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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<br>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., 5.7 to 6.3-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 examined the association between PTS symptom improvement and three treatment profiles (no EBP, early EBP use and delayed EBP use, defined as greater than one year). Using random effects logistic regression, we found that earlier EBP initiation was a strong predictor of PTSD improvement. Among the EBP group, decreased odds of improvement were seen in African-Americans, those who were prescribed medications, and had pain diagnoses and depression. There are some modifiable factors associated with treatment improvement, (timing of treatment, medications) that can be used to improve EBP care. |                             |                              |                                                |                                                                       |                                            |
| 15. SUBJECT TERMS<br>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—100% completed

**TASK 4.** Finalize study requirements, prepare for future funding, and dissemination of findings—80% completed (we are working on finalizing two last manuscripts)

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

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

To date, several milestones identified in the SOW were achieved to support the major goals. The following are subtasks that have been achieved as specified in Task 1-Update and merge existing data and datasets: IRB protocols were approved (**subtask 1a**), scientific approvals were obtained (**subtask 1b**), study staff were hired (**subtask 1c**), VA OEF/OIF/OND Roster was obtained from VA Central Office (**subtask 1d**), Roster was merged with VA National Patient Care Database and Corporate Data Warehouse (CDW) (**subtasks 1g, 1e**), the study sample was identified based on eligibility criteria (**subtask 1f**), and we extracted all relevant psychotherapy notes for all PTS visits (**subtask 1i**). We identified PCL measures (recorded in structured data) and, separately, we developed an NLP system to extract PCL scores from the unstructured text documents. It was validated to obtain a 98% positive predictive value. We then combined these PCL results with the set of PCL scores recorded in structured data and aligned the PCL data with the patients' outpatient psychotherapy billed visits in order to get an estimate of number of psychotherapy visits with corresponding PCL data (**subtasks 1j, 1k**) and identified those with multiple PTS and suicide measures for analysis (**subtasks 1h, subtask 1k**).

For Task 2-Use NLP to evaluate clinical notes, we performed seven annotation projects and annotated over 11,935 documents, 1297 of which were annotated by four people (quadruple-annotated) and 7,226 were double annotated (**subtasks 2a-2f**). We created an NLP system to analyze narrative text of the psychotherapy notes to determine the type of psychotherapy that the documents describe. During this time period it became clear that ARC was not the tool best suited to meet our research goals (**subtask 2b**: "Use the Automated Retrieval Console (ARC) algorithm designed to identify CPT and PE notes"). After consultation with the team, we moved to an updated NLP platform with improved performance and efficiency. Table 1 outlines the performance characteristics of the developed NLP system (**subtask 3a**). Please also see attached published manuscript for more information.

**Table 1. Performance characteristics of the developed NLP system**

| Document Classes  | TP  | Total NLP | Total Test set | PPV   | Sensitivity |
|-------------------|-----|-----------|----------------|-------|-------------|
| CPT_Group         | 303 | 328       | 319            | 0.924 | 0.950       |
| CPT_Individual    | 301 | 329       | 326            | 0.915 | 0.923       |
| Not_Psychotherapy | 241 | 260       | 267            | 0.927 | 0.903       |
| Other             | 221 | 260       | 269            | 0.850 | 0.822       |
| PE                | 315 | 330       | 326            | 0.955 | 0.966       |

Given that we met our performance standards for the algorithm, we were able to apply it to all the notes to determine which Veterans have completed EBT for PTS (**subtask 2g**). We then further refined the PTS cohort to the set of patients who will be included in main analyses, i.e., post-deployment mental health outpatient (MHO) visit at least one year prior to end of our study period with non-compensation and pension psychotherapy clinical notes available in VA data (**subtasks 2h and 3b**), as part of the process of combining the administrative and NLP-derived datasets to create the analytical cohort (**subtask 3b**).

To compare the effectiveness of evidence-based psychotherapy for PTS in Veterans (**Aim 1; subtasks 3c and 3d**), we used an approach that mimics a sequence of randomized trials (see Figure 1 Flow Chart), one trial beginning each month of the study period. We implemented propensity score models to achieve covariate balance, using matching (Appendix Tables A1-A3 present mean standardized differences for confounders for the matched samples). 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 of 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. To be able to include both versions of the PTSD Checklist (PCL; PTS outcome measure) in the same analysis, we converted PCL-C (PCL for DSM-IV) and PCL-5 (PCL for DSM-5) scores to z-scores (based on empirical baseline distributions). Our analyses targeted the observational

analogue of an intent-to-treat (ITT) analysis and a complete adherence analysis, for each of three treatment definition comparisons, as follows: CPT (individual or group) vs. non-EBP, PE vs non-EBP, and PE vs. CPT individual. After propensity score matching (**subtask 3d; see Appendix Tables A1-3 describing covariate balance in the matched samples**), we conducted the outcome analysis of change in PCL by treatment group, weighted by IPW and IPCW, with 95% confidence intervals from 500 bootstrapped samples. Figure 2 shows the mean PCL z-score at baseline and follow-up (6 months) for each of the six comparative effectiveness analyses.

Table 2 (below) presents the estimated treatment effects (difference-in-difference) for each of the six comparisons. The effect of CPT (individual or group) initiation was a 3.6 point (on PCL-C scale) greater improvement compared to non-EBP (95% CI: 2.1, 4.7), and the effect of completing 8 or more sessions of CPT was a 6.33 point (on PCL-C scale) greater improvement compared to non-EBP (95%CI: 4.6, 8.0). The effect of PE initiation was a 3.5 point (on PCL-C scale) greater improvement compared to non-EBP (95% CI: 1.9, 4.9), and the effect of completing 8 or more sessions of PE was a 5.7 point (on PCL-C scale) greater improvement compared to non-EBP (95%CI: 2.9, 8.4). The head-to-head comparison of PE to CPT (individual) showed similar effects on treatment initiation (PE vs. CPT: 0.6 point improvement on PCL-C scale, 95% CI: -2.9, 1.5) and treatment completion (PE vs. CPT: 1.3 point improvement on PCL-C scale, 95% CI: -1.4, 4.2). **In summary, Veterans with PTS receiving either CPT (group or individual) or PE experience a greater reduction (at least 3.5 points on PCL-C) in symptoms compared to those receiving non-EBP treatment, and both CPT (individual) and PE have very similar effects, on average.**

Table 2. Treatment Effect of Evidence Based Psychotherapy for PTS in VHA (Difference-in-Difference Analysis)

| Emulated Trial                               | Initiation/ITT Effect (95% CI) | Initiation Effect on PCL-C scale (for reference) | Completer Effect (95% CI) | Completer Effect on PCL-C scale (for reference) |
|----------------------------------------------|--------------------------------|--------------------------------------------------|---------------------------|-------------------------------------------------|
| <b>CPT (individual or group) vs. non-EBP</b> | -0.27 (-0.36,-0.19)            | -3.63 (-4.73, -2.05)                             | -0.48 (-0.60, -0.35)      | -6.33(-7.96,-4.64)                              |
| <b>PE vs. non-EBP</b>                        | -0.26 (-0.37,-0.14)            | -3.45(-4.91,-1.86)                               | -0.426 (-0.63,-0.22)      | -5.65 (-8.35,-2.92)                             |
| <b>PE vs. CPT individual</b>                 | 0.046 (-0.114,0.216)           | 0.61(-1.51,2.86)                                 | -0.101 (-0.315,0.107)     | -1.34 (-4.18,1.42)                              |

\*Effect is difference between propensity-score matched treatment and control group in change in z-scored PCL, weighted by inverse probability of having follow-up PCL. The complete adherence effect additionally accounted for treatment switching or lack of adherence using inverse probability of censoring weights. A negative value means treatment group had greater improvement (decrease) in symptoms than the control group, e.g., CPT completers had a 0.478 greater decrease in z-score (or, 6.3 points on PCL-C scale) compared to the non-EBT group

Figure 1. Consort diagram of sample selection showing number of person-trials with number of unique patients in parentheses.

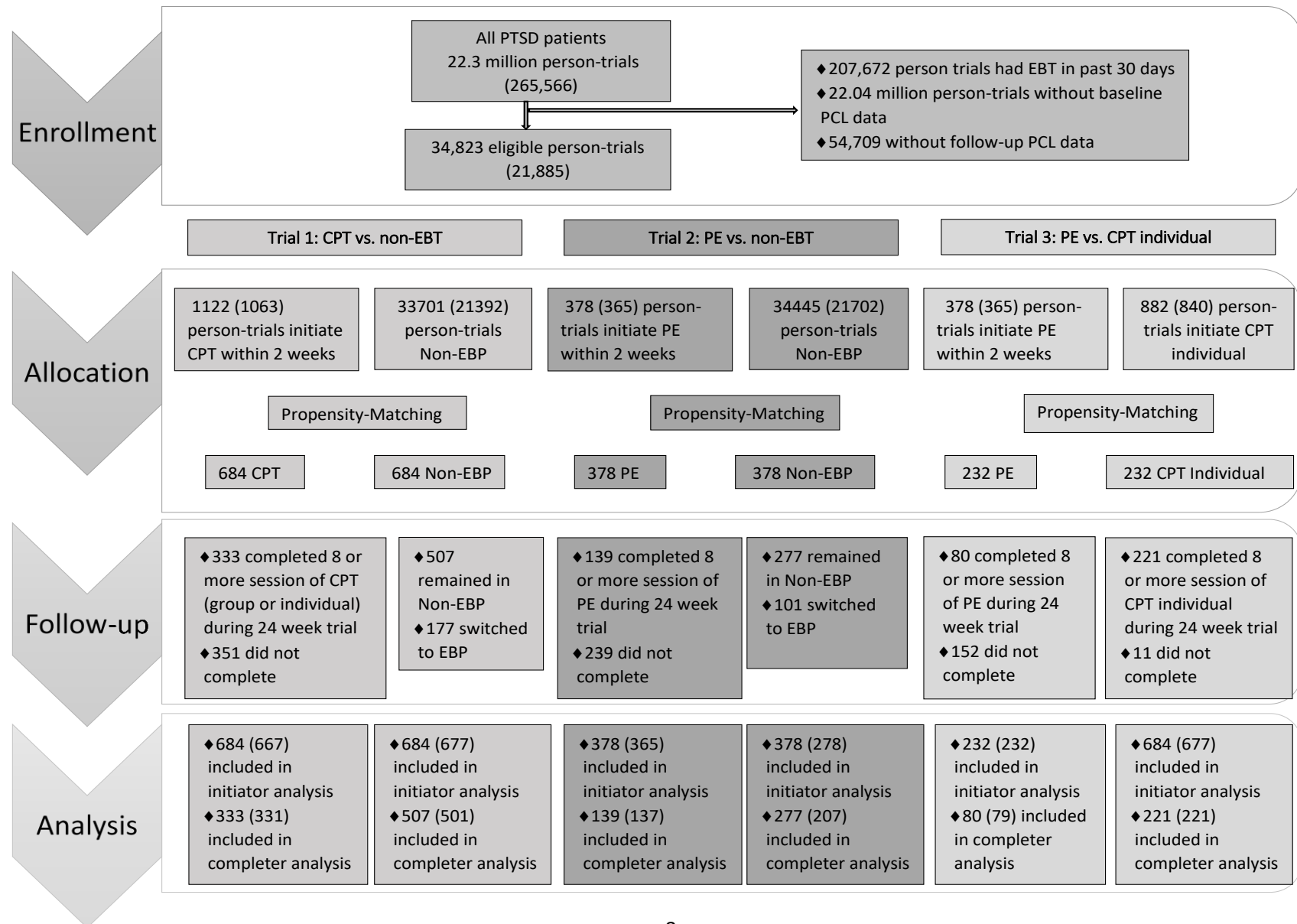
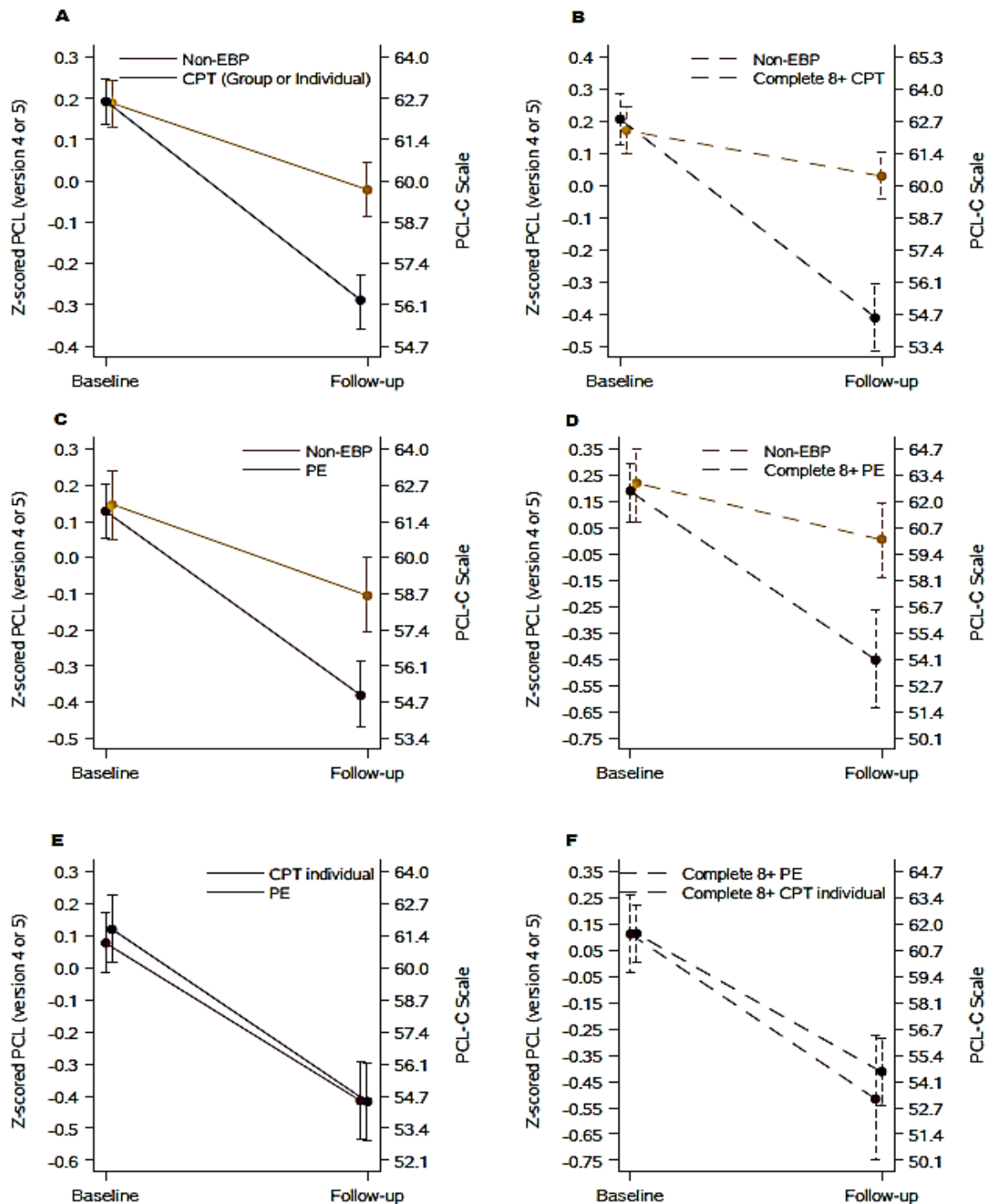


