proportional hazards regression, we also assessed factors associated with faster time to completion of PE or CPT from VA mental health entry. Over a 15-year period, 265,566 Iraq and Afghanistan War Veterans with PTS initiated psychotherapy in the VHA. While 22.8% initiated an EBP, only 9.1% completed treatment. Those who completed did so about three years after their initial mental health visit. Several factors were associated with EBP completion, including history of military sexual trauma (MST), older age, gender, and race/ethnicity. Prior psychotherapy sessions were associated with EBP completion, and initiation of psychotherapy in the last few years was associated with timelier EBP. Next, consistent with Aim 3, we are in the process of building an analytic dataset to examine the association between symptom improvement (measured by changes in PCL score over time) and three treatment profiles (no EBP, early EBP use and delayed EBP use, defined as greater than one year). Overall so far, we have found that those who are engaging in EBP for PTS are a minority of Veterans with PTS; however, Veterans that are engaging in EBPs are improving an average of 5-points on the PCL, which is a statistically significant difference. Furthermore, there are several factors that are associated with EBP completion, which provides valuable information to help better engage Veterans in the low utilization groups.

15. SUBJECT TERMS
Posttraumatic Stress, Cognitive Processing Therapy, Prolonged Exposure Therapy, Evidence Based Therapy, Comparative Effectiveness, Natural Language Processing

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1. **INTRODUCTION:**

Posttraumatic stress (PTS) is among the most common mental health problems among Service Members and Veterans returning from recent deployments, and despite the availability of evidence-based treatments (EBT), many of those with mental health problems do not seek or postpone seeking EBT for PTS, defined here as Prolonged Exposure Therapy (PE) and/or Cognitive Processing Therapy (CPT). This study will improve clinical care for the large number of Warfighters and Veterans who suffer from PTS by determining if Veterans receiving EBT outside of research trials demonstrate PTS symptom improvement in a clinical setting, whether these EBTs for PTS impact suicidality in a clinical setting, what factors are associated with PTS symptom improvement in those that benefit from EBT, and whether all Veterans benefit equally from EBTs for PTS.

2. **KEYWORDS:**

Posttraumatic stress
Cognitive Processing Therapy
Prolonged Exposure Therapy
Evidence based treatment

3. **ACCOMPLISHMENTS:**

a. **What were the major goals of the project?**

The major goals of this project are to determine the effectiveness of evidence-based therapies for posttraumatic stress (PTS) applied naturalistically in a clinical setting; factors associated with PTS symptom improvement; and optimal treatment trajectories for Veterans with PTS and complex comorbidities.

In order to accomplish these goals, we needed to update and merge several datasets from the Veterans Health Administration, drawn from electronic medical records, each one containing pertinent information needed to complete the study. Part of acquiring relevant data included defining the sample in order to obtain relevant clinical notes, and then using clinician coding and natural language processing (NLP) in order to determine those who received EBT for PTS and those who did not. Data analytic tasks will involve a series of complex analyses that will best answer our research questions.

The project work has been divided into four main tasks:

TASK 1. Update and Merge Existing Data and Datasets—100% completed
TASK 2. Use NLP to Evaluate Clinical Notes—100% completed.
TASK 3. Data Analysis—50% completed
TASK 4. Finalize study requirements, prepare for future funding, and dissemination of findings—20% completed

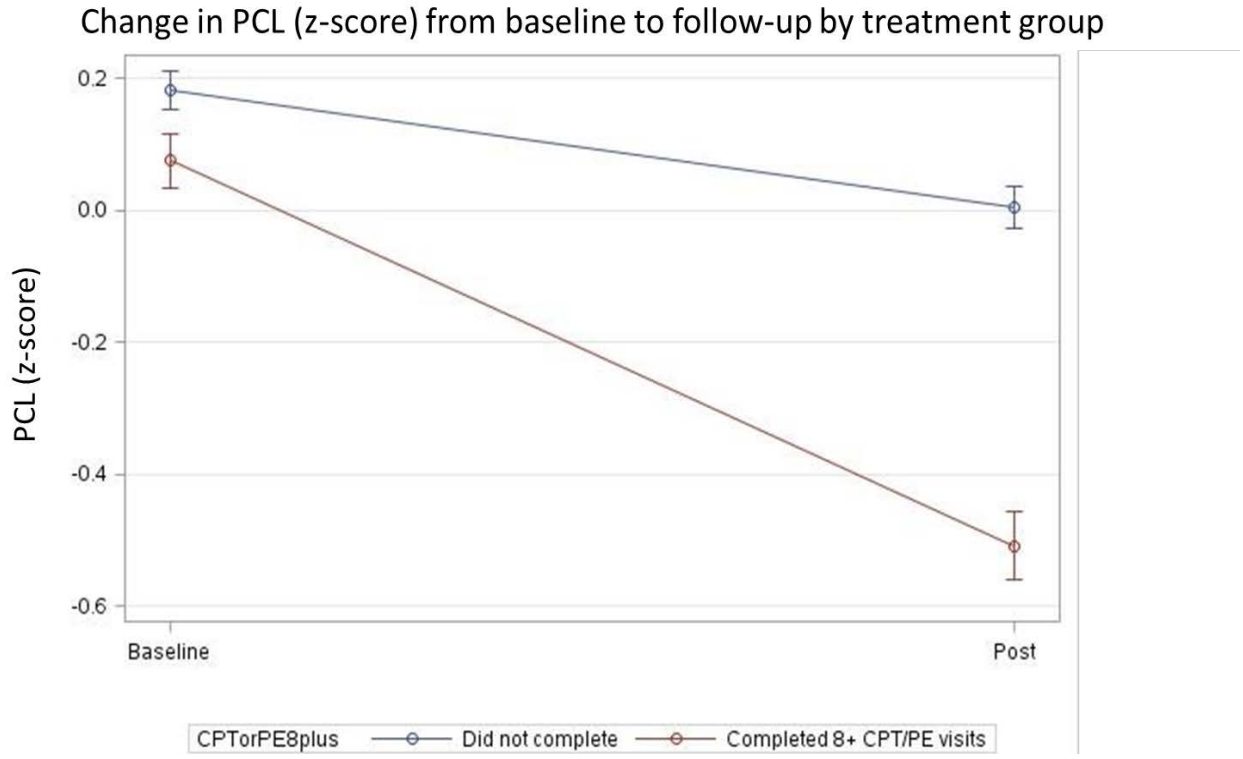
Progress on subtasks is described in detail in the following section.

b. **What was accomplished under these goals?**

To compare effectiveness of evidence-based psychotherapy for PTS in Veterans **(subtatsks 3c and 3d)**, we used an approach that mimics a sequence of randomized trials by implementing propensity score models within each trial to achieve covariate balance, using matching. We also dealt with the possible bias due to the requirement of having a PTS measurement at the end of the trial, using IP weighting. We added to the dataset individuals who met all eligibility criteria but did not have a final measurement, fit a logistic model for the probability of having a final measurement (given baseline and post-baseline covariates), and computed the IP weight for each person as 1 divided by the predicted value. We then fit the weighted outcome model (restricted to people with a final measurement, the others get weight 0). In each emulated trial baseline is a different time (i.e., each month in our study period). However, the end of follow-up is always 24 weeks after start of emulated trial, death, or administrative end of follow-up, whichever occurs first. In this analysis, each patient may contribute many replicates (up to number of months from initial MHO visit to the end of study), one per emulated target trial for which he or she meets the eligibility criteria, etc. In order to include both versions of the PTSD Checklist (PCL; PTS outcome measure) in the same analysis, we converted PCL-M (PCL for DSM-IV) and PCL-5 (PCL for DSM-5) scores to z-scores (based on empirical baseline distributions).

Before correcting for potential confounds, the estimated effect of EBT was -.49 PCL z-score units (95% CI: -.52, -.45), which translate to a 6.6-point improvement on the PCL-M scale. After propensity score matching **(subtask 3d),** the estimated effect of EBT was -.41 PCL z-score units (95% CI: -.46, -.35), which translates to 5.4-point improvement on the PCL-M scale. Figure 1 shows the mean PCL z-score at baseline and follow-up (6 months) in the EBT completers and non-completers. The EBT completer groups experienced a significant improvement in PCL scores compared to the non-completers.

Figure 1



We also have completed an analysis of factors associated with completing evidence-based psychotherapy (EBP) for PTS (Aim 2). We found that over a 15-year period, 265,566 Iraq and Afghanistan war Veterans in VHA care were identified as having PTS and treated within mental health clinics. While 22.8% initiated an evidence-based psychotherapy protocol during this period, only 9.1% completed treatment. Significantly more Veterans completed CPT than PE, and Veterans who completed EBPs did so in an average of three years after their initial mental health visit. Furthermore, we found many demographic, military and clinical factors associated with completing an adequate dose of EBP, and doing so in a timely manner, with many similar associated factors across both CPT and PE, but some unique to each.

More specifically, of this cohort of 265,566 Veterans, 5,154 (1.9%) completed at least 8 sessions of PE, 12,782 (4.8%) dropped out of treatment (i.e, early termination), and 247,630 (93.3%) received no PE during any 24-week period after their first mental health visit **(subtask 3e)**; 19,067 (7.4%) completed at least 8 sessions of CPT, 29,006 (10.9%) were early terminators, and 216,953 (81.7%) received no CPT during any 24-week period. Baseline characteristics of this cohort is reported in Table 1a and 1b. The largest differences between those who initiated PE and those who did not were that those who initiated

PE were more likely to be married, to have multiple deployments, to report military sexual trauma, and to have a history of TBI (Table 1a). The largest differences between those who initiated CPT and those who did not were that those who initiated CPT were more likely to be women and to report military sexual trauma (Table 1b).