Figure 2. Line figures of Z-scored PCL at baseline and follow-up by treatment group. Patients who initiated EBP within 2 weeks of baseline were matched to non-EBP controls (propensity score matching) and the resulting matched sample was weighted by inverse probability of follow-up. Figures A, C and E are analogous to an ITT analyses, where patients in the treatment group may not have perfect adherence to their assigned treatment. Figure B, D and F are analogous to a complete adherence analysis, where patients who deviated from their assigned treatment strategy were artificially censored and the uncensored patients were weighted by inverse probability of censoring.



We conducted a sensitivity analysis for treatment effect on PCL outcomes (**subtasks 3c and 3d** using the cloning/censoring/weighting approach (BMJ 2018;360:k182 | doi: 10.1136/bmj.k182; Journal of Clinical Epidemiology 96 (2018) 12e22, <https://doi.org/10.1016/j.jclinepi.2017.11.021>), as described in the Appendix. The treatment definitions in the sensitivity analyses are slightly different, in particular, patients (clones) assigned to EBP were allowed to initiate treatment at any point during trial (not restricted to first two weeks). Results were qualitatively similar to those reported above using propensity-matched approach, with CPT and PE out-performing non-EBP care, except the effect of PE was found to be slightly larger than that of CPT (individual), (PE completers had a 3.3 point (PCL-C scale) greater improvement than CPT individual completers (95% CI: 2.6, 10.6)(Appendix Table A5).

For the suicidality outcome analyses (**subtask 3c-3d**), we used a similar ‘sequence of trials’ approach as described above for PCL outcome. The sample was restricted to those with data on suicidality at baseline (up to 6 months prior) and at follow-up (N person-trials=403,217). In preliminary analyses, comparing initiators of PE to non-EBP, similar changes in risk for suicidal thoughts (ratio of within-group odds-ratios for follow-up vs. baseline: 1.01 95% CI: 0.93, 1.08) were observed. The change in risk of suicidal thoughts among those who initiated CPT (individual or group) was equivalent to that seen in the non-EBP care group (ratio of within-group odds ratios for follow-up vs. baseline: 1.03 95% CI: 0.98, 1.07).

Next, we examined factors associated with completing PE and CPT for PTSD among a cohort of 265,566 veterans (**Aim 2**). In this published manuscript (see attached), we measured three hierarchical outcomes related to utilization of PE and CPT (individual or group) during any 24-week period: (1) receipt of eight or more sessions of PE or CPT; (2) receipt of 1–7 sessions of PE/CPT; and (3) no PE/CPT treatment. An additional outcome is time from first mental health visit to completion of the first full-dose of PE or CPT. To assess whether statistically significant differences exist between groups, we used Kruskal Wallis tests or Mann-Whitney tests for continuous variables and Chi-Square or Fisher's Exact tests for categorical variables. We used log rank tests to compare the survival distributions of different groups. We conducted regression analyses focused on three outcome variables: (1) ordered logistic regressions for the three-category outcome variable: no EBP, early termination, or EBP completers in any 24 weeks during follow-up; (2) binary logistic regressions for EBP completers vs. early terminators; and (3) Cox proportional hazards regressions for time to completion of the first PE/CPT. In regression analyses, we considered  $p < 0.001$  as statistically significant.

We found that 5,154 veterans (1.9%) completed PE and 12,782 (4.8%) were early terminators during any 24-week period (Appendix Table A6) (**subtask 3e**). In addition to being older and more educated, those who completed PE were more likely to be African-American, Officers, and National Guard or Reservists. The largest differences between those who initiated PE and those who did not were that initiators were more likely to be married and have multiple deployments, military sexual trauma, medications, and a history of pain, TBI, depression, alcohol abuse or dependence, drug abuse or dependence, and suicide ideation or attempt. In addition, those who initiated PE were more likely to live in an urban area, be service connected, and have served in a combat zone. Appendix Table A7 shows factors associated with the PE outcome (**subtask 3f**). The odds of completing progressively larger numbers of PE treatment sessions were greater for those in their 30s and 40s, African-Americans, married individuals, Reservists,

Officers, those serving in a combat zone, those with multiple deployments, those with military sexual trauma, non-smokers or those without schizophrenia or bipolar diagnosis, those with a history of pain, TBI, depression, alcohol abuse or dependence, or suicide ideation or attempt, and those who entered VA mental health treatment after 2005, lived in urban areas, or were service connected. Appendix Table A8 shows factors associated with shorter time to completion of PE from VA mental health entry, based on a Cox proportional hazards model. Patients completed PE in less time if they were in their 30's and 40's, African-American, married individuals (relative to the divorced, separated or single), Reservists, Officers, had multiple deployments, experienced military sexual trauma, took medications, had no diagnosis of schizophrenia, had a history of pain, TBI, depression or suicide ideation or attempt, entered VA mental health care after 2005, were service connected or served in a combat zone.

As shown in Appendix Table A8, 19,607 veterans (7.4%) completed CPT and 29,006 (10.9%) were early terminators during any 24-week period. In addition to being older and more educated, those who completed CPT were more likely to be African-American, National Guard or Reservists, and Officers. The largest differences between those who initiated CPT and those who did not were that initiators were more likely to be women, or to report military sexual trauma, or to take medication, or have a history of bipolar, psychosis, pain, TBI, depression, alcohol abuse or dependence, drug abuse or dependence, or suicide ideation or attempt. In addition, patients who initiated CPT were more likely to be service connected or have served in a combat zone. Compared to those who terminated early, those who completed eight or more sessions were more likely to receive both individual and group formats of CPT. Appendix Table A9 shows factors associated with achievement of our hierarchal outcome categories (no CPT, early termination, or completion) during any 24-week period based on ordered logistic regression. The odds of completing progressively larger number of CPT treatment sessions were greater for people 30 years or older, non-Hispanics, married individuals, Reserve members, Officers, those who did not take medications, or were service connected, served in a combat zone, or received group format or both individual and group formats of CPT, relative to individual CPT. Appendix Table A10 shows factors associated with faster time to completion of CPT from VA mental health entry, based on a Cox proportional hazards model. Patients completed CPT in less time if they were 30 years or older, non-Hispanic, married, Reservists, Officers, or entered VA mental health care after 2005, served in a combat zone, or received group format or both individual and group formats of CPT, relative to individual format of CPT.

Next, we examined factors associated with PTSD symptom improvement in a cohort of 30,008 veterans who received mental health treatment and had  $\geq 1$  PTSD symptom measure(s) (**Aim 3**). PTSD symptom improvement was defined as at least 10 points reduction in PTSD Checklist (PCL) score from baseline. We examined profiles of those who completed an early EBP (within a year of first mental health visit), those who initiated a delayed EBP, and those who did not initiate EBP (**subtask 3g**). We compared demographic characteristics, military service characteristics, comorbidities, and prescription of medications recommended for treating PTSD between veterans who initiated an early EBP, those who initiated a delayed EBP, and those who did not initiate EBP. To identify statistically significant differences among the three groups, we used Kruskal Wallis test for continuous variables and Chi-Square or Fisher's Exact tests for categorical variables.

We fit a random effects logistic regression to compare PTSD symptom improvement in the early-EBP and delayed-EBP groups (any EBP) with the no-EBP group (model 1) (**subtask 3h**). Covariates of interest included demographic characteristics, military characteristics, comorbidities, MST history, history of smoking, and prescription of medication recommended to treat PTSD. Using the same method, we fit a second random effects logistic regression to compare PTSD symptom improvement in those that had engaged in EBP (model 2). When propensity score models were conducted as a sensitivity analysis, we found similar results as in our regression models for PTSD improvement (**subtask 3i**).

In separate regression models, we added interactions between comorbidities (depression, TBI, substance use disorder and pain) and EBP initiation groups in order to test whether veterans with complex comorbidities were less likely to achieve PTSD symptom improvement compared with those without complex comorbidities. In regression analyses, we considered  $p < 0.001$  as statistically significant.

Of the cohort of 30,008 veterans, 8,116 (27.1%) initiated EBP within one year of their first mental health visit, 5,314 (17.7%) initiated EBP at least one year after their first mental health visit, and 16,578 (55.3%) never initiated EBP (Table 3). At baseline, compared with veterans who never initiated EBP, those who initiated EBP were older, less likely to be white, more likely to be female, married, in the Navy, reservists, officers, and to have education levels higher than high school, multiple deployments and a history of military sexual trauma. Veterans who never initiated EBP were more likely to smoke in the year before their first mental health visit and take medications one year before or after their mental health visit. Compared with veterans who initiated an early EBP or never initiated EBP, those who initiated a delayed EBP had the highest burdens of all comorbid conditions, and on average, the largest number of comorbidities (2.93, SD: 1.94). The delayed-EBP group also had the highest mean PCL score at baseline (58.6, SD: 13.2).

Results of random effects logistic regressions were shown in Table 4. In model 1, both the early-EBP and delayed-EBP groups had increased odds of PTSD symptom improvement compared with the no-EBP group (respectively: OR=1.68, 95%CI: 1.59-1.77 and OR=1.28, 95%CI: 1.20-1.36). Females (OR=1.22, 95%CI: 1.11-1.35), those never married relative to the married (OR=1.14, 95%CI: 1.07-1.21), officers relative to the enlisted (OR=1.28, 95%CI: 1.13-1.45), and those with higher baseline PCL score (OR=1.08, 95%CI: 1.07-1.08) were associated with higher odds of PTSD symptom improvement. Decreased odds of PTSD symptom improvement were seen in African Americans (OR=0.73, 95%CI: 0.69-0.78), those who were prescribed medications (OR=0.90, 95%CI: 0.85-0.95), and those with pain diagnoses (OR=0.76, 95%CI: 0.72-0.80), TBI (OR=0.87, 95%CI: 0.82-0.93), or depression (OR=0.82, 95%CI: 0.78-0.87).

Model 2 was focused on comparing the early-EBP group with the delayed-EBP group while excluding the no-EBP group. The odds of PTSD symptom improvement were 1.31 times (95%CI: 1.22-1.40) as high for the early-EBP group as for the delayed-EBP group. Higher baseline PCL score continued to be associated with higher odds of improvement (OR=1.08, 95%CI: 1.07-1.08). Decreased odds of improvement were seen in older (OR=0.99, 95%CI: 0.98-1.00), African-Americans (OR=0.73, 95%CI: 0.66-0.80), those who

were prescribed medications (OR=0.81, 95%CI: 0.75-0.88), or had pain diagnoses (OR=0.69, 95%CI: 0.64-0.75).