Using ordered logistic regression, we identified factors associated with achievement of hierarchal outcome categories (no PE, PE dropout, PE completion) during any 24-week period (Table 2a; **subtask 3f**). The odds of meeting progressively higher standards of PE treatment were greater for people in their 30s and 40s, African-Americans, Hispanics, married people, reserve members, officers, those with multiple deployments, those with military sexual trauma, non-smokers, those with a history of TBI, and those who entered VA mental health treatment between 2008 and 2010. For hierarchal outcome categories of CPT during any 24-week period (Table 2b; **subtask 3f**), the odds of meeting progressively higher standards of CPT treatment were greater for people in their 30s, 40s, and 50's as well as women, African-Americans, never married people, National Guard members, officers, those with multiple deployments, those with military sexual trauma, non-smokers, those with a history of TBI, and those who entered VA mental health treatment between 2007 and 2008 or between 2014 and 2017.

Using Cox proportional hazards regression, we assessed factors associated with faster time to completion of PE or CPT from VA mental health entry. Patients completed PE in less time if they were in their 30's, 40's, and 50's, were women, African-American, married, in the reserves, were officers, had multiple deployments, experienced military sexual trauma, and entered VA mental health care after 2005. Interestingly, though PE completion rates did not improve across years, time to PE completion improved steadily and dramatically across years (Table 3a). Patients completed CPT in less time if they were in their 30's through their 60's, were American Indian or Alaskan Native, in the National Guard, were officers, had multiple deployments, experienced military sexual trauma, were non-smokers, had drug use disorder diagnoses, and entered VA mental health care after 2005. As was the case with PE, though CPT completion rates did not improve across years (above), time to CPT completion improved steadily and dramatically across years (Table 3b).

Consistent with Aim 3, we are in the process of building an analytic dataset to examine the association between symptom improvement (measured by changes in PCL score over time) and 3 treatment profiles: no EBP, early EBP use and delayed EBP use (**subtask 3g in progress**).

Table 1a. Patient Characteristics by PE Status in any 24 Weeks during Follow-up (N=265,566)

	No PE (n=247,630, 93.3%)	**1-7 PE Sessions (n=12,782, 4.8%)**	**8+ PE Sessions (n=5,154, 1.9%)**	**P value**
Baseline Age on index date	32.0 (8.6)	32.0 (8.3)	33.6 (8.9)	<0.001
Baseline Age categories				<0.001
<30	133,820 (54.0%)	6,714 (52.5%)	2,307 (44.8%)	
30-39	65,605 (26.5%)	3,621 (28.3%)	1,516 (29.4%)	
40-49	37,767 (15.3%)	1,999 (15.6%)	1,063 (20.6%)	
50-59	9,507 (3.8%)	412 (3.2%)	245 (4.8%)	
60-69	928 (0.4%)	36 (0.3%)	23 (0.5%)	
70+	3 (0%)	0 (0%)	0 (0%)	
Gender				0.918
Male	221,398 (89.4%)	11,401 (89.2%)	4,606 (89.4%)	
Female	26,227 (10.6%)	1,381 (10.8%)	548 (10.6%)	
Missing	5 (0%)	0(0%)	0(0%)	
Race				<0.001
White	176,405 (71.2%)	9,086 (71.1%)	3,480 (67.5%)	
Black or African American	42,037 (17.0%)	2,175 (17.0%)	1,092 (21.2%)	
American Indian or Alaska Native	2,942 (1.2%)	169 (1.3%)	59 (1.1%)	
Asian	3,958 (1.6%)	212 (1.7%)	94 (1.8%)	
Native Hawaiian or Other Pacific Islander	2,946 (1.2%)	166 (1.3%)	56 (1.1%)	
Multi-races	2,988 (1.2%)	152 (1.2%)	69 (1.3%)	
Missing	16,354 (6.6%)	822 (6.4%)	304 (5.9%)	
Ethnicity				<0.001
Hispanic or Latino	30,325 (12.3%)	1,725 (13.5%)	686 (13.3%)	
Not Hispanic or Latino	205,317 (82.9%)	10,544 (82.5%)	4,256 (82.6%)	
Other	8,028 (3.2%)	330 (2.6%)	144 (2.8%)	
Missing	3,960 (1.6%)	183 (1.4%)	68 (1.3%)	
Marital status				<0.001
Married	121,414 (49.0%)	6,654 (52.1%)	2,766 (53.7%)	
Never married	63,257 (25.5%)	2,935 (23.0%)	1,190 (23.1%)	
Divorced/separated/single	57,767 (23.3%)	2,950 (23.1%)	1,095 (21.3%)	
Widow/Widower/widowed	745 (0.3%)	28 (0.2%)	19 (0.4%)	
Missing	4,447 (1.8%)	215 (1.7%)	84 (1.6%)	
Education				<0.001
<High school diploma	3,434 (1.4%)	145 (1.1%)	58 (1.1%)	
High school diploma	207,813 (83.9%)	10,686 (83.6%)	4,128 (80.1%)	
>HS diploma	33,266 (13.4%)	1,818 (14.2%)	904 (17.5%)	
Missing	3,117 (1.3%)	133 (1.0%)	64 (1.2%)	
Service branch				0.026
Air force	13,612 (5.5%)	718 (5.6%)	302 (5.9%)	
Army	175,803 (71.0%)	9,082 (71.1%)	3,633 (70.5%)	

	No PE (n=247,630, 93.3%)	1-7 PE Sessions (n=12,782, 4.8%)	8+ PE Sessions (n=5,154, 1.9%)	P value
Coast Guard	140 (0.1%)	6 (0.1%)	0 (0%)	
Marine	41,335 (16.7%)	2,198 (17.2%)	844 (16.4%)	
Navy	16,740 (6.8%)	778 (6.1%)	375 (7.3%)	
Component				<0.001
Active Duty (regular)	165,576 (66.9%)	8,558 (67.0%)	3,202 (62.1%)	
Guard	52,599 (21.2%)	2,639 (20.7%)	1,173 (22.8%)	
Reserve	29,455 (11.9%)	1,585 (12.4%)	779 (15.1%)	
Rank				<0.001
Enlisted	238,580 (96.4%)	12,252 (95.9%)	4,878 (94.6%)	
Officer	7,726 (3.1%)	471 (3.7%)	252 (4.9%)	
Warrant	1,324 (0.5%)	59 (0.5%)	24 (0.5%)	
Number of Deployments				<0.001
Single deployment	136,303 (55.0%)	6,723 (52.6%)	2,645 (51.3%)	
Multiple deployments	110,431 (44.6%)	6,017 (47.1%)	2,493 (48.4%)	
Missing	896 (0.4%)	42 (0.3%)	16 (0.3%)	
Military Sexual Trauma	15,917 (6.4%)	963 (7.5%)	422 (8.2%)	<0.001
Smoking *	24,159 (9.8%)	1,092 (8.5%)	417 (8.1%)	<0.001
PTS medication *	22,126 (8.9%)	1,151 (9.0%)	439 (8.5%)	0.556
# comorbidities *	1.31 (0.58)	1.33 (0.58)	1.32 (0.59)	0.466
Comorbidities *				
Schizophrenia	143 (0.1%)	5 (0.04%)	0 (0%)	0.158
Bipolar	2,296 (0.9%)	117 (0.9%)	32 (0.6%)	0.074
Psychosis	314 (0.1%)	11 (0.1%)	6 (0.1%)	0.438
Pain	63,820 (25.8%)	3,267 (25.6%)	1,414 (27.4%)	0.021
TBI	7,003 (2.8%)	419 (3.3%)	184 (3.6%)	<0.001
Depression	27,346 (11.0%)	1,379 (10.8%)	539 (10.5%)	0.287
Alcohol abuse	4,807 (1.9%)	224 (1.8%)	90 (1.8%)	0.201
Alcohol dependence	3,097 (1.3%)	144 (1.1%)	74 (1.4%)	0.221
Drug abuse	1,641 (0.7%)	71 (0.6%)	33 (0.6%)	0.339
Drug dependence	827 (0.3%)	46 (0.4%)	15 (0.3%)	0.763
Suicide	854 (0.3%)	60 (0.5%)	20 (0.4%)	0.062
# therapy sessions before 1st PE, excluding 0 therapy	N/A	(n=11,141) 13.8 (22.5)	(n=4,528) 15.8 (25.2)	<0.001

Note: P-values for continuous variables are based on Kruskal Wallis test or Mann-Whitney Test, and p values for categorical variables are based on Chi-Square or Fisher's Exact test. * Measured in the year prior to index date.

Table 1b. Patient Characteristics by CPT Status in any 24 Weeks during Follow-up (N=265,566)

	No CPT (n=216,953, 81.7%%)	**1-7 CPT Sessions (n=29,006, 10.9%)**	**8+ CPT Sessions (n=19,607, 7.4%)**	**P value**
Baseline age on index date	32.0 (8.5)	32.0 (8.3)	33.5 (9.1)	<0.001
Baseline age categories				<0.001
<30	118,339 (54.6%)	15,354 (52.9%)	9,148 (46.7%)	
30-39	57,088 (26.3%)	8,144 (28.1%)	5,510 (28.1%)	
40-49	32,532 (15.0%)	4,456 (15.4%)	3,841 (19.6%)	
50-59	8,176 (3.8%)	982 (3.4%)	1,006 (5.1%)	
60-69	816 (0.4%)	70 (0.2%)	101 (0.5%)	
70+	2 (0%)	0 (0%)	1 (0%)	
Gender				<0.001
Male	195,075 (89.9%)	25,354 (87.4%)	16,976 (86.6%)	
Female	21,875 (10.1%)	3,652 (12.6%)	2,629 (13.4%)	
Missing	3 (0%)	0 (0%)	2 (0%)	
Race				<0.001
White	154,267 (71.1%)	20,921 (72.1%)	13,783 (70.3%)	
Black or African American	36,727 (16.9%)	4,843 (16.7%)	3,734 (19.0%)	
American Indian or Alaska Native	2,490 (1.2%)	386 (1.3%)	294 (1.5%)	
Asian	3,553 (1.6%)	396 (1.4%)	315 (1.6%)	
Native Hawaiian or Other Pacific Islander	2,532 (1.2%)	394 (1.4%)	242 (1.2%)	
Multi-races	2,583 (1.2%)	376 (1.3%)	250 (1.3%)	
Missing	14,801 (6.8%)	1,690 (5.8%)	989 (5.0%)	
Ethnicity				<0.001
Hispanic or Latino	26,666 (12.3%)	3,778 (13.0%)	2,292 (11.7%)	
Not Hispanic or Latino	179,679 (82.8%)	23,971 (82.6%)	16,467 (84.0%)	
Other	7,082 (3.3%)	857 (3.0%)	563 (2.9%)	
Missing	3,526 (1.6%)	400 (1.4%)	285 (1.5%)	
Marital status				<0.001
Married	106,420 (49.1%)	14,474 (49.9%)	9,940 (50.7%)	
Never married	55,733 (25.7%)	6,940 (23.9%)	4,709 (24.0%)	
Divorced/separated/single	50,197 (23.1%)	7,026 (24.2%)	4,589 (23.4%)	
Widow/Widower/widowed	642 (0.3%)	92 (0.3%)	58 (0.3%)	
Missing	3,961 (1.83%)	474 (1.6%)	311 (1.6%)	
Education				<0.001
<High school diploma	3,059 (1.4%)	362 (1.3%)	216 (1.1%)	
High school diploma	182,649 (84.2%)	24,302 (83.8%)	15,676 (80.0%)	
> High school diploma	28,541 (13.2%)	3,988 (13.8%)	3,459 (17.6%)	
Missing	2,704 (1.3%)	354 (1.2%)	256 (1.3%)	
Service branch				<0.001
Air force	11,818 (5.5%)	1,580 (5.5%)	1,234 (6.3%)	
Army	153,728 (70.9%)	20,737 (71.5%)	14,053 (71.7%)	

	No CPT (n=216,953, 81.7%%)	1-7 CPT Sessions (n=29,006, 10.9%)	8+ CPT Sessions (n=19,607, 7.4%)	P value
Coast Guard	129 (0.1%)	11 (0.04%)	6 (0.03%)	
Marine	36,658 (16.9%)	4,743 (16.4%)	2,976 (15.2%)	
Navy	14,620 (6.7%)	1,935 (6.7%)	1,338 (6.8%)	
Component				<0.001
Active Duty (regular)	145,732 (67.2%)	19,260 (66.4%)	12,344 (63.0%)	
Guard	45,567 (21.0%)	6,285 (21.7%)	4,559 (23.3%)	
Reserve	25,654 (11.8%)	3,461 (11.9%)	2,704 (13.8%)	
Rank				<0.001
Enlisted	209,204 (96.4%)	27,956 (96.4%)	18,550 (94.6%)	
Officer	6,594 (3.0%)	911 (3.1%)	944 (4.8%)	
Warrant	1,155 (0.5%)	139 (0.5%)	113 (0.6%)	
Number of Deployments				<0.001
Single deployment	119,614 (55.1%)	15,702 (54.1%)	10,355 (52.8%)	
Multiple deployments	96,582 (44.5%)	13,198 (45.5%)	9,161 (46.7%)	
Missing	757 (0.4%)	106 (0.4%)	91 (0.5%)	
Military sexual trauma	12,750 (5.9%)	2,543 (8.8%)	2,009 (10.3%)	<0.001
Smoking *	21,319 (9.8%)	2,710 (9.3%)	1,639 (8.4%)	<0.001
Took medication *	19,394 (8.9%)	2,571 (8.9%)	1,751 (8.9%)	0.914
# comorbidities *	1.31 (0.58)	1.31 (0.57)	1.33 (0.60)	0.309
Comorbidities *				
Schizophrenia	137 (0.06%)	9 (0.03%)	2 (0.01%)	0.002
Bipolar	1,987 (0.9%)	286 (1.0%)	172 (0.9%)	0.403
Psychosis	277 (0.13%)	30 (0.10%)	24 (0.12%)	0.544
Pain	56,096 (25.9%)	7,429 (25.6%)	4,976 (25.4%)	0.258
TBI	6,198 (2.9%)	862 (3.0%)	546 (2.8%)	0.429
Depression	23,982 (11.1%)	3,081 (10.6%)	2,201 (11.2%)	0.055
Alcohol abuse	4,243 (2.0%)	509 (1.8%)	369 (1.9%)	0.058
Alcohol dependence	2,706 (1.3%)	342 (1.2%)	267 (1.4%)	0.204
Drug abuse	1,435 (0.7%)	180 (0.6%)	130 (0.7%)	0.717
Drug dependence	703 (0.3%)	93 (0.3%)	92 (0.5%)	0.003
Suicide	739 (0.3%)	108 (0.4%)	87 (0.4%)	0.054
# therapy sessions before 1st CPT, excluding 0 therapy	N/A	(n=23,965) 13.1 (21.9)	(n=16,701) 14.9 (21.6)	<0.001

Note: P values for continuous variables are based on Kruskal Wallis test or Mann-Whitney test, and p values for categorical variables are based on Chi-Square or Fisher's Exact test. * Measured in the year prior to index date.

Table 2a. Ordered Logistic Regression (Comparing 3 groups: 0, 1-7 and 8+ sessions of PE)

	Odds Ratio (95% CI)	P value
Baseline Age category		
<30	ref	
30-39	1.14 (1.09-1.18)	<0.001

	Odds Ratio (95% CI)	P value
40-49	1.14 (1.09-1.20)	<0.001
50-59	0.95 (0.87-1.04)	0.282
60+	0.87 (0.67-1.14)	0.316
70+*	No observation	-
Gender		
Male	ref	
Female	0.90 (0.85-0.96)	0.001
Race		
White	ref	
Black /African American	1.10 (1.06-1.15)	<0.001
American Indian or Alaska Native	1.07 (0.94-1.23)	0.319
Asian	1.10 (0.97-1.23)	0.129
Native Hawaiian or Other Pacific Islander	1.03 (0.89-1.18)	0.713
Multi-races	1.03 (0.90-1.19)	0.628
Missing	0.97 (0.90-1.03)	0.309
Ethnicity		
Hispanic or Latino	ref	
Not Hispanic or Latino	0.89 (0.85-0.94)	<0.001
Other	0.74 (0.66-0.82)	<0.001
Missing	0.78 (0.68-0.90)	<0.001
Marital status		
Married	ref	
Never married	0.87 (0.84-0.91)	<0.001
Divorced/separated/single	0.91 (0.87-0.94)	<0.001
Widow/Widower/widowed	0.81 (0.61-1.10)	0.173
Missing	0.94 (0.83-1.07)	0.370
Service branch		
Air force	ref	
Army	1.00 (0.93-1.07)	0.930
Coast Guard	0.57 (0.25-1.30)	0.178
Marine	1.06 (0.98-1.14)	0.158
Navy	0.91 (0.84-1.00)	0.045
Component		
Active Duty (regular)	ref	
Guard	1.02 (0.98-1.06)	0.423
Reserve	1.12 (1.06-1.17)	<0.001
Rank		
Enlisted	ref	
Officer	1.24 (1.15-1.35)	<0.001
Warrant	0.82 (0.66-1.03)	0.091
Number of Deployments		
Single deployment	ref	
Multiple deployments	1.11 (1.08-1.15)	<0.001
Missing	0.92 (0.70-1.21)	0.549

	Odds Ratio (95% CI)	P value
Military sexual trauma	1.34 (1.25-1.44)	<0.001
Smoking**	0.86 (0.81-0.91)	<0.001
Pain**	1.01 (0.98-1.05)	0.469
TBI**	1.19 (1.10-1.30)	<0.001
Year of 1st mental health visit		
2001-2005	ref	
2006	1.16 (1.06-1.26)	0.001
2007	1.12 (1.03-1.21)	0.005
2008	1.22 (1.13-1.31)	<0.001
2009	1.25 (1.16-1.35)	<0.001
2010	1.17 (1.09-1.26)	<0.001
2011	1.08 (1.00-1.17)	0.038
2012	1.09 (1.01-1.18)	0.023
2013	1.06 (0.98-1.14)	0.151
2014	0.99 (0.91-1.08)	0.795
2015-2017	0.92 (0.80-1.07)	0.299

Note: *Only 3 patients in the 70+ group, all in one category (none users), OR not estimated.
** Measured in the year prior to index date.

Table 2b. Ordered Logistic Regression (Comparing 3 groups: 0, 1-7 and 8+ sessions of CPT)

	Odd Ratio (95% CI)	P value
Baseline age category		
<30	ref	
30-39	1.15 (1.12-1.18)	<0.001
40-49	1.23 (1.19-1.27)	<0.001
50-59	1.17 (1.10-1.23)	<0.001
60-69	1.03 (0.87-1.22)	0.726
70+	3.61 (0.30-43.08)	0.310
Gender		
Male	ref	
Female	1.08 (1.04-1.12)	<0.001
Race		
White	ref	
Black /African American	0.99 (0.97-1.02)	0.566
American Indian or Alaska Native	1.19 (1.09-1.30)	<0.001
Asian	0.89 (0.82-0.97)	0.005
Native Hawaiian or Other Pacific Islander	1.08 (0.99-1.18)	0.082
Multi-races	1.05 (0.96-1.14)	0.312
Missing	0.80 (0.77-0.84)	<0.001
Ethnicity		
Hispanic or Latino	ref	
Not Hispanic or Latino	0.96 (0.93-0.99)	0.010
Other	0.90 (0.84-0.96)	0.002
Missing	0.89 (0.82-0.98)	0.012

	Odd Ratio (95% CI)	P value
Marital status		
Married	Ref	
Never married	0.95 (0.93-0.98)	<0.001
Divorced/separated/single	1.00 (0.97-1.02)	0.852
Widow/Widower/widowed	0.93 (0.78-1.11)	0.415
Missing	0.89 (0.82-0.96)	0.005
Service branch		
Air force	ref	
Army	1.01 (0.97-1.06)	0.609
Coast Guard	0.57 (0.34-0.94)	0.028
Marine	1.02 (0.97-1.08)	0.345
Navy	0.95 (0.89-1.00)	0.055
Component		
Active Duty (regular)	ref	
Guard	1.06 (1.03-1.08)	<0.001
Reserve	1.05 (1.02-1.08)	0.004
Rank		
Enlisted	ref	
Officer	1.17 (1.11-1.24)	<0.001
Warrant	0.90 (0.78-1.03)	0.124
Number of Deployments		
Single deployment	ref	
Multiple deployments	1.08 (1.06-1.10)	<0.001
Missing	1.19 (1.02-1.40)	0.029
Military sexual trauma	1.61 (1.54-1.68)	<0.001
Smoking*	0.91 (0.88-0.94)	<0.001
Schizophrenia*	0.35 (0.19-0.65)	0.001
Drug dependence*	1.30 (1.11-1.53)	0.001
Year of 1st mental health visit		
2001-2005	ref	
2006	1.09 (1.04-1.15)	0.001
2007	1.10 (1.04-1.15)	<0.001
2008	1.10 (1.05-1.16)	<0.001
2009	1.05 (1.00-1.10)	0.040
2010	1.01 (0.96-1.06)	0.677
2011	1.00 (0.96-1.05)	0.883
2012	1.02 (0.97-1.07)	0.490
2013	1.02 (0.97-1.07)	0.448
2014	0.89 (0.84-0.93)	<0.001
2015-2017	0.76 (0.69-0.84)	<0.001

Note: * Measured in the year prior to index date.