Testing of interactions in model 1 showed that the timing of treatment did not differentially impact PTSD symptom improvement in those with TBI, compared to those without TBI (joint test of interaction,  $p=0.039$ ) and those with pain, compared to those without pain (joint test of interaction,  $p=0.001$ ). Testing of interactions in model 2 showed that the timing of treatment did not differentially impact PTSD symptom improvement in those with depression, compared to those without depression (joint test of interaction,  $p=0.018$ ) and those with pain, compared to those without pain (joint test of interaction,  $p=0.003$ ).

Table 3. Baseline Characteristics of Veterans (n=30,008)

|                                              | <b>Early EBP<br/>N=8,116 (27.1%)</b> | <b>Delayed EBP<br/>N=5,314 (17.7%)</b> | <b>No EBP<br/>N=16,578 (55.3%)</b> | <b>P</b> |
|----------------------------------------------|--------------------------------------|----------------------------------------|------------------------------------|----------|
| <b>Baseline Age</b>                          | 34.1 (8.9)                           | 33.0 (8.5)                             | 32.7 (8.5)                         | <0.001   |
| <b>Gender</b>                                |                                      |                                        |                                    | <0.001   |
| Male                                         | 7,144 (88.0%)                        | 4,786 (90.1%)                          | 15,219 (91.8%)                     |          |
| Female                                       | 972 (12.0%)                          | 528 (9.9%)                             | 1,359 (8.2%)                       |          |
| <b>Race</b>                                  |                                      |                                        |                                    | 0.001    |
| White                                        | 5,783 (71.3%)                        | 3,753 (70.6%)                          | 11,996 (72.4%)                     |          |
| Black or African American                    | 1,326 (16.3%)                        | 883 (16.6%)                            | 2,439 (14.7%)                      |          |
| American Indian or Alaska Native             | 94 (1.2%)                            | 85 (1.6%)                              | 192 (1.2%)                         |          |
| Asian                                        | 176 (2.2%)                           | 107 (2.0%)                             | 342 (2.1%)                         |          |
| Native Hawaiian or<br>Other Pacific Islander | 123 (1.5%)                           | 91 (1.7%)                              | 270 (1.6%)                         |          |
| Multi-races                                  | 101 (1.2%)                           | 85 (1.6%)                              | 233 (1.4%)                         |          |
| Missing                                      | 513 (6.3%)                           | 310 (5.8%)                             | 1,106 (6.7%)                       |          |
| <b>Ethnicity</b>                             |                                      |                                        |                                    | 0.492    |
| Hispanic or Latino                           | 1,045 (12.9%)                        | 753 (14.2%)                            | 2,221 (13.4%)                      |          |
| Not Hispanic or Latino                       | 6,767 (83.4%)                        | 4,356 (82.0%)                          | 13,719 (82.8%)                     |          |
| Other                                        | 198 (2.4%)                           | 138 (2.6%)                             | 429 (2.6%)                         |          |
| Missing                                      | 106 (1.3%)                           | 67 (1.3%)                              | 209 (1.3%)                         |          |
| <b>Marital status</b>                        |                                      |                                        |                                    | 0.003    |
| Married                                      | 4,454 (54.9%)                        | 2,838 (53.4%)                          | 8,753 (52.8%)                      |          |
| Never married                                | 1,811 (22.3%)                        | 1,149 (21.6%)                          | 3,769 (22.7%)                      |          |
| Divorced/separated/single                    | 1,682 (20.7%)                        | 1,241 (23.4%)                          | 3,754 (22.6%)                      |          |
| Widow/Widower/widowed                        | 16 (0.2%)                            | 7 (0.1%)                               | 28 (0.2%)                          |          |
| Missing                                      | 153 (1.9%)                           | 79 (1.5%)                              | 274 (1.7%)                         |          |
| <b>Education</b>                             |                                      |                                        |                                    | <0.001   |
| <HS diploma                                  | 79 (1.0%)                            | 53 (1.0%)                              | 201 (1.2%)                         |          |
| HS diploma                                   | 6,566 (80.9%)                        | 4,461 (84.0%)                          | 14,064 (84.8%)                     |          |
| Some college                                 | 712 (8.8%)                           | 409 (7.7%)                             | 1,250 (7.5%)                       |          |
| Baccalaureate                                | 499 (6.2%)                           | 272 (5.1%)                             | 722 (4.4%)                         |          |
| Post Baccalaureate                           | 158 (2.0%)                           | 53 (1.0%)                              | 173 (1.0%)                         |          |

|                                                                    | <b>Early EBP<br/>N=8,116 (27.1%)</b> | <b>Delayed EBP<br/>N=5,314 (17.7%)</b> | <b>No EBP<br/>N=16,578 (55.3%)</b> | <b>P</b> |
|--------------------------------------------------------------------|--------------------------------------|----------------------------------------|------------------------------------|----------|
| Unknown                                                            | 102 (1.3%)                           | 66 (1.2%)                              | 168 (1.0%)                         |          |
| <b>Service branch</b>                                              |                                      |                                        |                                    | <0.001   |
| Air force                                                          | 606 (7.5%)                           | 263 (5.0%)                             | 994 (6.0%)                         |          |
| Army                                                               | 5,384 (66.3%)                        | 3,840 (72.3%)                          | 11,708 (70.6%)                     |          |
| Coast Guard                                                        | 3 (0.04%)                            | 1 (0.02%)                              | 7 (0.04%)                          |          |
| Marine                                                             | 1,461 (18.0%)                        | 818 (15.4%)                            | 2,765 (16.7%)                      |          |
| Navy                                                               | 662 (8.2%)                           | 392 (7.4%)                             | 1,104 (6.7%)                       |          |
| <b>Component</b>                                                   |                                      |                                        |                                    | 0.001    |
| Active Duty (regular)                                              | 5,594 (68.9%)                        | 3,689 (69.4%)                          | 11,711 (70.6%)                     |          |
| Guard                                                              | 1,516 (18.7%)                        | 996 (18.7%)                            | 3,110 (18.8%)                      |          |
| Reserve                                                            | 1,006 (12.4%)                        | 629 (11.8%)                            | 1,757 (10.6%)                      |          |
| <b>Rank</b>                                                        |                                      |                                        |                                    | <0.001   |
| Enlisted                                                           | 7,651 (94.3%)                        | 5,120 (96.4%)                          | 15,996 (96.5%)                     |          |
| Officer                                                            | 409 (5.0%)                           | 173 (3.3%)                             | 502 (3.0%)                         |          |
| Warrant                                                            | 56 (0.7%)                            | 21 (0.4%)                              | 80 (0.5%)                          |          |
| <b>Number of Deployments</b>                                       |                                      |                                        |                                    | 0.002    |
| Single deployment                                                  | 3,802 (46.9%)                        | 2,593 (48.8%)                          | 8,189 (49.4%)                      |          |
| Multiple deployments                                               | 4,280 (52.7%)                        | 2,702 (50.9%)                          | 8,341 (50.3%)                      |          |
| Missing                                                            | 34 (0.4%)                            | 19 (0.4%)                              | 48 (0.3%)                          |          |
| <b>Military sexual trauma</b>                                      | 667 (8.2%)                           | 422 (7.9%)                             | 897 (5.4%)                         | <0.001   |
| <b>Smoking 1 year before index date</b>                            | 651 (8.0%)                           | 458 (8.6%)                             | 1,602 (9.7%)                       | <0.001   |
| <b>Took medication in 1 year before or 1 year after index date</b> | 6,144 (75.7%)                        | 4,000 (75.3%)                          | 12,951 (78.1%)                     | <0.001   |
| <b>Comorbidities</b>                                               |                                      |                                        |                                    |          |
| Schizophrenia                                                      | 56 (0.7%)                            | 63 (1.2%)                              | 155 (0.9%)                         | 0.012    |
| Bipolar                                                            | 741 (9.1%)                           | 777 (14.6%)                            | 1,878 (11.3%)                      | <0.001   |
| Psychosis                                                          | 126 (1.6%)                           | 162 (3.1%)                             | 394 (2.4%)                         | <0.001   |
| Pain                                                               | 5,899 (72.7%)                        | 4,322 (81.3%)                          | 12,110 (73.1%)                     | <0.001   |
| TBI                                                                | 1,345 (16.6%)                        | 1,078 (20.3%)                          | 2,473 (14.9%)                      | <0.001   |
| Depression                                                         | 5,121 (63.1%)                        | 3,843 (72.3%)                          | 10,537 (63.6%)                     | <0.001   |
| Alcohol abuse                                                      | 1,611 (19.9%)                        | 1,513 (28.5%)                          | 3,594 (21.7%)                      | <0.001   |
| Alcohol dependence                                                 | 1,162 (14.3%)                        | 1,198 (22.5%)                          | 2,482 (15.0%)                      | <0.001   |
| Drug abuse                                                         | 792 (9.8%)                           | 955 (18.0%)                            | 1,955 (11.8%)                      | <0.001   |
| Drug dependence                                                    | 615 (7.6%)                           | 778 (14.6%)                            | 1,465 (8.8%)                       | <0.001   |
| Suicide ideation and attempt                                       | 865 (10.7%)                          | 887 (16.7%)                            | 1,792 (10.8%)                      | <0.001   |
| <b>Total # comorbidities</b>                                       | 2.26 (1.67)                          | 2.93 (1.94)                            | 2.34 (1.68)                        | <0.001   |
| <b>Baseline PCL score (mean, std)</b>                              | 60.2 (12.2)                          | 58.6 (13.2)                            | 58.7 (13.0)                        | <0.001   |

Table 4. Random effects logistic regressions (for 10+ units of PCL reduction from baseline)

|                                              | <b>Model 1</b>    |          | <b>Model 2</b>    |          |
|----------------------------------------------|-------------------|----------|-------------------|----------|
|                                              | <b>OR (95%CI)</b> | <b>P</b> | <b>OR (95%CI)</b> | <b>P</b> |
| <b>Group</b>                                 |                   |          |                   |          |
| No EBP                                       | ref               | ref      | -                 | -        |
| Early EBP                                    | 1.68 (1.59-1.77)  | <0.001   | 1.31 (1.22-1.40)  | <0.001   |
| Delayed EBP                                  | 1.28 (1.20-1.36)  | <0.001   | ref               | ref      |
| <b>Baseline age</b>                          | 1.00 (0.99-1.00)  | 0.008    | 0.99 (0.98-1.00)  | <0.001   |
| <b>Female</b>                                | 1.22 (1.11-1.35)  | <0.001   | 1.25 (1.09-1.43)  | 0.001    |
| <b>Race</b>                                  |                   |          |                   |          |
| White                                        | ref               | ref      | ref               | ref      |
| Black or African American                    | 0.73 (0.69-0.78)  | <0.001   | 0.73 (0.66-0.80)  | <0.001   |
| American Indian or Alaska Native             | 0.69 (0.56-0.86)  | 0.001    | 0.77 (0.57-1.03)  | 0.081    |
| Asian                                        | 0.77 (0.65-0.90)  | 0.001    | 0.69 (0.55-0.87)  | 0.002    |
| Native Hawaiian or<br>Other Pacific Islander | 0.78 (0.66-0.94)  | 0.007    | 0.76 (0.58-0.98)  | 0.038    |
| Multi-races                                  | 0.78 (0.64-0.95)  | 0.013    | 0.89 (0.67-1.18)  | 0.406    |
| Missing                                      | 0.82 (0.74-0.90)  | <0.001   | 0.80 (0.70-0.93)  | 0.003    |
| <b>Marital Status</b>                        |                   |          |                   |          |
| Married                                      | ref               | ref      | ref               | ref      |
| Never married                                | 1.14 (1.07-1.21)  | <0.001   | 1.10 (1.00-1.20)  | 0.041    |
| Divorced, separated or single                | 1.00 (0.94-1.06)  | 0.924    | 1.00 (0.92-1.09)  | 0.949    |
| Widowed or widower                           | 0.99 (0.58-1.70)  | 0.974    | 0.84 (0.38-1.83)  | 0.654    |
| Missing                                      | 1.10 (0.92-1.31)  | 0.313    | 1.09 (0.84-1.41)  | 0.517    |
| <b>Service branch</b>                        |                   |          |                   |          |
| Air force                                    | ref               | ref      | ref               | ref      |
| Army                                         | 0.96 (0.88-1.06)  | 0.459    | 0.94 (0.82-1.08)  | 0.386    |
| Coast Guard                                  | 0.62 (0.18-2.20)  | 0.464    | 1.10 (0.18-6.91)  | 0.918    |
| Marine                                       | 0.95 (0.85-1.06)  | 0.322    | 0.92 (0.78-1.07)  | 0.284    |
| Navy                                         | 0.98 (0.87-1.11)  | 0.796    | 0.97 (0.81-1.16)  | 0.731    |
| <b>Component</b>                             |                   |          |                   |          |
| Active Duty (regular)                        | ref               | ref      | ref               | ref      |
| Guard                                        | 1.07 (1.01-1.14)  | 0.034    | 1.05 (0.96-1.16)  | 0.279    |
| Reserve                                      | 1.08 (1.00-1.16)  | 0.059    | 1.10 (0.99-1.22)  | 0.089    |
| <b>Rank</b>                                  |                   |          |                   |          |
| Enlisted                                     | ref               | ref      | ref               | ref      |
| Officer                                      | 1.28 (1.13-1.45)  | <0.001   | 1.33 (1.13-1.57)  | 0.001    |
| Warrant                                      | 1.27 (0.93-1.73)  | 0.134    | 1.47 (0.95-2.27)  | 0.086    |
| <b>Number of Deployments</b>                 |                   |          |                   |          |
| Single deployment                            | ref               | ref      | ref               | ref      |
| Multiple deployments                         | 1.05 (1.00-1.10)  | 0.052    | 1.04 (0.97-1.12)  | 0.219    |
| Missing                                      | 0.84 (0.56-1.24)  | 0.378    | 0.98 (0.57-1.69)  | 0.936    |
| <b>Military sexual trauma</b>                | 1.01 (0.90-1.12)  | 0.902    | 1.05 (0.91-1.23)  | 0.484    |
| <b>Smoking</b>                               | 1.03 (0.95-1.12)  | 0.431    | 0.94 (0.83-1.07)  | 0.368    |
| <b>Medication</b>                            | 0.90 (0.85-0.95)  | <0.001   | 0.81 (0.75-0.88)  | <0.001   |