Table 3a. Cox Proportional Hazards Regression for Completion of 1st Full-Dose PE

	Hazard Ratio (95% CI)	P value
Baseline Age category		
<30	ref	
30-39	1.30 (1.21-1.39)	<0.001
40-49	1.49 (1.37-1.62)	<0.001
50-59	1.33 (1.15-1.53)	<0.001
60+	1.29 (0.85-1.96)	0.228
70+	No observation	-
Gender		
Male	ref	
Female	0.83 (0.74-0.92)	0.001
Race		
White	ref	
Black or African American	1.27 (1.18-1.36)	<0.001
American Indian or Alaska Native	1.00 (0.77-1.29)	0.972
Asian	1.16 (0.95-1.43)	0.149
Native Hawaiian or Other Pacific Islander	0.91 (0.70-1.18)	0.482
Multi-races	1.16 (0.91-1.47)	0.220
Missing	0.93 (0.82-1.06)	0.273
Ethnicity		
Hispanic or Latino	ref	
Not Hispanic or Latino	0.88 (0.81-0.96)	0.003
Other	0.78 (0.64-0.94)	0.008
Missing	0.72 (0.56-0.92)	0.010
Marital status		
Married	ref	
Never married	0.94 (0.88-1.01)	0.111
Divorced/separated/single	0.87 (0.81-0.93)	<0.001
Widow/Widower/widowed	1.05 (0.67-1.64)	0.843
Missing	0.90 (0.71-1.13)	0.354
Service branch		
Air force	ref	
Army	0.98 (0.87-1.11)	0.794
Coast Guard	-*	-*
Marine	1.11 (0.97-1.27)	0.133
Navy	1.03 (0.88-1.20)	0.745
Component		
Active Duty (regular)	ref	
Guard	1.08 (1.01-1.17)	0.034
Reserve	1.22 (1.12-1.32)	<0.001
Rank		
Enlisted	ref	
Officer	1.33 (1.17-1.52)	<0.001
Warrant	0.73 (0.49-1.09)	0.125

	Hazard Ratio (95% CI)	P value
Number of Deployments		
Single deployment	ref	
Multiple deployments	1.15 (1.08-1.21)	<0.001
Missing	0.80 (0.49-1.31)	0.378
Military sexual trauma	1.47 (1.30-1.66)	<0.001
Smoking **	0.84 (0.76-0.93)	0.001
Depression **	0.92 (0.84-1.01)	0.087
Bipolar **	0.69 (0.49-0.98)	0.037
Pain **	1.07 (1.00-1.14)	0.052
TBI **	1.27 (1.09-1.47)	0.002
Year of 1st mental health visit		
2001-2005	Ref	
2006	1.41 (1.21-1.64)	<0.001
2007	1.37 (1.18-1.59)	<0.001
2008	1.67 (1.45-1.92)	<0.001
2009	1.91 (1.65-2.20)	<0.001
2010	2.07 (1.80-2.39)	<0.001
2011	2.06 (1.78-2.38)	<0.001
2012	2.40 (2.07-2.77)	<0.001
2013	2.37 (2.03-2.77)	<0.001
2014	3.32 (2.82-3.90)	<0.001
2015-2017	4.34 (3.36-5.60)	<0.001

* Coast guard group had no observation of outcome (full-dose PE).
**Measured in the year prior to index date.

Table 3b. Cox Proportional Hazards Regression for Completion of 1st Full-Dose CPT

	Hazard Ratio (95% CI)	P value
Baseline age category		
<30	ref	
30-39	1.22 (1.18-1.26)	<0.001
40-49	1.45 (1.39-1.52)	<0.001
50-59	1.51 (1.40-1.62)	<0.001
60-69	1.57 (1.29-1.92)	<0.001
70+	7.05 (0.99-50.17)	0.051
Gender		
Male	ref	
Female	1.03 (0.98-1.08)	0.279
Race		
White	ref	
Black or African American	1.04 (1.00-1.08)	0.072
American Indian or Alaska Native	1.25 (1.11-1.40)	<0.001
Asian	0.98 (0.87-1.09)	0.671
Native Hawaiian or Other Pacific Islander	1.01 (0.89-1.15)	0.841
Multi-races	1.03 (0.91-1.17)	0.619

	Hazard Ratio (95% CI)	P value
Missing	0.78 (0.73-0.84)	<0.001
Ethnicity		
Hispanic or Latino	ref	
Not Hispanic or Latino	1.02 (0.98-1.07)	0.332
Other	0.95 (0.86-1.04)	0.278
Missing	0.99 (0.87-1.12)	0.816
Marital status		
Married	ref	
Never married	1.02 (0.98-1.05)	0.374
Divorced/separated/single	0.99 (0.95-1.02)	0.444
Widow/Widower/widowed	0.83 (0.64-1.07)	0.146
Missing	0.88 (0.78-0.99)	0.031
Service branch		
Air force	ref	
Army	0.98 (0.92-1.04)	0.479
Coast Guard	0.48 (0.22-1.07)	0.074
Marine	1.01 (0.94-1.08)	0.864
Navy	0.91 (0.84-0.99)	0.023
Component		
Active Duty (regular)	ref	
Guard	1.07 (1.03-1.11)	<0.001
Reserve	1.08 (1.03-1.13)	0.001
Rank		
Enlisted	ref	
Officer	1.31 (1.22-1.40)	<0.001
Warrant	0.90 (0.75-1.09)	0.291
Number of Deployments		
Single deployment	ref	
Multiple deployments	1.09 (1.06-1.12)	<0.001
Missing	1.29 (1.05-1.59)	0.018
Military sexual trauma	1.65 (1.56-1.75)	<0.001
Smoking *	0.86 (0.82-0.91)	<0.001
Drug dependence *	1.59 (1.30-1.96)	<0.001
Schizophrenia *	0.18 (0.04-0.70)	0.014
Suicide *	1.34 (1.09-1.66)	0.006
Year of 1st mental health visit		
2001-2005	ref	
2006	1.21 (1.12-1.31)	<0.001
2007	1.30 (1.21-1.40)	<0.001
2008	1.52 (1.42-1.64)	<0.001
2009	1.69 (1.57-1.82)	<0.001
2010	1.88 (1.75-2.02)	<0.001
2011	2.24 (2.08-2.41)	<0.001
2012	2.66 (2.47-2.86)	<0.001
2013	3.15 (2.92-3.39)	<0.001

	Hazard Ratio (95% CI)	P value
2014	3.60 (3.31-3.91)	<0.001
2015-2017	3.96 (3.42-4.58)	<0.001

*Measured in the year prior to index date.

Given the complex details involved, we are currently continuing to work on refining the comparative effectiveness analyses **(subtask 3d)** and the results of this will soon be written up as a publication. Simultaneously, we are continuing to work on **subtask 3g,** which will be crafted into an additional manuscript.

What opportunities for training and professional development has the project provided?

Nothing to report (not a goal of this study).

c. How were the results disseminated to communities of interest?

We have already begun dissemination of our findings through our recently published paper **(subtask 4g):**

Maguen, S., Madden, E., Patterson, O.V., DuVall, S.L., Goldstein, L.A., Burkman, K., & Shiner B. (2018). Measuring Use of Evidence Based Psychotherapy for Posttraumatic Stress Disorder in a Large National Healthcare System. Administration and Policy in Mental Health and Mental Health Services Research. Epub ahead of print.

In addition, we submitted our second paper which is currently under review **(subtask 4g):**

Maguen, S., Li, Y., Madden, E., Seal, K., Neylan, T., Patterson, O.V., DuVall, S.L., & Shiner B. Factors Associated with Completing Evidence-Based Psychotherapy for PTSD among Veterans in a National Healthcare System.

Finally, we have submitted a conference abstract for the International Society for Traumatic Stress Studies **(subtask 4c):**

Maguen, S., Madden, E., Li, Y., Patterson, O.V., DuVall, S.L., & Shiner B. Using Natural Language Processing to Examine National Trends of Evidence-Based Psychotherapies for PTSD in the VA.

This is the first of several conference submissions to come.

d. **What do you plan to do during the next reporting period to accomplish the goals?**

We have several goals for the next reporting period. First, we will finalize our comparative effectiveness analyses and submit a paper for publication. Next, we will complete the Aim 3 database, as well as subtasks 3h and 3i, comparing those who received early, late and no EBT on our PTS and suicide outcomes.

4. **IMPACT:**

a. **What was the impact on the development of the principal discipline(s) of the project?**

Multiple researchers have already reached out to us related to our NLP paper, as well as related to the PTS outcomes that we have developed. We have received several communications that our work has been extremely helpful in shedding light on "lifetime" prevalence of EBPs in the VA system (20% of Veterans who received psychotherapy had at least some EBP), which we published in our first paper. Prior papers have only been able to report cross-sectional prevalence rates because EBPs across the implementation period could not be determined prior to the NLP algorithm that we developed with our team. Furthermore, researchers have reached out to us to consult about how we were able to consolidate PTS outcomes, since this has been a challenge in the past. Having both the developed algorithm and a precedent for using NLP to determine missing PTS data will allow the field to answer questions that were not possible before due to the limitations of the data.

b. **What was the impact on other disciplines?**

We created an NLP system to determine the type of psychotherapy described in clinical notes, and we also developed an NLP system to extract PCL scores, both of which potentially have a broader impact as it results in previously unavailable data for a range of other studies in a wide range of disciplines.

c. **What was the impact on technology transfer?**

Once the project is complete we will be able to share our algorithms to further research in this area.

d. **What was the impact on society beyond science and technology?**

Nothing to report yet.

5. **CHANGES / PROBLEMS:**

Similar to the challenges that we faced when trying to extract PTS data, we are facing similar challenges with suicide data, which is not available on all patients. We are working with our data team and other researchers who have used these suicide data to use multiple sources so we can create the most comprehensive suicide variables available.

We are also continuing to experience delays in the VINCI computing infrastructure. For example, without notice, there will be OIC scans that will cause delays in access to VINCI. We are in communication with the managers of VINCI when this happens, yet they inform us that these delays are out of their control and associated with security measures.

6. **PRODUCTS:**

In addition to developing an algorithm to identify EBPs in the VA electronic medical record as well as a way to identify additional PTS measures in the clinical notes, we have published one article with another one currently under review:

Maguen, S., Madden, E., Patterson, O.V., DuVall, S.L., Goldstein, L.A., Burkman, K., & Shiner B. (2018). Measuring Use of Evidence Based Psychotherapy for Posttraumatic Stress Disorder in a Large National Healthcare System. Administration and Policy in Mental Health and Mental Health Services Research. Epub ahead of print.

In addition, we submitted our second paper which is currently under review:

Maguen, S., Li, Y., Madden, E., Seal, K., Neylan, T., Patterson, O.V., DuVall, S.L., & Shiner B. Factors Associated with Completing Evidence-Based Psychotherapy for PTSD among Veterans in a National Healthcare System. Under review.

In addition to these products, we have submitted an initial request for information for a follow-up JWMRP grant that builds upon the current framework that we have created in the current investigation. We were approved to move forward and submit a pre-application, and we are currently submitting this pre-application to be considered for funding **(subtask 4b in progress).** Dr. Brian Shiner is also submitting a pre-application that builds on the algorithm that we have created and we both look forward to hearing back about these submitted applications.

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

a. What individuals have worked on the project?

Name:	*Shira Maguen*
Project Role:	*Principle Investigator, San Francisco VAMC*
Researcher Identifier (e.g. ORCID ID):	*N/A*
Nearest person month worked:	*3*
Contribution to Project:	*Dr. Maguen has provided coordination, oversight, and management of all tasks outlined in the research plan, working closely with her co-investigators.*

Name:	*Brian Shiner*
Project Role:	*Co-investigator, White River Junction VAMC*
Researcher Identifier (e.g. ORCID ID):	*N/A*
Nearest person month worked:	*1.5*
Contribution to Project:	*Dr. Shiner has helped the team use his natural language processing algorithms to identify the use of evidence-based psychotherapy for PTS. He has also assisted with methods related to this project, given his prior experience with NLP.*

Name:	*Erin Madden*
Project Role:	*Statistician*
Researcher Identifier (e.g. ORCID ID):	*N/A*
Nearest person month worked:	*1.5*
Contribution to Project:	*Ms. Madden has worked to acquire the data sources used for this project, built the initial cohort and derived administrative-*

based datasets for the cohort. She has also carried out validation study design and analyses.

Name: *Yongmei Li*
Project Role: *Statistician*
Researcher Identifier (e.g. ORCID ID): N//A
Nearest person month worked: *6*
Contribution to Project: *Ms. Li is assisting with administrative-based datasets for the cohort and will help with subsequent analyses.*

Name: *Scott Duvall/Olga Patterson/Corinne Halls*
Project Role: *NLP Expert, Salt Lake City VAMC*
Researcher Identifier (e.g. ORCID ID): *N/A*
Nearest person month worked: *1*
Contribution to Project: *Drs. Duvall and Patterson advised the study team on NLP methods and are starting to test and modify the algorithm. Ms. Halls is overseeing annotation and coding for NLP team.*

Name: *Kristine Burkman*
Project Role: *Clinical Psychologist Coder*
Researcher Identifier (e.g. ORCID ID): *N/A*
Nearest person month worked: *2*
Contribution to Project: *Dr. Burkman is a clinical psychologist who has coded clinical notes during the performance evaluation phase of the study and continues to assist on consultation related EBP given that she is a therapist who uses these treatments in clinical practice.*

Name: *Callan Lujan*
Project Role: *Project Coordinator, San Francisco VAMC*
Researcher Identifier (e.g. ORCID ID): N/A
Nearest person month worked: *6*
Contribution to Project: *Ms. Lujan works as the project coordinator, managing IRB correspondence, HRPO correspondence, annual and quarterly report preparation as well as maintaining the safe storage of data.*

b. **Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?**

Nothing to report.

c. **What other organizations were involved as partners?**

As mentioned above, we are working with the Salt Lake City VAMC.

8. **SPECIAL REPORTING REQUIREMENTS**

a. **COLLABORATIVE AWARDS:** *For collaborative awards, independent reports are required from **BOTH** the Initiating PI and the Collaborating/Partnering PI. A duplicative report is acceptable; however, tasks shall be clearly marked with the responsible PI and research site. A report shall be submitted to https://ers.amedd.army.mil for each unique award.*

b. **QUAD CHARTS:** *If applicable, the Quad Chart (available on https://www.usamraa.army.mil) should be updated and submitted with attachments.*

9. **APPENDICES:** *Attach all appendices that contain information that supplements, clarifies or supports the text. Examples include original copies of journal articles, reprints of manuscripts and abstracts, a curriculum vitae, patent applications, study questionnaires, and surveys, etc. Reminder: Pages shall be consecutively numbered throughout the report. **DO NOT RENUMBER PAGES IN THE APPENDICES.***

Does Evidence-Based PTS Treatment Reduce PTS Symptoms and Suicide in Iraq and Afghanistan Veterans Seeking VA Care?

JW140056

PI: Shira Maguen, Ph.D.

Org: Northern California Institute for Research and Education (NCIRE)

Award Amount: $763,732 (directs)+ $407,070 (F&A)

Study/Product Aim(s)

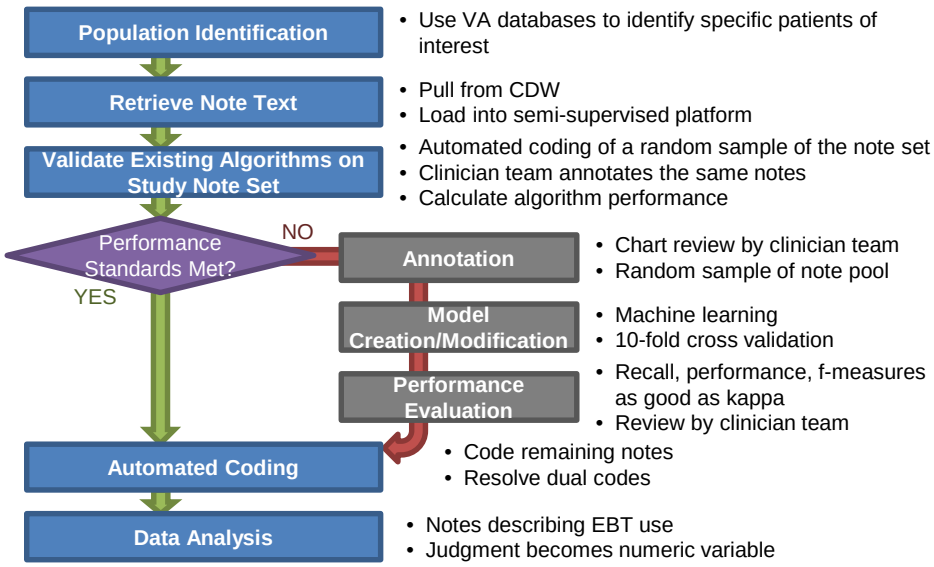
- **Aim 1**: Determine whether Iraq and Afghanistan Veterans that receive EBT for PTS across the entire Veterans Administration (VA) demonstrate improvement in PTS and suicide symptoms.
- **Aim 2**: Determine what percentage of Veterans with PTS complete a minimally-adequate dose of EBT for PTS, as well as factors associated with treatment completion.
- **Aim 3**: Determine the association between treatment profiles (early, delayed, and no EBT) and symptom improvement in Veterans with PTS, including those with complex comorbidities (depression, TBI, substance use disorders, and/or pain disorders).

Approach

Retrospective cohort study using multiple sources of VA data from 2007 to 2014. Sample will include Iraq and Afghanistan Veterans with PTS who are new users enrolled in the VA health care system.

Natural Language Processing (NLP) will be used to determine receipt of evidence-based psychotherapy for PTS.

Natural Language Processing Methods



Timeline and Cost

Activities / CY	15	16	17	18	19
Update and Merge Existing Data and Datasets					
Use NLP to Evaluate Clinical Notes					
Data Analysis					
Finalize Study Requirements, Prepare for Future Funding, and Disseminate Findings					
Estimated Budget ($763,732)	**$51,177**	**$193,098**	**$198,451**	**$160,503**	**$160,503**

Updated: April 2018 (SFVAMC – San Francisco, CA)

Goals/Milestones

CY15 Goals – *Update and Merge Existing Data and Datasets*
- ☑ Update and merge multiple VA datasets
- ☑ Population identification
- ☑ Retrieve note text
- ☑ Begin developing standardized annotation guide

CY16 Goals – *Use NLP to Evaluate Clinical Notes*
- ☑ Complete creation of standardized annotation guide
- ☑ Quadruple annotation of 650 psychotherapy notes

CY17 Goals –
- ☑ Build classifier to remove irrelevant notes
- ☑ Annotation of enriched set of 650 notes (exceeded goal)
- ☑ Build NLP model for types of EBT
- ☑ Automated coding
- ☑ Begin Data Analysis

CY18 Goals – *Complete Data Analysis*
- ❑ Complete data analysis
- ❑ Finalize study requirements

CY19 Goals – *Disseminate Findings*
- ☑ Prepare for future funding
- ❑ Disseminate findings

Administration and Policy in Mental Health and Mental Health Services Research
https://doi.org/10.1007/s10488-018-0850-5

ORIGINAL REPORT

Measuring Use of Evidence Based Psychotherapy for Posttraumatic Stress Disorder in a Large National Healthcare System

Shira Maguen[1,2,8] · Erin Madden[1] · Olga V. Patterson[3,4] · Scott L. DuVall[3,4] · Lizabeth A. Goldstein[1,2] · Kristine Burkman[1,2] · Brian Shiner[5,6,7]

Abstract
To derive a method of identifying use of evidence-based psychotherapy (EBP) for post-traumatic stress disorder (PTSD), we used clinical note text from national Veterans Health Administration (VHA) medical records. Using natural language processing, we developed machine-learning algorithms to classify note text on a large scale in an observational study of Iraq and Afghanistan veterans with PTSD and one post-deployment psychotherapy visit by 8/5/15 (N = 255,968). PTSD visits were linked to 8.1 million psychotherapy notes. Annotators labeled 3467 randomly-selected psychotherapy notes (kappa = 0.88) to indicate receipt of EBP. We met our performance targets of overall classification accuracy (0.92); 20.2% of veterans received ≥ one session of EBP over the study period. Our method can assist with identifying EBP use and studying EBP-associated outcomes in routine clinical practice.