|                             | Model 1          |        | Model 2          |        |
|-----------------------------|------------------|--------|------------------|--------|
|                             | OR (95%CI)       | P      | OR (95%CI)       | P      |
| Schizophrenia               | 1.27 (0.99-1.62) | 0.063  | 1.37 (0.95-1.98) | 0.095  |
| Bipolar                     | 1.07 (0.99-1.15) | 0.084  | 1.07 (0.96-1.19) | 0.218  |
| Psychosis                   | 0.85 (0.73-1.00) | 0.051  | 0.77 (0.61-0.98) | 0.033  |
| Pain                        | 0.76 (0.72-0.80) | <0.001 | 0.69 (0.64-0.75) | <0.001 |
| TBI                         | 0.87 (0.82-0.93) | <0.001 | 0.91 (0.83-0.99) | 0.035  |
| Depression                  | 0.82 (0.78-0.87) | <0.001 | 0.78 (0.73-0.84) | <0.001 |
| Alcohol abuse               | 0.95 (0.89-1.01) | 0.092  | 0.97 (0.89-1.07) | 0.579  |
| Alcohol dependence          | 1.00 (0.93-1.07) | 0.915  | 0.94 (0.85-1.05) | 0.285  |
| Drug abuse                  | 1.07 (0.98-1.17) | 0.133  | 1.05 (0.92-1.19) | 0.485  |
| Drug dependence             | 0.93 (0.84-1.02) | 0.135  | 0.94 (0.81-1.08) | 0.360  |
| Suicide ideation or attempt | 0.97 (0.89-1.04) | 0.380  | 0.95 (0.85-1.06) | 0.360  |
| Baseline PCL score          | 1.08 (1.07-1.08) | <0.001 | 1.08 (1.07-1.08) | <0.001 |

Note: Model 1 compares PTSD symptom improvement in the early-EBP and delayed-EBP groups (any EBP) with the no-EBP group. Model 2 compares PTSD symptom improvement in the early-EBP group with the delayed-EBP group.

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

Although not an explicit goal of this study, this project has provided multiple opportunities for training and professional development. First, our project coordinator (Callan Lujan) who was recently accepted into a PhD program for clinical psychology, assisted with several of the manuscripts and was able to be a co-author on several publications and presentations. Second, our research fellow (Nicholas Holder) also learned a great deal from the current project and took the lead on two conference presentations and a submitted paper. We were also able to teach many of our colleagues about NLP and share our findings, most recently this week during a local research week presentation at SFVAHCS and UCSF.

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

In addition to completing this final report (**subtask 4a**), we have disseminated of our findings through our recently published papers (**subtask 4d**):

1. 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, 45, 519-529.

2. Maguen, S., Li, Y., Madden, E., Seal, K., Neylan, T., Patterson, O.V., DuVall, S.L., Lujan, C., & Shiner B. Factors Associated with Completing Evidence-Based Psychotherapy for PTSD among Veterans in a National Healthcare System. *Psychiatry Research*, 274, 112-128

We have the following papers currently under review:

1. Holder, N., Shiner, B., Li, Y., Madden, E., Neylan, T., Seal, K., Lujan, C., Patterson, O., DuVall, S., Maguen, S. (Under Review). Timing of Evidence-Based Psychotherapy for Posttraumatic Stress Disorder Initiation in the Veterans Health Administration. *Psychological Trauma: Theory, Research, Practice, and Policy*
2. Maguen, S., Holder, N., Madden, Li, Y., Seal, K.H., Neylan, T.C., Lujan, C., Patterson, O., DuVall, S., and Shiner, B. (Under review). Evidence-based Psychotherapy Trends among Posttraumatic Stress Disorder Patients in a National Healthcare System, 2001-2014. *American Journal of Psychiatry*

We are preparing the following papers for publication:

1. Maguen, S., Holder, N., Shiner, B., Li, Y., Madden, E., Neylan, T., Seal, K., Lujan, C., Patterson, O., DuVall, S., Shiner, B. (In Prep). Factors Associated with PTSD Symptom Improvement among Iraq and Afghanistan Veterans Receiving Evidenced-Based Psychotherapy
2. Maguen, S., Madden, E., Holder, N., Li, Y., Neylan, T., Seal, K., Lujan, C., Patterson, O., DuVall, S., Shiner, B. (In Prep) Comparative effectiveness of evidence-based psychotherapy in Veterans with PTSD utilizing natural language processing of electronic health records.

We have presented the following at various conferences (**subtask 4c**):

1. Maguen, S., Li, Y. Madden, E., Li, Y., Patterson, O.V., DuVall, S.L., & Shiner B. (2018, August). Military Sexual Trauma and Evidence-Based Psychotherapy in Iraq and Afghanistan Veterans With PTSD. Paper presented at the Annual Meeting of the American Psychological Association, San Francisco, CA.
2. Maguen, S., Madden, E., Li, Y., Patterson, O.V., DuVall, S.L., & Shiner B. (2018, November). Using Natural Language Processing to Examine National Trends of Evidence-Based Psychotherapies for PTSD in the VA. Paper presented at the International Society of Traumatic Stress Studies' (ISTSS) Annual Conference in Washington D.C.

3. Holder, N., Shiner, B., Li, Y., Madden, E., Neylan, T., Seal, K., Lujan, C., Patterson, O., DuVall, S., & Maguen, S. (2019, April). Providing evidence-based psychotherapy for posttraumatic stress disorder to veterans with a history of suicidal ideation and/or attempt. Paper presented at the American Association for Suicidology Annual Meeting, Denver, CO.

Submitted and accepted abstracts to be presented this month:

1. Holder, N., Li, Y., Madden, E., Shiner, B. R., Lujan, C., Neylan, T. C., Patterson, O., DuVall, S., & Maguen, S. (2019, May). Timing of initiation of evidence-based psychotherapy for posttraumatic stress disorder among Veterans in the Veterans Health Administration. Poster to be presented at the American Psychiatric Association Annual Meeting, San Francisco, CA.

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

Nothing to report.

**4. IMPACT:**

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

The impact of this project has been far-reaching. First, we have been contacted by multiple investigators who are interested in the algorithm that we developed to identify CPT and PE in the electronic medical records because they wanted to use it in order to further research on evidence-based psychotherapies. We have been in multiple discussions to figure out collaborations where we could work together to apply for DoD funding to further some of these research questions. We have been contacted by five separate research groups and are in discussion with investigators from the National Center for PTSD, planning for future collaboration. We are discussing other collaborations as well.

Second, we have been approached each time we present our work, and are told how this information has not previously been available and is very helpful for clinicians and researchers in the mental health field. Prior to our work, there was not a way for researchers to identify CPT and PE in the medical records for over a decade since these treatments were implemented in the VA. Furthermore, there was not any information about whether these treatments were useful outside of clinical trials or how many people completed minimally adequate doses of these treatments, as well as the factors associated with completion. Finally, there was no information available on factors associated with improvement from

these treatments. We have been able to provide many of these answers to clinicians and researchers and help stimulate further research in this area, now that appropriate tools are available to answer some of the pressing and clinically relevant research questions.

**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. These tools help with accessibility to previously unavailable data for a range of other studies in a wide range of disciplines. For example, a researcher in another discipline may want to better understand the association between EBPs and diabetes or EBPs and cardiac outcomes, and our algorithm can help with those research questions. Similarly, while before the availability of PCL scores were low due to clinicians who put the score in the notes rather than enter it through the data systems through which the information could be pulled, we have now removed this barrier for anyone across fields who want to increase the number of PCLs in their VA data.

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

The algorithms that we developed can assist with better being able to identify those who engage in particular types of psychotherapy and PTSD measures, benefitting VA, DoD, and academia.

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

Nothing to report.

**5. CHANGES/PROBLEMS:**

Nothing to report.

**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 two articles:

1. 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, 45, 519-529.

2. Maguen, S., Li, Y., Madden, E., Seal, K., Neylan, T., Patterson, O.V., DuVall, S.L., Lujan, C., & Shiner B. Factors Associated with Completing Evidence-Based Psychotherapy for PTSD among Veterans in a National Healthcare System. Psychiatry Research, 274, 112-128

In addition to these products, we have submitted an initial request for information for a follow-up JWMPR 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?

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

|                                               |                                                                                                                                                                                                                                                   |
|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Name:</i>                                  | <i>Brian Shiner</i>                                                                                                                                                                                                                               |
| <i>Project Role:</i>                          | <i>Co-investigator, White River Junction VAMC</i>                                                                                                                                                                                                 |
| <i>Researcher Identifier (e.g. ORCID ID):</i> | <i>N/A</i>                                                                                                                                                                                                                                        |
| <i>Nearest person month worked:</i>           | <i>1.5</i>                                                                                                                                                                                                                                        |
| <i>Contribution to Project:</i>               | <i>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.</i> |

|                                               |                     |
|-----------------------------------------------|---------------------|
| <i>Name:</i>                                  | <i>Erin Madden</i>  |
| <i>Project Role:</i>                          | <i>Statistician</i> |
| <i>Researcher Identifier (e.g. ORCID ID):</i> | <i>N/A</i>          |
| <i>Nearest person month worked:</i>           | <i>12</i>           |

*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 organization instructions were involved as partners?**

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

## 8. **SPECIAL REPORTING REQUIREMENTS**

- a. **COLLABORATIVE AWARDS:**

Nothing to report.

- b. **QUAD CHARTS:** See document on page 23.

## 9. **APPENDICES:** See documents starting on page 24.

# 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)

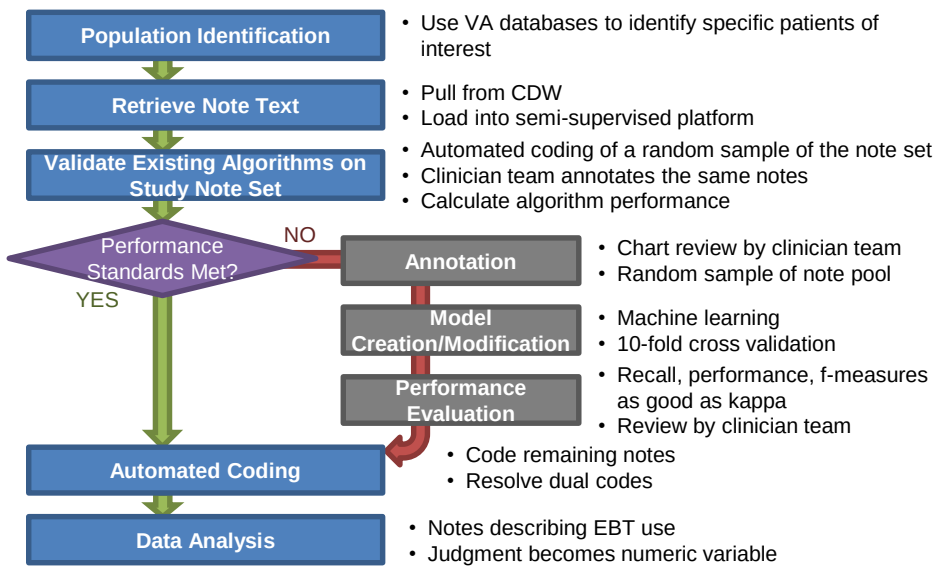
## Study/Product Aim(s)

- 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 | \$256,729 | \$144,656 | \$118,072 |

## 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 –Data Analysis

- ✓ 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 –Data Analysis

- ✓ Data analysis

### CY19 Goals – Complete Data Analysis and Disseminate Findings

- ✓ Complete data analysis
- ✓ Finalize study requirements
- ✓ Prepare for future funding
- ✓ Disseminate findings

Updated: May 2019 (SFVAMC – San Francisco, CA)

## Appendix:

Table A1. Standardized Differences of Characteristics of Propensity-Matched CPT (group or individual) and non-EBP standard of care.