Keywords Posttraumatic stress disorder · Natural language processing · Evidence-based medicine · Health services utilization · Psychotherapy

Introduction

The US Veterans Health Administration (VHA) has implemented multiple effective treatments for posttraumatic stress disorder (PTSD), including two specific psychotherapy protocols, cognitive processing therapy (CPT) and prolonged exposure (PE; Karlin et al. 2010). Cognitive processing therapy is comprised of 12 weekly 60-min sessions of cognitive therapy, where veterans address maladaptive thoughts associated with their worst traumatic event. Cognitive processing therapy can be administered either in an individual therapy format or a group format (Resick et al. 2015, 2017). Prolonged exposure consists of 9–12 weekly 90-min sessions of trauma-associated imaginal and in-vivo exposures. It is administered in an individual therapy format, although trials are underway to examine administration in a group format (e.g., Smith et al. 2015). Research trials of CPT and PE have resulted in statistically significant and clinically meaningful improvement in veterans' PTSD symptoms (e.g. Haagen et al. 2015; Monson et al. 2006; Schnurr and Lunney 2015; Schnurr et al. 2007; Voelkel et al. 2015). The VHA Uniform Mental Health Services Package mandated the availability of these treatments in VHA clinics beginning in 2008 (Kussman 2008), and they have been implemented in many settings (Chard et al. 2010; Tuerk et al. 2011; Rosen et al. 2016, 2017; Yoder et al. 2012). Studies on a *local* or *regional* level have estimated that approximately 6–13% of VHA patients with PTSD receive PE or CPT (Lu et al. 2016; Mott et al. 2014; Shiner et al. 2013).

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Given the high prevalence of PTSD among VHA patients (e.g. Seal et al. 2007), as well as the resources invested in training providers nationwide, being able to identify use of evidence-based psychotherapies for PTSD on a *national* level is important. First, it allows an understanding of implementation patterns, including barriers to and facilitators of use. Second, it facilitates evaluation of whether patients improve in naturalistic settings (outside of research trials) and which patients improve most when receiving these treatments. Third, it allows us to better understand dropout rates and associated factors. Consequently, we need accurate measures of the use of these psychotherapies. While administrative data elucidate whether a patient received psychotherapy, they do not contain information about specific treatments utilized, including whether CPT or PE were administered. While CPT was implemented in 2006 and PE in 2007, templated notes for these treatments were not implemented until 2015 and are still inconsistently used (Shiner et al. in press). Subsequently, the VHA has not been able to study whether these treatments have been systematically implemented and whether they are effective on a larger scale.

Although manual review of treatment notes at a regional or national level would be challenging and labor-intensive, automated coding of note text using natural language processing (NLP) is one method that can efficiently deliver important information from large and unstructured data (Meystre et al. 2008). Shiner et al. (2012, 2013) were able to use NLP methods to better understand the percentage of veterans with newly diagnosed PTSD who received CPT or PE within six sites in the New England VHA region. In this study, our goal was to extend Shiner and colleagues' work by applying automated coding to a large *national* pool of mental health treatment notes in order to identify use of CPT and PE. Shiner et al.'s work was limited to a regional evaluation and the tool they used (the Automated Retrieval Console, or ARC; D'Avolio et al. 2010) ran processes in series rather than in parallel, so it could not be reasonably scaled up for national, longitudinal work. Another significant difference is that this work allows us to identify evidence-based psychotherapys (EBPs) delivered in both group and individual formats. Group CPT is reported to have spread rapidly in the VA and being able to identify group CPT will allow us to detect patterns of implementation. We hypothesized that automated coding using NLP would be able to detect and discriminate between note text describing evidence-based protocols for PTSD and other psychotherapy.

Method

Participants

We retrospectively identified 255,968 veterans of the wars in Iraq and Afghanistan who had at least two post-deployment encounters (inpatient and/or outpatient) with a PTSD diagnosis (ICD-9 309.81), and at least one post-deployment clinic visit with a psychotherapy procedure code (see list of procedure codes in Appendix 1) at one of 130 VHA facilities from October 2001 to August 2015. Next, all psychotherapy clinic visits for these patients were identified and linked to clinical notes. We excluded 3085 (1.19%) patients who did not have any notes associated with their psychotherapy procedure coded visits. Our text corpus consisted of a total of 8,168,330 clinical notes associated with psychotherapy visits for 255,933 patients across outpatient and inpatient settings.

Natural Language Processing Method

We created an NLP system to analyze narrative text of the psychotherapy notes to determine the type of psychotherapy that the documents describe. The system was built using Leo packages that extend the Unstructured Information Management Architecture Asynchronous Scaleout (UIMAAS) framework (Ferrucci and Lally 2004; Cornia et al. 2014). The system utilized LIBSVM implementation of a support-vector machine (SVM) algorithm (Chang and Lin 2011). LIBSVM is a library for support vector classification and regression. SVM is a supervised algorithm that requires a set of training examples to develop a machine learning model. The SVM algorithm was chosen because it is a robust machine learning algorithm that is appropriate for large sparse feature sets and is generally accepted to be the most accurate for imbalanced sets. In addition, applying SVM algorithm is fast, which is essential when working with large datasets (Baharudin et al. 2010). We performed manual annotation of psychotherapy notes in order to create a reference document set for training and validating the NLP system.

Annotation of a Reference Standard

The goal of manual annotation was to review each note in the selected set and assign a label that reflects the type and format of psychotherapy that the clinical note described. We used the following eight labels: (1) CPT individual, (2) CPT group, (3) PE individual, (4) PE group, (5) other individual psychotherapy, (6) other group psychotherapy, (7) other family or couples' psychotherapy, and (8) not psychotherapy.

Two practicing VHA clinicians who are trained in and provide evidence-based psychotherapies at the VHA (i.e., one staff psychologist, K.B., and one psychology postdoctoral fellow, L.A.G.), and two professional clinical chart annotators performed multiple rounds of annotation. The psychology and professional clinical chart annotation team collaborated to iteratively create annotation guidelines describing the code definitions (see Appendix 3 for example). All four annotators completed the first two rounds

of annotation on the same document set to evaluate inter-annotator agreement. Once an acceptable level of agreement (kappa ≥ 0.8) was achieved, the professional clinical chart annotators reviewed additional documents. The documents were labeled using annotation tools on a centralized virtual workspace provided by the VA Informatics and Computing Infrastructure (VINCI).

The main challenge with selecting documents for annotation for our project was the large differences between the prevalence of each type of therapy in our large body of national clinical notes. Machine learning classifiers do not perform well if the training set is highly imbalanced. One of the approaches to creating the most accurate model is to oversample classes with low prevalence (Batuwita and Palade 2013). However, we had no formal way of performing document selection to oversample for relevant documents. Thus, we utilized an iterative approach to perform a series of steps multiple times: (1) using random stratified selection of documents from the complete unlabeled set; (2) annotation of the selected documents; (3) training a preliminary SVM classifier model using the annotated set; and (4) applying the newly trained preliminary model on the full dataset. In each iteration of this method, we used stratification either simply by location code within VA (total number of locations is 130), or using additional stratification by labels assigned by the latest trained SVM model. The goal of each iteration was to arrive at a balanced document set where each document type is evenly represented. In addition to random stratified selection, we performed targeted selection of documents that indicated unusual situations, such as a patient having both PE and CPT sessions on the same day, which is highly unlikely.

All preliminary training of SVM models was performed without manual feature selection. Once the last annotation iteration was completed and a balanced document set was identified, the full annotated document set was split into training and testing sets, and only after that the training set was manually reviewed to guide creation of the feature set for the final NLP system.

NLP System Development

The final annotated set of 3467 clinical documents was randomly split into a two-thirds training set (N = 2960) and a one-third (N = 1507) validation set. There were four steps in the development of our NLP system. First, we built a set of features for a machine learning classifier using a sparse binary bag-of-words document representation. This method encodes a document as an unordered set of words with a value of "1" if the word is present in the document and, if the word is absent, the value of "0" is implied. We amended this set by removing most frequently used irrelevant words (e.g. a, an, is, was, the). Second, we removed misleading irrelevant phrases. For example, the phrase "CPT code" stands for current procedural terminology, a way to code procedures for clinical visits. However, "CPT" also stands for "cognitive processing therapy." Therefore, the phrase "CPT code" was removed. Third, we created a set of features representing salient phrases, which are indicative of one of the categories. The values for these features were set to "2" to give them a bigger weight. For example, occurrence of the phrase "cognitive processing therapy" in a document is more important to determining if the document reports on a CPT session than the words "cognitive," "processing," and "therapy" separately. The total number of features in the training set was 16,516.

Document level classification was performed using LIBSVM implementation of a linear multi-label SVM classifier. The manually annotated document set indicated that clinical reports documenting PE group sessions were extremely rare (which is consistent with the fact that VA clinicians have not received training on this format so far), so only a single PE category was used. Similarly, all documents reporting other psychotherapy sessions were combined into a single category of "other psychotherapy." Thus, classification was performed using five labels: PE, CPT individual, CPT group, other psychotherapy, and not psychotherapy. While the algorithm is designed for multi-label classification, internally it performs a series of binary classifications as "one-against-one" classifications and then aggregates the results of these classifications using voting to assign a single most probable label out of the five labels (Hsu and Lin 2002). The accuracy of the classification model on the training set was 0.89. Finally, after developing the machine learning model, we validated the system on the test document set.

We analyzed system accuracy for each category separately and for the system as a whole. Measures included true positive count (TP: the number of documents in each category that the system and the reference standard agreed describe the performed psychotherapy; we also included true negative, false positive, and false negative counts), positive predictive value (PPV: the proportion of true positive documents to the total number of documents in each category identified by the system), sensitivity (the proportion of the true positive documents to the total number of documents in each category identified by the annotators), specificity (the proportion of the true negative documents to the total number of documents in each category identified by the annotators), and classification accuracy (the proportion of documents across all categories that the system and the reference standard agreed on to the total number of documents reviewed).

Analysis of Psychotherapy Receipt

Once the automated coding process was complete, we performed analyses comparing various methods for assessing psychotherapy delivery. For each patient, we calculated psychotherapy received in three ways: (1) mean number of individual or group psychotherapy sessions using psychotherapy current procedural technology codes (see Appendix 1), (2) mean number of psychotherapy sessions using automated classification of all documents, and (3) mean number of sessions of each specific EBP using NLP-based automated coding of individual psychotherapy documents. We repeated these analyses for the subpopulation of patients who received any EBP.

In order to account for potential bias from varying observation times, we performed a separate analysis restricting the dataset to the first 4.1 years (median observation time among entire cohort) from initial psychotherapy procedure coded visit among the 130,416 patients who were observed for at least that long (i.e., initial visit was at least 4.1 years before end of study), and repeated the analyses described above. All statistical analyses were completed in SAS, Enterprise Guide version 7.1 (Cary, NC).

Results

After the initial two rounds of annotation and training, the agreement between annotators was excellent (kappa = 0.88; 95% CI 0.85–0.90). Table 1 outlines the frequencies of documents in each category in the training and testing sets. The frequencies of some labels were too small to build an accurate machine learning model. As distinguishing among these categories was not essential, they were combined. Prolonged exposure individual and group were combined into the PE category and psychotherapy sessions other than PE and CPT types were merged into the "other psychotherapy" category.

NLP system validation showed an acceptable level of performance with PE accuracy of 0.99, CPT individual and CPT group accuracy of 0.97, and overall classification accuracy of 0.92 (see Table 2). Additionally, sensitivity, specificity, PPV, and negative predictive value (NPV) measures of PE and CPT individual and group were all 0.90 or greater (see Table 2). The NLP system was then applied to the full dataset. In total, the automated coding process using NLP identified 3,705,968 psychotherapy notes, including 84,445 PE notes, 196,018 CPT individual notes and 121,211 CPT group notes. As we moved from analytic methods reliant on procedure coding to methods reliant on automated coding of note text using NLP, our estimates of the use of psychotherapy decreased (Table 3). Using administrative coding, it appears that patients received an average of 18.7 sessions of psychotherapy over a median of 4.1 years, whereas using automated review of note text it appears that patients received 14.5 sessions. This means that some services administratively coded as psychotherapy appeared to be other services when the notes were reviewed. A total of 51,852 patients (20.2%) received at least one session of PE or CPT over the study period. These patients received an average of 7.8 sessions of EBP, although they had an average total of 38.9 individual psychotherapy sessions. This means that patients who received EBP for PTSD also received an equal or greater number of sessions of other forms of individual psychotherapy as part of their course of treatment. Restricting the period of observation to 4.1 years did not meaningfully change the results (see Appendix 2).

Table 1 Frequency of documents in each category for training and testing sets

Categories	Document count	
	Training set	Testing set
CPT individual	619	321
CPT group	577	312
PE individual	326	303
PE group[a]	7	5
Other individual psychotherapy[a]	433	170
Other group psychotherapy[a]	384	127
Other family/couple psychotherapy[a]	4	0
Not psychotherapy	610	269
Total	2960	1507

PE prolonged exposure, *CPT* cognitive processing therapy

[a]For the testing set we combined PE group with PE individual, given the low frequency of PE group (n = 308); we also combined other individual, group and family/couple psychotherapy into "other psychotherapy" (n = 297)

Discussion

We achieved our goal of deriving a method to identify VHA PTSD EBP notes on a national level and confirmed our hypothesis that an NLP system could distinguish between EBP notes and general psychotherapy notes on a large scale. Although the VHA invested in system-wide training programs to implement EBP for PTSD over a decade ago, this is the first time it is possible to identify receipt of EBP from EMRs on a national level across the implementation period. Our system can facilitate further research to determine the percentage of veterans that receive minimally adequate EBP for PTSD as well as their level of symptom improvement in a VHA clinic setting outside of a clinical trial using patient reported outcomes stored in the EMR (e.g., Maguen et al. 2014). More specifically, we can use the algorithm to determine how many sessions of EBPs each individual received

Table 2 Performance characteristics of the developed system

Performance	PE	CPT individual	CPT group	Other psych	Not psych	Total
Document counts						
TP	303	301	287	255	241	1387
TN	1190	1153	1172	1173	1220	
FP	9	33	23	37	18	
FN	5	20	25	42	28	
NLP system total	312	334	310	292	259	1507
Reference total	308	321	312	297	269	1507
Performance metrics						
Recall (sensitivity)	0.984	0.938	0.920	0.859	0.896	
Specificity	0.992	0.972	0.981	0.969	0.985	
Precision (PPV)	0.971	0.901	0.926	0.873	0.931	
NPV	0.996	0.983	0.979	0.965	0.978	
Accuracy	0.991	0.965	0.968	0.948	0.969	0.920

PE prolonged exposure, *CPT* cognitive processing therapy, *TP* true positive, *TN* true negative, *FP* false positive, *FN* false negative, *PPV* positive predictive value, *NPV* negative predictive value

NLP system total = number of documents labeled with corresponding class by the NLP system (same as TP + false positive). Reference total = number of documents labeled with corresponding class by the human annotators (same as TP + false negative). Classifier was tested on a testing set of 1507 documents, which were not used for system training

Table 3 Comparing methods to estimate use of prolonged exposure and cognitive processing therapy among all patients

	Estimated mean number of sessions among the total pool of patients M ± SD (n = 255,933)	Estimated mean number of sessions among the pool of patients receiving one session of PE or CPT M ± SD (n = 51,852)
Administrative data—any psychotherapy	18.7 ± 30.5	40.7 ± 45.3
NLP—any psychotherapy	14.5 ± 32.2	38.9 ± 51.8
NLP-CPT and/or PE	1.58 ± 4.59	7.79 ± 7.48
NLP-CPT individual	0.766 ± 2.73	3.78 ± 5.05
NLP-CPT group	0.474 ± 2.63	2.34 ± 5.45
NLP-CPT individual or group	1.24 ± 4.1	6.12 ± 7.28
NLP-PE	0.338 ± 1.78	1.67 ± 3.67

NLP natural language processing, *PE* prolonged exposure, *CPT* cognitive processing therapy

and whether dose is associated with measures of PTSD symptom outcomes tracked in the EMR (Hebenstreit et al. 2015; Maguen et al. 2014; Seal et al. 2016).

Given that there are regional and site differences in the implementation of EBPs for PTSD, it is critical to be able to determine automated coding accuracy using NLP on a national level. While Shiner et al. (2013) demonstrated that automated coding of psychotherapy notes using NLP was possible on a *regional* level, we were able to build on and extend their work by using a different platform, expanding to a *national* level, and identifying EBP for PTSD delivered in different formats (e.g., CPT group). This also will allow for comparisons of delivery methods of EBP for PTSD (Dreyer et al. 2010), which to date have only been compared in clinical trials (e.g., CPT individual vs. group; Resick et al. 2017). We found that about 20% of Iraq and Afghanistan veterans received at least one session of EBP for PTSD over nearly 15 years of observation. This is lower than we would expect from other studies using administrative data that were not able to isolate receipt of EBP for PTSD (Cully et al. 2008; Harpaz-Rotem and Rosenheck 2011; Seal et al. 2010; Spoont et al. 2010). However, low receipt of EBP for PTSD is consistent with more recent studies demonstrating that few veterans are initiating EBPs for PTSD and that dropout levels are high among those who do initiate (Kehle-Forbes et al. 2016).

Being able to identify patients who engaged in EBP for PTSD will help improve care for veterans in several ways. It will help us understand which individuals are most likely to receive and benefit from these treatments.

It will also help us understand how many sessions are needed to receive a "minimally adequate" dose of treatment. For example, if some individuals drop out of treatment because they are better, this is important information that can help modify the delivery of care. Being able to identify patients who engaged in EBP for PTSD will also help us to understand predictors of dropout and improvement. Additionally, given that we have longitudinal data, it can help inform us about the average length of time to EBP engagment as well as the typical trajectories of care. For example, we found that those receiving about eight sessions of EBP also received an average of nearly 40 individual psychotherapy sessions during the study period. In follow up analyses, we examined the number of psychotherapy sessions prior to the first session of EBP as well as after the last session of EBP for those who completed *any* EBP sessions. We found that veterans attended a mean of 25 sessions (median = 10) prior to their first session of EBP and a mean of 19 sessions (median = 7) after their last session of EBP. Consequently, it seems that on average, patients are getting additional treatment before and after EBP, with a larger percentage of sessions happening prior to EBP. This could represent efforts to address patients' readiness for PTSD treatment (e.g., Zubkoff et al. 2016), treatment of comorbid mental health conditions (e.g., Shiner et al. 2017), or post-EBP care for patients that may continue to have symptoms or relapse over time.