Note: Ideally, for covariate balance, standardized mean differences have absolute value of  $\leq 0.1$  for all potential confounders of treatment selection and PCL outcomes.

| Variable                       | Non- EBP(N=684)          | CPT (group or individual) (N=684) | Standardized Mean Difference |
|--------------------------------|--------------------------|-----------------------------------|------------------------------|
| age (Mean $\pm$ SD (N))        | 37.39 $\pm$ 9.34 (N=684) | 36.87 $\pm$ 9.03 (N=684)          | -0.05655                     |
| age (Median (min-max))         | 35.41 (21.76-63.87)      | 34.55 (20.65-69.44)               |                              |
| PCL_zscore (Mean $\pm$ SD (N)) | 0.19 $\pm$ 0.84 (N=684)  | 0.19 $\pm$ 0.84 (N=684)           | 0.00780                      |
| PCL_zscore (Median (min-max))  | 0.30 (-2.79 to 1.88)     | 0.30 (-3.17 to 1.88)              |                              |
| Alcohol Abuse                  |                          |                                   | -0.00428                     |
| 0                              | 591 (86.4%)              | 592 (86.5%)                       |                              |
| 1                              | 93 (13.6%)               | 92 (13.5%)                        |                              |
| Total                          | 684                      | 684                               |                              |
| Alcohol Dependence             |                          |                                   | 0.05075                      |
| 0                              | 612 (89.5%)              | 601 (87.9%)                       |                              |
| 1                              | 72 (10.5%)               | 83 (12.1%)                        |                              |
| Total                          | 684                      | 684                               |                              |
| Drug Abuse                     |                          |                                   | 0.07410                      |
| 0                              | 642 (93.9%)              | 629 (92.0%)                       |                              |
| 1                              | 42 (6.1%)                | 55 (8.0%)                         |                              |
| Total                          | 684                      | 684                               |                              |
| Drug Dependence                |                          |                                   | 0.01927                      |

| Variable  | Non- EBP(N=684) | CPT (group or individual) (N=684) | Standardized Mean Difference |
|-----------|-----------------|-----------------------------------|------------------------------|
| 0         | 648 (94.7%)     | 645 (94.3%)                       |                              |
| 1         | 36 (5.3%)       | 39 (5.7%)                         |                              |
| Total     | 684             | 684                               |                              |
| Psychosis |                 |                                   | 0.00958                      |
| 0         | 481 (70.3%)     | 478 (69.9%)                       |                              |
| 1         | 203 (29.7%)     | 206 (30.1%)                       |                              |
| Total     | 684             | 684                               |                              |
| Pain      |                 |                                   | -0.04114                     |
| 0         | 302 (44.2%)     | 316 (46.2%)                       |                              |
| 1         | 382 (55.8%)     | 368 (53.8%)                       |                              |
| Total     | 684             | 684                               |                              |
| Suicide   |                 |                                   | 0.06853                      |
| 0         | 633 (92.5%)     | 620 (90.6%)                       |                              |
| 1         | 51 (7.5%)       | 64 (9.4%)                         |                              |
| Total     | 684             | 684                               |                              |
| TBI       |                 |                                   | 0.01629                      |
| 0         | 582 (85.1%)     | 578 (84.5%)                       |                              |
| 1         | 102 (14.9%)     | 106 (15.5%)                       |                              |
| Total     | 684             | 684                               |                              |

Table A2. Standardized Differences of Characteristics of Propensity-Matched PE and non-EBP standard of care

Note: Ideally, for covariate balance, standardized mean differences have absolute value of  $\leq 0.1$  for all potential confounders of treatment selection and PCL outcomes.

| Variable                       | Non-EBP (N= 378)         | PE (N=378)               | Std Difference |
|--------------------------------|--------------------------|--------------------------|----------------|
| age (Mean $\pm$ SD (N))        | 37.17 $\pm$ 8.52 (N=378) | 36.73 $\pm$ 8.78 (N=378) | -0.05131       |
| age (Median (min-max))         | 35.63 (21.83-65.62)      | 34.79 (22.81-64.38)      |                |
| PCL_zscore (Mean $\pm$ SD (N)) | 0.14 $\pm$ 0.93 (N=378)  | 0.12 $\pm$ 0.87 (N=378)  | -0.02011       |

| <b>Variable</b>               | <b>Non-EBP (N= 378)</b> | <b>PE (N=378)</b>    | <b>Std Difference</b> |
|-------------------------------|-------------------------|----------------------|-----------------------|
| PCL_zscore (Median (min-max)) | 0.22 (-2.94 to 1.88)    | 0.22 (-2.56 to 1.88) |                       |
| Alcohol Abuse                 |                         |                      | 0.05445               |
| 0                             | 331 (87.6%)             | 324 (85.7%)          |                       |
| 1                             | 47 (12.4%)              | 54 (14.3%)           |                       |
| Total                         | 378                     | 378                  |                       |
| Alcohol Dependence            |                         |                      | 0.09129               |
| 0                             | 340 (89.9%)             | 329 (87.0%)          |                       |
| 1                             | 38 (10.1%)              | 49 (13.0%)           |                       |
| Total                         | 378                     | 378                  |                       |
| Drug Abuse                    |                         |                      | -0.01142              |
| 0                             | 356 (94.2%)             | 357 (94.4%)          |                       |
| 1                             | 22 (5.8%)               | 21 (5.6%)            |                       |
| Total                         | 378                     | 378                  |                       |
| Drug Dependence               |                         |                      | 0.08687               |
| 0                             | 358 (94.7%)             | 350 (92.6%)          |                       |
| 1                             | 20 (5.3%)               | 28 (7.4%)            |                       |
| Total                         | 378                     | 378                  |                       |
| Psychosis                     |                         |                      | 0.03459               |
| 0                             | 267 (70.6%)             | 261 (69.0%)          |                       |
| 1                             | 111 (29.4%)             | 117 (31.0%)          |                       |
| Total                         | 378                     | 378                  |                       |
| Pain                          |                         |                      | 0.17555               |
| 0                             | 195 (51.6%)             | 162 (42.9%)          |                       |
| 1                             | 183 (48.4%)             | 216 (57.1%)          |                       |
| Total                         | 378                     | 378                  |                       |
| Suicide                       |                         |                      | -0.07018              |
| 0                             | 346 (91.5%)             | 353 (93.4%)          |                       |
| 1                             | 32 (8.5%)               | 25 (6.6%)            |                       |

| Variable | Non-EBP (N= 378) | PE (N=378)  | Std Difference |
|----------|------------------|-------------|----------------|
| Total    | 378              | 378         |                |
| TBI      |                  |             | 0.17663        |
| 0        | 337 (89.2%)      | 314 (83.1%) |                |
| 1        | 41 (10.8%)       | 64 (16.9%)  |                |
| Total    | 378              | 378         |                |

Table A3. Standardized Differences of Characteristics of Propensity Matched PE and CPT (individual).

Note: Ideally, for covariate balance, standardized mean differences have absolute value of  $\leq 0.1$  for all potential confounders of treatment selection and PCL outcomes.

| Variable                       | CPT individual (N=232)   | PE (N=232)               | Std Difference |
|--------------------------------|--------------------------|--------------------------|----------------|
| age (Mean $\pm$ SD (N))        | 36.60 $\pm$ 9.11 (N=232) | 36.72 $\pm$ 8.67 (N=232) | 0.01418        |
| age (Median (min-max))         | 34.44 (22.84-60.17)      | 34.95 (23.21-64.38)      |                |
| PCL_zscore (Mean $\pm$ SD (N)) | 0.11 $\pm$ 0.99 (N=232)  | 0.07 $\pm$ 0.88 (N=232)  | -0.04397       |
| PCL_zscore (Median (min-max))  | 0.22 (-2.87 to 1.88)     | 0.15 (-2.56 to 1.88)     |                |
| Alcohol Abuse                  |                          |                          | 0.00000        |
| 0                              | 213 (91.8%)              | 213 (91.8%)              |                |
| 1                              | 19 (8.2%)                | 19 (8.2%)                |                |
| Total                          | 232                      | 232                      |                |
| Alcohol Dependence             |                          |                          | 0.05033        |
| 0                              | 217 (93.5%)              | 214 (92.2%)              |                |
| 1                              | 15 (6.5%)                | 18 (7.8%)                |                |
| Total                          | 232                      | 232                      |                |
| Drug Abuse                     |                          |                          | 0.03126        |
| 0                              | 228 (98.3%)              | 227 (97.8%)              |                |
| 1                              | 4 (1.7%)                 | 5 (2.2%)                 |                |

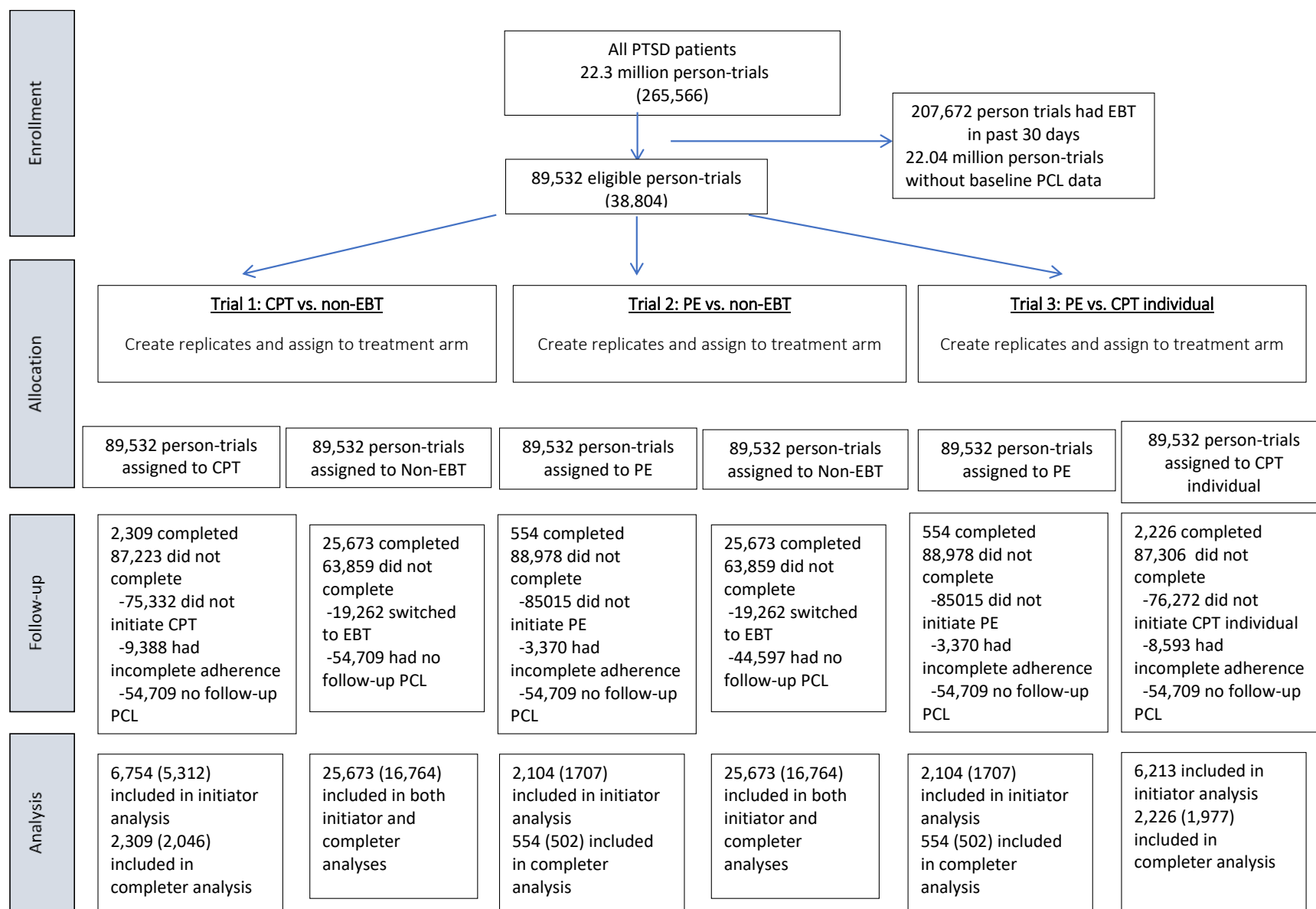
| Variable        | CPT individual (N=232) | PE (N=232)  | Std Difference |
|-----------------|------------------------|-------------|----------------|
| Total           | 232                    | 232         |                |
| Drug Dependence |                        |             | 0.02175        |
| 0               | 223 (96.1%)            | 222 (95.7%) |                |
| 1               | 9 (3.9%)               | 10 (4.3%)   |                |
| Total           | 232                    | 232         |                |
| Psychosis       |                        |             | 0.21082        |
| 0               | 192 (82.8%)            | 172 (74.1%) |                |
| 1               | 40 (17.2%)             | 60 (25.9%)  |                |
| Total           | 232                    | 232         |                |
| Pain            |                        |             | -0.02588       |
| 0               | 111 (47.8%)            | 114 (49.1%) |                |
| 1               | 121 (52.2%)            | 118 (50.9%) |                |
| Total           | 232                    | 232         |                |
| Suicide         |                        |             | -0.02175       |
| 0               | 222 (95.7%)            | 223 (96.1%) |                |
| 1               | 10 (4.3%)              | 9 (3.9%)    |                |
| Total           | 232                    | 232         |                |
| TBI             |                        |             | -0.03513       |
| 0               | 193 (83.2%)            | 196 (84.5%) |                |
| 1               | 39 (16.8%)             | 36 (15.5%)  |                |
| Total           | 232                    | 232         |                |

### **Sensitivity Analyses for PCL outcome, using the approach of cloning/censoring/weighting**

We conducted a sensitivity analysis for treatment effect on PCL outcomes using the cloning/censoring/weighting approach (BMJ 2018;360:k182 doi: 10.1136/bmj.k182; Journal of Clinical Epidemiology 96 (2018) 12e22, <https://doi.org/10.1016/j.jclinepi.2017.11.021>), where patients are cloned at baseline and each of the clones is assigned to one of the treatment strategies, then followed and artificially censored at earliest of treatment switching or failure to initiate. For instance, if a patient

(clone) is assigned to PE and they initiate CPT, they are censored. Then, an extended cox model of the censoring process is built, in each treatment arm separately, to get estimated probability of remaining uncensored. The uncensored patients in each arm are retained and the inverse probability of censoring weights are finally used as weights in model of the outcome. The analogue of intention-to-treat analysis using observational data is to compare initiators of assigned treatment (i.e., regardless of subsequent adherence), e.g. at least one PE visit versus at least one CPT (individual) visit within a 24-week period. Similarly, the analog to the per-protocol analysis using observational data uses inverse probability of censoring weighting (*The International Journal of Biostatistics*, Vol. 4 [2008], Iss. 1, Art. 22). In the real world it is very common for patients to 'drop-out' of treatment and not complete the minimally adequate amount of psychotherapy. Patients who completed follow-up under their assigned treatment strategy are retained and given a weight proportional to inverse of probability of having remained uncensored until end of study. Since the outcome of our target trial is the change in PCL score from baseline (trial start date) to trial end (24 weeks later), the outcome analysis is further restricted to patients who have follow-up PCL. After applying artificial censoring and restriction to those with follow-up PCL data, the resulting analytical samples (which were weighted by the inverse probability of censoring and follow-up in the model of the outcomes), are shown in Figure A1.

Figure A1. Sample selection for sensitivity analyses using the analytical approach of cloning/censoring/weighting



Baseline characteristics of the 89,532 person trials (i.e., sample to be cloned/censored/weighted) are show in table A4. below.

Table A4. Baseline characteristics of all eligible person-trials (pooled).

| Characteristic                            | All Eligible Person-Trials<br>(N=89,532) |
|-------------------------------------------|------------------------------------------|
| <b><u>Sociodemographic data</u></b>       |                                          |
| Age, mean (SD), y                         | 37.44 (9.43)                             |
| Male, No. (%)                             | 80511 (89.9%)                            |
| Racial Category, No. (%)                  |                                          |
| White                                     | 65868 (73.6%)                            |
| Black                                     | 13388 (15.0%)                            |
| American Indian or Alaska Native          | 1097 (1.2%)                              |
| Asian                                     | 1743 (1.9%)                              |
| Native Hawaiian or other Pacific Islander | 1646 (1.8%)                              |
| Multi-race                                | 1195 (1.3%)                              |
| Unknown                                   | 4595 (5.1%)                              |
| Ethnicity, No. (%)                        |                                          |
| Hispanic or Latino                        | 11817 (13.2%)                            |
| Not Hispanic or Latino                    | 73988 (82.6%)                            |
| Other                                     | 2627 (2.9%)                              |
| Unknown                                   | 1100 (1.2%)                              |
| Education, No. (%)                        |                                          |
| <HS diploma                               | 1047 (1.2%)                              |
| HS diploma                                | 72642 (81.1%)                            |
| >HS diploma                               | 14642 (16.4%)                            |
| Missing                                   | 1201 (1.3%)                              |
| Marital Status, No. (%)                   |                                          |
| Married                                   | 49417 (55.2%)                            |
| Never married                             | 18160 (20.3)                             |
| Divorced, separated, or single            | 20153 (22.5)                             |
| Widowed, widower                          | 321 (0.4)                                |

| Characteristic                                              | All Eligible Person-Trials<br>(N=89,532) |
|-------------------------------------------------------------|------------------------------------------|
| Unknown                                                     | 1481 (1.7)                               |
| <b><u>Military Service Data</u></b>                         |                                          |
| End of last deployment date, mean (SD)                      | 05/20/07 (950.4)                         |
| Branch of Service, No. (%)                                  |                                          |
| Air force                                                   | 5130 (5.7)                               |
| Army                                                        | 66769 (74.6)                             |
| Coast Guard                                                 | 50 (0.1)                                 |
| Marine                                                      | 11991 (13.4)                             |
| Navy                                                        | 5592 (6.2)                               |
| Military component, No. (%)                                 |                                          |
| Active duty                                                 | 52714 (58.9)                             |
| Guard                                                       | 23747 (26.5)                             |
| Reserve                                                     | 13071 (14.6)                             |
| Military rank, No. (%)                                      |                                          |
| Enlisted                                                    | 85885 (95.9)                             |
| Officer                                                     | 3135 (3.5)                               |
| Warrent                                                     | 512 (0.6)                                |
| Number of deployments, No. (%)                              |                                          |
| Single                                                      | 48387 (54.0)                             |
| Multiple                                                    | 40846 (45.6)                             |
| Missing                                                     | 299 (0.3)                                |
| <b><u>VA utilization data</u></b>                           |                                          |
| First mental health outpatient clinic visit date, mean (SD) | 09/26/09 (948.8)                         |
| Percent Service Connection, No. (%)                         |                                          |
| 0%                                                          | 1519 (1.7)                               |
| 1-30%                                                       | 764 (0.9)                                |
| 30-70%                                                      | 12229 (13.7)                             |
| 70-100%                                                     | 75020 (83.8)                             |
| Drive time to nearest facility, No. (%), hours              |                                          |

| Characteristic                               | All Eligible Person-Trials<br>(N=89,532) |
|----------------------------------------------|------------------------------------------|
| 0-1.78hr                                     | 21793 (24.3)                             |
| 1.79-4.14hr                                  | 22023 (24.6)                             |
| 4.15-5.38hr                                  | 21979 (24.5)                             |
| 5.39-9.34hr                                  | 22035 (24.6)                             |
| Unknown                                      | 1702 (1.9)                               |
| Prior Psychotherapy for PTSD, mean (SD)      |                                          |
| Non-EBT/Other Psychotherapy                  | 21.45 (34.31)                            |
| Cognitive Processing Therapy CPT             | 1.88 (5.08)                              |
| Prolonged Exposure Therapy PE                | 0.47 (2.15)                              |
| Acute care service use in past year, No. (%) |                                          |
| Non-psychiatric hospital admission           | 2907 (3.2)                               |
| Residential Mental Health                    | 53 (0.1)                                 |
| Residential Substance Abuse                  | 800 (0.9)                                |
| RRTP PTSD admission                          | 1762 (2.0)                               |
| Acute mental health admission                | 3646 (4.1)                               |
| ER visits                                    | 6565 (7.3)                               |
| Comorbid conditions, No. (%)                 |                                          |
| Alcohol abuse                                | 11897 (13.3)                             |
| Alcohol dependence                           | 10705 (12.0)                             |
| Depression                                   | 48422 (54.1)                             |
| Drug abuse                                   | 6702 (7.5)                               |
| Drug dependence                              | 6565 (7.3)                               |
| Psychosis                                    | 27168 (30.3)                             |
| Pain                                         | 46329 (51.7)                             |
| Suicide                                      | 6974 (7.8)                               |
| TBI                                          | 12673 (14.2)                             |
| MST                                          | 6895 (7.7)                               |
| PCL at baseline (z-score), mean (SD)         | -0.00 (1.00)                             |
| Medication data (past 90 days), No. (%)      |                                          |

| Characteristic             | All Eligible Person-Trials<br>(N=89,532) |
|----------------------------|------------------------------------------|
| Mirtazapine                | 370 (0.4)                                |
| Prazosin                   | 966 (1.1)                                |
| Fluoxetine                 | 372 (0.4)                                |
| Citalopram                 | 822 (0.9)                                |
| Sertraline                 | 1208 (1.3)                               |
| Amitriptyline              | 97 (0.1)                                 |
| Venlafaxine                | 675 (0.8)                                |
| Paroxetine                 | 209 (0.2)                                |
| Duloxetine                 | 69 (0.1)                                 |
| Escitalopram               | 25 (0.0)                                 |
| Imipramine                 | 4 (0.0)                                  |
| Fluvoxamine                | 1 (0.0)                                  |
| Desvenlafaxine             | 2 (0.0)                                  |
| Amitriptyline-Perphenazine | 9 (9.0)                                  |
| Any Medications            | 4820 (5.4)                               |

Table A5: Treatment effect of evidence-based psychotherapy for PTS in VHA, estimated using the cloning/censoring/weighting approach

| Emulated Trial        | Initiation/ITT Effect* (95% CI)** | Initiation Effect on PCL-M scale (for reference) | Completer Effect* (95% CI)** | Completer Effect on PCL-M scale (for reference) |
|-----------------------|-----------------------------------|--------------------------------------------------|------------------------------|-------------------------------------------------|
| CPT vs. non-EBP       | -0.130 (-0.122, -0.078)           | -1.72 (-1.62, -1.03)                             | -0.377 (-0.386, -0.297)      | -4.98 (-5.10, -3.93)                            |
| PE vs. non-EBP        | -0.323 (-0.316, -0.238)           | -4.27 (-4.18, -3.14)                             | -0.538 (-0.585, -0.410)      | -7.12 (-7.74, -5.42)                            |
| PE vs. CPT individual | -0.183 (-0.236, -0.140)           | -2.42 (-3.12, -1.86)                             | -0.249 (-0.801, -0.194)      | -3.29 (-10.59, -2.57)                           |

\*Effect is difference between treatment and control group in change in PCL scores, adjusted for baseline PCL z-score, and weighted by inverse probability of censoring and inverse probability of follow-up. A negative value means treatment group had greater improvement (decrease) in symptoms than the control group, e.g., CPT completers had a 0.377 greater decrease in z-score compared to the non-EBT group.

\*\*95% CI estimated with non-parametric bootstrap based on 500 samples.

Table A6: Patient Characteristics by PE Status in any 24 Weeks during Follow-up (N=265,566).

|                                           | <b>No PE<br/>(n=247,630,<br/>93.3%)</b> | <b>1-7 PE Sessions<br/>(n=12,782,<br/>4.8%)</b> | <b>8+ PE Sessions<br/>(n=5,154,<br/>1.9%)</b> | <b>P value</b> |
|-------------------------------------------|-----------------------------------------|-------------------------------------------------|-----------------------------------------------|----------------|
| <b>Baseline Age on index date</b>         | 32.0 (8.6)                              | 32.0 (8.3)                                      | 33.6 (8.9)                                    | <0.001         |
| <b>Baseline Age categories</b>            |                                         |                                                 |                                               | <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%)                                        |                |
| <b>Gender</b>                             |                                         |                                                 |                                               | 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%)                                         |                |
| <b>Race</b>                               |                                         |                                                 |                                               | <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%)                                    |                |
| <b>Ethnicity</b>                          |                                         |                                                 |                                               | <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%)                                     |                |
| <b>Marital status</b>                     |                                         |                                                 |                                               | <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%)                                     |                |
| <b>Education</b>                          |                                         |                                                 |                                               | <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%)                                   |                |

|                                                                             | <b>No PE<br/>(n=247,630,<br/>93.3%)</b> | <b>1-7 PE Sessions<br/>(n=12,782,<br/>4.8%)</b> | <b>8+ PE Sessions<br/>(n=5,154,<br/>1.9%)</b> | <b>P value</b> |
|-----------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------------|-----------------------------------------------|----------------|
| Missing                                                                     | 3,117 (1.3%)                            | 133 (1.0%)                                      | 64 (1.2%)                                     |                |
| <b>Service branch</b>                                                       |                                         |                                                 |                                               | 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%)                                 |                |
| 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%)                                    |                |
| <b>Component</b>                                                            |                                         |                                                 |                                               | <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%)                                   |                |
| <b>Rank</b>                                                                 |                                         |                                                 |                                               | <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%)                                     |                |
| <b>Number of Deployments</b>                                                |                                         |                                                 |                                               | <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%)                                     |                |
| <b>Military Sexual Trauma</b>                                               | 15,917 (6.4%)                           | 963 (7.5%)                                      | 422 (8.2%)                                    | <0.001         |
| <b>Smoking *</b>                                                            | 24,159 (9.8%)                           | 1,092 (8.5%)                                    | 417 (8.1%)                                    | <0.001         |
| <b>PTSD medication *</b>                                                    | 22,126 (8.9%)                           | 1,151 (9.0%)                                    | 439 (8.5%)                                    | 0.556          |
| <b># comorbidities *</b>                                                    | 1.31 (0.58)                             | 1.33 (0.58)                                     | 1.32 (0.59)                                   | 0.466          |
| <b>Comorbidities *</b>                                                      |                                         |                                                 |                                               |                |
| 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          |
| <b># therapy sessions before<br/>1<sup>st</sup> PE, excluding 0 therapy</b> | N/A                                     | (n=11,141)<br>13.8 (22.5)                       | (n=4,528)<br>15.8 (25.2)                      | <0.001         |