There are some important limitations to this work that should be noted. First, we conducted this study with Iraq and Afghanistan veterans, who are the newest veterans of war in the VHA system. Consequently, results may not generalize to all veterans. Second, while rates of EBPs for PTSD were low, this may be due to patient preferences, which we were not able to assess. Third, participation in a CPT or PE session does not reflect the intensity or quality of the intervention, Although measuring quality of individual sessions was not the focus of the current study, it is an important goal for future studies.

Despite these limitations, our findings suggest that automated coding using NLP is a method to identify use of EBPs. As far as we are aware, this is the first large-scale national application of automated coding to identify EBPs in VHA psychotherapy notes. This method holds great promise for answering multiple previously inaccessible questions that can assist clinicians and local and national leaders alike to understand current EBP practices and outcomes, and ultimately improve care for those with PTSD.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Appendix 1

See Table 4.

Table 4 Psychotherapy procedure codes used in the VHA

CPT code	CPT description	Category (g = group; i = individual; m = medication; o = other)
4062F	Patient referral for psychotherapy documented (MDD, MDD ADOL)	o
4064F	Antidepressant pharmacotherapy prescribed (MDD, MDD ADOL)	m
4065F	Antipsychotic pharmacotherapy prescribed (MDD)	m
90804	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an office or outpatient facility, approximately 20–30 mins face-to-face with the patient	i
90805	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an office or outpatient facility, approximately 20–30 mins face-to-face with the patient; with medical evaluation and management services	i
90806	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an office or outpatient facility, approximately 45–50 mins face-to-face with the patient	i
90807	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an office or outpatient facility, approximately 45–50 mins face-to-face with the patient; with medical evaluation and management services	i
90808	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an office or outpatient facility, approximately 75–80 mins face-to-face with the patient	i

Table 4 (continued)

CPT code	CPT description	Category (g = group; i = individual; m = medication; o = other)
90809	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an office or outpatient facility, approximately 75–80 mins face-to-face with the patient; with medical evaluation and management services	i
90810	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an office or outpatient facility, approximately 20–30 mins face-to-face with the patient	i
90811	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an office or outpatient facility, approximately 20–30 mins face-to-face with the patient; with medical evaluation and management services	i
90812	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an office or outpatient facility, approximately 45–50 mins face-to-face with the patient	i
90813	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an office or outpatient facility, approximately 45 to 50 mins face-to-face with the patient; with medical evaluation and management services	i
90814	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an office or outpatient facility, approximately 75–80 mins face-to-face with the patient	i
90815	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an office or outpatient facility, approximately 75–80 mins face-to-face with the patient; with medical evaluation and management services	i
90816	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an inpatient hospital, partial hospital or residential care setting, approximately 20–30 mins face-to-face with the patient	i
90817	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an inpatient hospital, partial hospital or residential care setting, approximately 20–30 mins face-to-face with the patient; with medical evaluation and management services	i
90818	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an inpatient hospital, partial hospital or residential care setting, approximately 45–50 mins face-to-face with the patient	i
90819	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an inpatient hospital, partial hospital or residential care setting, approximately 45–50 mins face-to-face with the patient; with medical evaluation and management services	i
90821	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an inpatient hospital, partial hospital or residential care setting, approximately 75–80 mins face-to-face with the patient	i
90822	Individual psychotherapy, insight oriented, behavior modifying and/or supportive, in an inpatient hospital, partial hospital or residential care setting, approximately 75–80 mins face-to-face with the patient; with medical evaluation and management services	i
90823	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an inpatient hospital, partial hospital or residential care setting, approximately 20–30 mins face-to-face with the patient	i
90824	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an inpatient hospital, partial hospital or residential care setting, approximately 20–30 mins face-to-face with the patient; with medical evaluation and management services	i
90826	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an inpatient hospital, partial hospital or residential care setting, approximately 45–50 mins face-to-face with the patient	i
90827	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an inpatient hospital, partial hospital or residential care setting, approximately 45–50 mins face-to-face with the patient; with medical evaluation and management services	i
90828	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an inpatient hospital, partial hospital or residential care setting, approximately 75–80 mins face-to-face with the patient	i

Table 4 (continued)

CPT code	CPT description	Category (g = group; i = individual; m = medication; o = other)
90829	Individual psychotherapy, interactive, using play equipment, physical devices, language interpreter, or other mechanisms of non-verbal communication, in an inpatient hospital, partial hospital or residential care setting, approximately 75–80 mins face-to-face with the patient; with medical evaluation and management services	i
90832	Psychotherapy, 30 mins with patient and/or family member	i
90833	Psychotherapy, 30 mins with patient and/or family member when performed with an evaluation and management service (list separately in addition to the code for primary procedure)	i
90834	Psychotherapy, 45 mins with patient and/or family member	i
90836	Psychotherapy, 45 mins with patient and/or family member when performed with an evaluation and management service (list separately in addition to the code for primary procedure)	i
90837	Psychotherapy, 60 mins with patient and/or family member	i
90838	Psychotherapy, 60 mins with patient and/or family member when performed with an evaluation and management service (list separately in addition to the code for primary procedure)	i
90841	Individual medical psychotherapy by a physician, with continuing medical diagnostic evaluation, and drug management when indicated, including insight oriented, behavior modifying or supportive psychotherapy (face-to-face with the patient); time unspecified	i
90843	Individual medical psychotherapy by a physician, with continuing medical diagnostic evaluation, and drug management when indicated, including insight oriented, behavior modifying or supportive psychotherapy (face-to-face with the patient); approximately 20–30 mins	i
90844	Individual medical psychotherapy by a physician, with continuing medical diagnostic evaluation, and drug management when indicated, including insight oriented, behavior modifying or supportive psychotherapy (face-to-face with the patient); approximately 45–50 mins	i
90853	Group psychotherapy (other than of a multiple-family group)	g
90855	Interactive individual medical psychotherapy	i
90857	Interactive group psychotherapy	g
90862	Pharmacologic management, including prescription, use, and review of medication with no more than minimal medical psychotherapy	m
90863	Pharmacologic management, including prescription and review of medication, when performed with psychotherapy services (list separately in addition to the code for primary procedure)	m

Appendix 2

See Table 5.

Table 5 Comparing methods to estimate use of PE and CPT in first 4 years of psychotherapy

	Estimated mean number of sessions among the total pool of patients M ± SD n = 130,416	Estimated mean number of sessions among the pool of patients receiving one session of PE or CPT M ± SD (n = 21,783)
Administrative data—any psychotherapy	18.7 ± 25.4	40.7 ± 36.6
NLP—any psychotherapy	13.3 ± 27.2	37.6 ± 44.3
NLP-CPT and/or PE	1.26 ± 4.11	7.55 ± 7.34
NLP-CPT individual	0.575 ± 2.37	3.44 ± 4.86
NLP-CPT group	0.354 ± 2.16	2.12 ± 4.91
NLP-CPT individual or group	0.971 ± 3.65	5.81 ± 7.18
NLP-PE	0.283 ± 1.61	1.7 ± 3.62

NLP natural language processing, *PE* prolonged exposure, *CPT* cognitive processing therapy

Appendix 3: CPT and PE Guidelines for Annotation

Cognitive Processing Therapy (CPT)—Individual Therapy

- If the title or body *of the note* states "CPT Session #n", *and is an individual session*, consider it CPT—individual.

  Examples of CPT notes:

  - "Content: this was the fifth session of cognitive processing therapy (CPT) for PTSD."
  - "Cognitive processing therapy: initial session."

- *Not* to be confused with CBT (cognitive behavioral therapy) or with CPT (current procedural terminology) code sets. If numbers follow the initials CPT, it is likely referring to a CPT code.

Cognitive processing therapy (CPT) is a cognitive-behavioral therapy for PTSD and related conditions. CPT typically consists of 12, 50-min therapy sessions. CPT utilizes trauma-specific cognitive challenging techniques to help patients move past inaccurate negative thoughts (called "stuck points") and progress toward recovery. Additionally, this therapy can be conducted with or without a written trauma account and in individual or group formats.

- Additional phrases in the body of the text may identify a CPT session:

  - Safety module
  - Impact statement
  - Trust module
  - Intimacy module
  - Esteem module
  - Power/control module
  - Trauma account
  - Stuck point(s)
  - Challenging questions
  - Patterns of problematic thinking
  - Socratic questioning
  - Final impact statement

Cognitive Processing Therapy (CPT)—Group Therapy

- If the title or body *of the note* states "CPT Session #n", *and is a group session*, consider it CPT—group therapy.
- Same criteria as listed in CPT-individual above, but note is clearly referring to a CPT *group* therapy session.

Prolonged Exposure (PE)—Individual Therapy

The goal of prolonged exposure therapy is to promote processing of the trauma memory and to reduce distress and avoidance evoked by the trauma reminders. The imaginal exposure typically occurs during the therapy session and consists of retelling the trauma to the therapist. For the in vivo exposure, the clinician works with the client to establish a fear and avoidance hierarchy and typically assigns exposures to these list items as homework progressively. Both components work by facilitating emotional processing so that the problematic traumatic memories and avoidances habituate (desensitize).

- To address the traumatic memories and triggers that are reminders of the trauma, the core components of prolonged exposure therapy are:

  1. *Imaginal exposure*, revisiting the traumatic memory, repeated recounting it aloud, and processing the revisiting experience, and
  2. *in vivo exposure*, the repeated confrontation with situations and objects that cause distress but are not inherently dangerous.
  3. Additional phrases found in the body of the text may identify a PE session:

     - In vivo hierarchy
     - Hot spots

- Examples of PE notes:

  Prolonged exposure imaginal sessions.
  Time in session (in minutes): 90.
  Session Number: 5.

- If the title or body of the note says "PE Session #n", and is an individual session, consider it PE-individual therapy.
- Check the note's content carefully to make sure PE does not refer to "physical exam" or "pulmonary embolism".

Prolonged Exposure (PE)—Group Therapy (Combined with Individual)

If the title or body of the note says "PE Session #n", and is a group session, consider it PE-group therapy.

Same criteria as listed in PE-individual therapy above, but note is clearly referring to a PE-*group* therapy session.

Do not annotate as PE unless it is clearly only PE and not combined with DBT or some other modality. Only capture PE group for notes that indicate *both* imaginal and in vivo components were present, and another modality was not be used concurrently.

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