Table A7: Ordered Logistic Regression (Comparing 3 groups: 0, 1-7 and 8+ sessions of PE)

|                                           | Odds Ratio (95% CI) | P value |
|-------------------------------------------|---------------------|---------|
| <b>Baseline Age category</b>              |                     |         |
| <30                                       | ref                 |         |
| 30-39                                     | 1.14 (1.09-1.18)    | <0.001  |
| 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   |
| <b>Gender</b>                             |                     |         |
| Male                                      | ref                 |         |
| Female                                    | 0.90 (0.85-0.96)    | 0.001   |
| <b>Race</b>                               |                     |         |
| 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   |
| <b>Ethnicity</b>                          |                     |         |
| 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  |
| <b>Marital status</b>                     |                     |         |
| 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   |
| <b>Service branch</b>                     |                     |         |
| 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   |
| <b>Component</b>                          |                     |         |
| Active Duty (regular)                     | ref                 |         |
| Guard                                     | 1.02 (0.98-1.06)    | 0.423   |
| Reserve                                   | 1.12 (1.06-1.17)    | <0.001  |
| <b>Rank</b>                               |                     |         |
| Enlisted                                  | ref                 |         |
| Officer                                   | 1.24 (1.15-1.35)    | <0.001  |
| Warrant                                   | 0.82 (0.66-1.03)    | 0.091   |
|                                           |                     |         |

|                                                   | Odds Ratio (95% CI) | P value |
|---------------------------------------------------|---------------------|---------|
| <b>Number of Deployments</b>                      |                     |         |
| Single deployment                                 | ref                 |         |
| Multiple deployments                              | 1.11 (1.08-1.15)    | <0.001  |
| Missing                                           | 0.92 (0.70-1.21)    | 0.549   |
| <b>Military sexual trauma</b>                     | 1.34 (1.25-1.44)    | <0.001  |
| <b>Smoking**</b>                                  | 0.86 (0.81-0.91)    | <0.001  |
| <b>Pain**</b>                                     | 1.01 (0.98-1.05)    | 0.469   |
| <b>TBI**</b>                                      | 1.19 (1.10-1.30)    | <0.001  |
| <b>Year of 1<sup>st</sup> mental health visit</b> |                     |         |
| 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 A8: Cox Proportional Hazards Regression for Completion of 1<sup>st</sup> Full-Dose PE

|                                           | Hazard Ratio (95% CI) | P value |
|-------------------------------------------|-----------------------|---------|
| <b>Baseline Age category</b>              |                       |         |
| <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   |
| <b>Gender</b>                             |                       |         |
| Male                                      | ref                   |         |
| Female                                    | 0.83 (0.74-0.92)      | 0.001   |
| <b>Race</b>                               |                       |         |
| 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   |

|                                                   | Hazard Ratio (95% CI) | P value |
|---------------------------------------------------|-----------------------|---------|
| <b>Ethnicity</b>                                  |                       |         |
| 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   |
| <b>Marital status</b>                             |                       |         |
| 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   |
| <b>Service branch</b>                             |                       |         |
| 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   |
| <b>Component</b>                                  |                       |         |
| Active Duty (regular)                             | ref                   |         |
| Guard                                             | 1.08 (1.01-1.17)      | 0.034   |
| Reserve                                           | 1.22 (1.12-1.32)      | <0.001  |
| <b>Rank</b>                                       |                       |         |
| Enlisted                                          | ref                   |         |
| Officer                                           | 1.33 (1.17-1.52)      | <0.001  |
| Warrant                                           | 0.73 (0.49-1.09)      | 0.125   |
| <b>Number of Deployments</b>                      |                       |         |
| Single deployment                                 | ref                   |         |
| Multiple deployments                              | 1.15 (1.08-1.21)      | <0.001  |
| Missing                                           | 0.80 (0.49-1.31)      | 0.378   |
| <b>Military sexual trauma</b>                     | 1.47 (1.30-1.66)      | <0.001  |
| <b>Smoking **</b>                                 | 0.84 (0.76-0.93)      | 0.001   |
| <b>Depression **</b>                              | 0.92 (0.84-1.01)      | 0.087   |
| <b>Bipolar **</b>                                 | 0.69 (0.49-0.98)      | 0.037   |
| <b>Pain **</b>                                    | 1.07 (1.00-1.14)      | 0.052   |
| <b>TBI **</b>                                     | 1.27 (1.09-1.47)      | 0.002   |
| <b>Year of 1<sup>st</sup> mental health visit</b> |                       |         |
| 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  |

|           | Hazard Ratio (95% CI) | P value |
|-----------|-----------------------|---------|
| 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 A8. Patient Characteristics by CPT Status in any 24-Weeks during Follow-up (N=265,566)

|                                              | No CPT<br>(n=216,953,<br>81.7%) | 1-7 CPT Sessions<br>(n=29,006,<br>10.9%) | 8+ CPT Sessions<br>(n=19,607,<br>7.4%) | P      |
|----------------------------------------------|---------------------------------|------------------------------------------|----------------------------------------|--------|
| <b>Baseline Age</b>                          | 32.0 (8.5)                      | 32.0 (8.3)                               | 33.5 (9.1)                             | <0.001 |
| <b>Baseline age categories</b>               |                                 |                                          |                                        | <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%)                                 |        |
| <b>Gender</b>                                |                                 |                                          |                                        | <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%)                                 |        |
| <b>Race</b>                                  |                                 |                                          |                                        | <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<br>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%)                             |        |
| <b>Ethnicity</b>                             |                                 |                                          |                                        | <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%)                             |        |
| <b>Marital status</b>                        |                                 |                                          |                                        | <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%)                             |        |
| <b>Education</b>                             |                                 |                                          |                                        | <0.001 |

|                                                                                  | <b>No CPT<br/>(n=216,953,<br/>81.7%)</b> | <b>1-7 CPT Sessions<br/>(n=29,006,<br/>10.9%)</b> | <b>8+ CPT Sessions<br/>(n=19,607,<br/>7.4%)</b> | <b>P</b> |
|----------------------------------------------------------------------------------|------------------------------------------|---------------------------------------------------|-------------------------------------------------|----------|
| <HS diploma                                                                      | 3,059 (1.4%)                             | 362 (1.3%)                                        | 216 (1.1%)                                      |          |
| HS diploma                                                                       | 182,649 (84.2%)                          | 24,302 (83.8%)                                    | 15,676 (80.0%)                                  |          |
| Some college                                                                     | 16,108 (7.4%)                            | 2,262 (7.8%)                                      | 1,762 (9.0%)                                    |          |
| Baccalaureate                                                                    | 9,893 (4.6%)                             | 1,405 (4.8%)                                      | 1,336 (6.8%)                                    |          |
| Post Baccalaureate                                                               | 2,540 (1.2%)                             | 321 (1.1%)                                        | 361 (1.8%)                                      |          |
| Unknown                                                                          | 2,704 (1.3%)                             | 354 (1.2%)                                        | 256 (1.3%)                                      |          |
| <b>Service branch</b>                                                            |                                          |                                                   |                                                 | <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%)                                  |          |
| 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%)                                    |          |
| <b>Component</b>                                                                 |                                          |                                                   |                                                 | <0.001   |
| Active Duty                                                                      | 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%)                                   |          |
| <b>Rank</b>                                                                      |                                          |                                                   |                                                 | <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%)                                      |          |
| <b>Number of Deployments</b>                                                     |                                          |                                                   |                                                 | <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%)                                       |          |
| <b>Military sexual trauma</b>                                                    | 12,750 (5.9%)                            | 2,543 (8.8%)                                      | 2,009 (10.3%)                                   | <0.001   |
| <b>Smoking yr before index date</b>                                              | 21,319 (9.8%)                            | 2,710 (9.3%)                                      | 1,639 (8.4%)                                    | <0.001   |
| <b>Medication</b>                                                                | 139,601 (64.4%)                          | 19,542 (67.4%)                                    | 13,300 (67.8%)                                  | <0.001   |
| <b># Comorbidities</b>                                                           | 2.4 (1.8)                                | 2.9 (2.0)                                         | 3.2 (2.1)                                       | <0.001   |
| <b>Comorbidities</b>                                                             |                                          |                                                   |                                                 |          |
| Schizophrenia                                                                    | 3,148 (1.5%)                             | 366 (1.3%)                                        | 277 (1.4%)                                      | 0.038    |
| Bipolar                                                                          | 26,749 (12.3%)                           | 4,561 (15.7%)                                     | 3,354 (17.1%)                                   | <0.001   |
| Psychosis                                                                        | 6,245 (2.9%)                             | 996 (3.4%)                                        | 753 (3.8%)                                      | <0.001   |
| Pain                                                                             | 159,145 (73.4%)                          | 23,443 (80.8%)                                    | 16,163 (82.4%)                                  | <0.001   |
| TBI                                                                              | 30,899 (14.2%)                           | 5,663 (19.5%)                                     | 4,012 (20.5%)                                   | <0.001   |
| Depression                                                                       | 134,134 (61.8%)                          | 20,727 (71.5%)                                    | 14,719 (75.1%)                                  | <0.001   |
| Alcohol abuse                                                                    | 45,929 (21.2%)                           | 7,920 (27.3%)                                     | 6,032 (30.8%)                                   | <0.001   |
| Alcohol dependence                                                               | 33,600 (15.5%)                           | 6,357 (21.9%)                                     | 5,228 (26.7%)                                   | <0.001   |
| Drug abuse                                                                       | 28,149 (13.0%)                           | 5,288 (18.2%)                                     | 4,128 (21.1%)                                   | <0.001   |
| Drug dependence                                                                  | 22,482 (10.4%)                           | 4,354 (15.0%)                                     | 3,538 (18.0%)                                   | <0.001   |
| Suicide ideation or attempt                                                      | 22,842 (10.5%)                           | 4,779 (16.5%)                                     | 3,828 (19.5%)                                   | <0.001   |
| # Other therapies before 1 <sup>st</sup> CPT                                     | N/A                                      | 10.8 (20.5)                                       | 12.7 (20.6)                                     | <0.001   |
| # Other therapies before 1 <sup>st</sup> CPT,<br>excluding those with no therapy | N/A                                      | (n=23,965)<br>13.1 (21.9)                         | (n=16,701)<br>14.9 (21.6)                       | <0.001   |

*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.

Medication: Took any of 13 PTSD medications in the year before or after index date.

Comorbidities other than suicide ideation or attempt were defined as 2+ diagnoses at outpatient or 1+ diagnosis at inpatient or fee basis settings before 09/12/2015 (the last date for PTSD diagnosis for this cohort); suicide ideation or attempt was defined as any diagnosis at any setting before 09/12/2015.

Table A9. Odds of Completing Progressively Larger Number of CPT Sessions (defined as No CPT, Early Termination or 1-7 sessions, and CPT Completers or 8+ sessions) by Patient Characteristics using Ordered Logistic Regression

|                                           | Odd Ratio (95% CI) | <i>P</i> |
|-------------------------------------------|--------------------|----------|
| <b>Baseline age category</b>              |                    |          |
| <30                                       | ref                |          |
| 30-39                                     | 1.16 (1.13-1.19)   | <0.001   |
| 40-49                                     | 1.27 (1.23-1.31)   | <0.001   |
| 50-59                                     | 1.23 (1.16-1.30)   | <0.001   |
| 60-69                                     | 1.17 (0.99-1.38)   | 0.072    |
| 70+                                       | 4.20 (0.36-48.55)  | 0.250    |
| <b>Gender</b>                             |                    |          |
| Male                                      | ref                |          |
| Female                                    | 1.16 (1.12-1.20)   | <0.001   |
| <b>Race</b>                               |                    |          |
| White                                     | ref                |          |
| Black /African American                   | 1.01 (0.98-1.04)   | 0.597    |
| American Indian or Alaska Native          | 1.15 (1.06-1.25)   | 0.001    |
| Asian                                     | 0.94 (0.87-1.02)   | 0.157    |
| Native Hawaiian or Other Pacific Islander | 1.09 (1.00-1.19)   | 0.059    |
| Multi-races                               | 1.04 (0.95-1.13)   | 0.422    |
| Missing                                   | 0.87 (0.83-0.91)   | <0.001   |
| <b>Ethnicity</b>                          |                    |          |
| Hispanic or Latino                        | ref                |          |
| Not Hispanic or Latino                    | 0.97 (0.94-0.99)   | 0.034    |
| Other                                     | 0.92 (0.86-0.99)   | 0.017    |
| Missing                                   | 0.91 (0.83-1.00)   | 0.042    |
| <b>Marital status</b>                     |                    |          |
| Married                                   | Ref                |          |
| Never married                             | 0.91 (0.89-0.94)   | <0.001   |
| Divorced/separated/single                 | 0.90 (0.87-0.92)   | <0.001   |
| Widow/Widower/widowed                     | 0.84 (0.70-1.01)   | 0.062    |
| Missing                                   | 0.91 (0.84-0.99)   | 0.025    |
| <b>Service branch</b>                     |                    |          |

|                                                   | <b>Odd Ratio (95% CI)</b> | <b>P</b> |
|---------------------------------------------------|---------------------------|----------|
| Air Force                                         | ref                       |          |
| Army                                              | 0.98 (0.94-1.03)          | 0.426    |
| Coast Guard                                       | 0.55 (0.33-0.91)          | 0.020    |
| Marine                                            | 1.03 (0.98-1.08)          | 0.242    |
| Navy                                              | 0.93 (0.87-0.98)          | 0.008    |
| <b>Component</b>                                  |                           |          |
| Active Duty                                       | ref                       |          |
| Guard                                             | 1.06 (1.03-1.09)          | <0.001   |
| Reserve                                           | 1.07 (1.04-1.11)          | <0.001   |
| <b>Rank</b>                                       |                           |          |
| Enlisted                                          | ref                       |          |
| Officer                                           | 1.27 (1.20-1.34)          | <0.001   |
| Warrant                                           | 0.95 (0.83-1.09)          | 0.453    |
| <b>Number of Deployments</b>                      |                           |          |
| Single deployment                                 | ref                       |          |
| Multiple deployments                              | 1.10 (1.08-1.12)          | <0.001   |
| Missing                                           | 1.20 (1.02-1.41)          | 0.028    |
| <b>Military sexual trauma</b>                     | 1.48 (1.42-1.55)          | <0.001   |
| <b>Smoking</b>                                    | 0.88 (0.85-0.91)          | <0.001   |
| <b>Medication</b>                                 | 1.00 (0.98-1.02)          | 0.941    |
| <b>Schizophrenia</b>                              | 0.62 (0.56-0.68)          | <0.001   |
| <b>Bipolar</b>                                    | 1.05 (1.02-1.09)          | 0.001    |
| <b>Psychosis</b>                                  | 0.96 (0.90-1.02)          | 0.184    |
| <b>Pain</b>                                       | 1.39 (1.35-1.42)          | <0.001   |
| <b>TBI</b>                                        | 1.35 (1.32-1.39)          | <0.001   |
| <b>Depression</b>                                 | 1.38 (1.34-1.41)          | <0.001   |
| <b>Alcohol abuse</b>                              | 1.17 (1.14-1.20)          | <0.001   |
| <b>Alcohol dependence</b>                         | 1.32 (1.28-0.36)          | <0.001   |
| <b>Drug abuse</b>                                 | 1.13 (1.09-1.17)          | <0.001   |
| <b>Drug dependence</b>                            | 1.18 (1.14-1.23)          | <0.001   |
| <b>Suicide ideation or attempt</b>                | 1.32 (1.28-1.37)          | <0.001   |
| <b>Year of 1<sup>st</sup> mental health visit</b> |                           |          |
| 2001-2005                                         | ref                       |          |
| 2006                                              | 1.11 (1.05-1.17)          | <0.001   |
| 2007                                              | 1.14 (1.08-1.20)          | <0.001   |
| 2008                                              | 1.16 (1.11-1.22)          | <0.001   |
| 2009                                              | 1.13 (1.08-1.19)          | <0.001   |
| 2010                                              | 1.12 (1.06-1.17)          | <0.001   |
| 2011                                              | 1.15 (1.09-1.20)          | <0.001   |
| 2012                                              | 1.20 (1.15-1.26)          | <0.001   |
| 2013                                              | 1.27 (1.21-1.33)          | <0.001   |
| 2014                                              | 1.19 (1.12-1.25)          | <0.001   |
| 2015-2017                                         | 1.14 (1.03-1.26)          | 0.009    |

Table A10. Cox Proportional Hazards Regression for Completion of First CPT

|                                           | Hazard Ratio (95% CI) | <i>P</i> |
|-------------------------------------------|-----------------------|----------|
| <b>Baseline age category</b>              |                       |          |
| <30                                       | ref                   |          |
| 30-39                                     | 1.24 (1.20-1.29)      | <0.001   |
| 40-49                                     | 1.52 (1.45-1.59)      | <0.001   |
| 50-59                                     | 1.61 (1.50-1.73)      | <0.001   |
| 60-69                                     | 1.82 (1.49-2.23)      | <0.001   |
| 70+                                       | 8.69 (1.22-61.85)     | 0.031    |
| <b>Gender</b>                             |                       |          |
| Male                                      | ref                   |          |
| Female                                    | 1.13 (1.07-1.19)      | <0.001   |
| <b>Race</b>                               |                       |          |
| White                                     | ref                   |          |
| Black or African American                 | 1.05 (1.01-1.09)      | 0.012    |
| American Indian or Alaska Native          | 1.20 (1.07-1.35)      | 0.002    |
| Asian                                     | 1.04 (0.93-1.16)      | 0.483    |
| Native Hawaiian or Other Pacific Islander | 1.02 (0.89-1.16)      | 0.745    |
| Multi-races                               | 1.02 (0.90-1.16)      | 0.725    |
| Missing                                   | 0.85 (0.79-0.91)      | <0.001   |
| <b>Ethnicity</b>                          |                       |          |
| Hispanic or Latino                        | ref                   |          |
| Not Hispanic or Latino                    | 1.03 (0.98-1.08)      | 0.207    |
| Other                                     | 0.98 (0.89-1.07)      | 0.610    |
| Missing                                   | 1.01 (0.89-1.14)      | 0.932    |
| <b>Marital status</b>                     |                       |          |
| Married                                   | ref                   |          |
| Never married                             | 0.96 (0.92-0.99)      | 0.023    |
| Divorced/separated/single                 | 0.87 (0.84-0.91)      | <0.001   |
| Widow/Widower/widowed                     | 0.74 (0.57-0.96)      | 0.024    |
| Missing                                   | 0.89 (0.79-1.00)      | 0.057    |
| <b>Service branch</b>                     |                       |          |
| Air Force                                 | ref                   |          |
| Army                                      | 0.95 (0.90-1.01)      | 0.097    |
| Coast Guard                               | 0.47 (0.21-1.05)      | 0.066    |
| Marine                                    | 1.01 (0.94-1.08)      | 0.732    |
| Navy                                      | 0.90 (0.83-0.97)      | 0.006    |
| <b>Component</b>                          |                       |          |
| Active Duty                               | ref                   |          |
| Guard                                     | 1.07 (1.03-1.11)      | 0.001    |
| Reserve                                   | 1.10 (1.05-1.15)      | <0.001   |
| <b>Rank</b>                               |                       |          |
| Enlisted                                  | ref                   |          |
| Officer                                   | 1.41 (1.32-1.51)      | <0.001   |
| Warrant                                   | 0.96 (0.80-1.16)      | 0.698    |

|                                                   | Hazard Ratio (95% CI) | <i>P</i> |
|---------------------------------------------------|-----------------------|----------|
| <b>Number of Deployments</b>                      |                       |          |
| Single deployment                                 | ref                   |          |
| Multiple deployments                              | 1.11 (1.08-1.15)      | <0.001   |
| Missing                                           | 1.29 (1.05-1.59)      | 0.015    |
| <b>Military sexual trauma</b>                     | 1.49 (1.41-1.58)      | <0.001   |
| <b>Smoking</b>                                    | 0.84 (0.80-0.88)      | <0.001   |
| <b>Medication</b>                                 | 0.99 (0.96-1.02)      | 0.686    |
| <b>Schizophrenia</b>                              | 0.67 (0.59-0.76)      | <0.001   |
| <b>Bipolar</b>                                    | 1.05 (1.00-1.09)      | 0.033    |
| <b>Psychosis</b>                                  | 0.95 (0.88-1.03)      | 0.239    |
| <b>Pain</b>                                       | 1.35 (1.31-1.41)      | <0.001   |
| <b>TBI</b>                                        | 1.33 (1.28-1.38)      | <0.001   |
| <b>Depression</b>                                 | 1.40 (1.35-1.45)      | <0.001   |
| <b>Alcohol abuse</b>                              | 1.18 (1.14-1.23)      | <0.001   |
| <b>Alcohol dependence</b>                         | 1.38 (1.33-1.44)      | <0.001   |
| <b>Drug abuse</b>                                 | 1.14 (1.08-1.19)      | <0.001   |
| <b>Drug dependence</b>                            | 1.23 (1.17-1.29)      | <0.001   |
| <b>Suicide ideation or attempt</b>                | 1.32 (1.27-1.38)      | <0.001   |
| <b>Year of 1<sup>st</sup> mental health visit</b> |                       |          |
| 2001-2005                                         | ref                   |          |
| 2006                                              | 1.23 (1.14-1.33)      | <0.001   |
| 2007                                              | 1.36 (1.27-1.47)      | <0.001   |
| 2008                                              | 1.62 (1.51-1.74)      | <0.001   |
| 2009                                              | 1.84 (1.72-1.98)      | <0.001   |
| 2010                                              | 2.11 (1.96-2.27)      | <0.001   |
| 2011                                              | 2.60 (2.41-2.79)      | <0.001   |
| 2012                                              | 3.20 (2.98-3.45)      | <0.001   |
| 2013                                              | 4.00 (3.71-4.32)      | <0.001   |
| 2014                                              | 4.93 (4.54-5.37)      | <0.001   |
| 2015-2017                                         | 6.09 (5.27-7.05)      | <0.001   |



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

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## 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  $\geq$  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 (Kusman 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 psychotherapies (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 ( $\kappa \geq 0.8$ ) 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,

**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 <sup>a</sup>                          | 7              | 5           |
| Other individual psychotherapy <sup>a</sup>    | 433            | 170         |
| Other group psychotherapy <sup>a</sup>         | 384            | 127         |
| Other family/couple psychotherapy <sup>a</sup> | 4              | 0           |
| Not psychotherapy                              | 610            | 269         |
| Total                                          | 2960           | 1507        |

PE prolonged exposure, CPT cognitive processing therapy

<sup>a</sup>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” ( $n=297$ )

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).

## 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<br>M ± SD<br>(n = 255,933) | Estimated mean number of sessions among the pool of patients receiving one session of PE or CPT<br>M ± SD<br>(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; Spont 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 engagement 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<br>M ± SD<br>n = 130,416 | Estimated mean number of sessions among the pool of patients receiving one session of PE or CPT<br>M ± SD<br>(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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# Factors associated with completing evidence-based psychotherapy for PTSD among veterans in a national healthcare system

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## ABSTRACT

Little is known about predictors of initiation and completion of evidence-based psychotherapy (EBP) for post-traumatic stress disorder (PTSD), with most data coming from small cohort studies and post-hoc analyses of clinical trials. We examined patient and treatment factors associated with initiation and completion of EBP for PTSD in a large longitudinal cohort. We conducted a national, retrospective cohort study of all Iraq and Afghanistan War veterans who had a post-deployment PTSD diagnosis from 10/01–9/15 at a Veterans Health Administration facility and had at least one coded post-deployment psychotherapy visit. We examined utilization of PE and CPT (individual or group) during any 24-week period. We used ordered logistic, logistic, and Cox proportional hazards regressions to examine variables associated with EBP initiation, early termination, and completion, and time to completion. Over a 15-year period, of 265,566 veterans with PTSD, 22.8% initiated an EBP, and only 9.1% completed treatment. Completers did so about three years after their initial mental health visit. Factors positively associated with EBP completion included military sexual trauma, older age, race/ethnicity (i.e., African-American race for PE), combat, and multiple deployments. The VHA has become timelier in delivering EBP for PTSD, and several subgroups are more likely to complete EBP.

## 1. Introduction

The US Veterans Health Administration (VHA) has implemented two specific posttraumatic stress disorder (PTSD) evidence-based psychotherapy (EBP) protocols, Cognitive Processing Therapy (CPT) and Prolonged Exposure (PE; Karlin et al., 2010; Kussman, 2008). Research trials of CPT and PE have resulted in improved PTSD symptoms among veterans (e.g. Haagen et al., 2015; Monson et al., 2006; Schnurr et al., 2007, 2015; Suris et al., 2013; Voelkel et al., 2015). Cross-sectional studies have estimated that fewer than 13% of all VHA patients undergoing PTSD treatment receive any PE or CPT over a six to twelve-month period (Lu et al., 2016; Shiner et al., 2013; Sripada et al., 2018). A recent 15-year longitudinal cohort study of Iraq and Afghanistan veterans who initiated psychotherapy for PTSD in the VHA showed that 20% ever received any sessions of PE or CPT (Maguen et al., 2018).

Additionally, up to half of veterans who start individual EBPs in a clinical setting drop out of treatment (Kehle-Forbes et al., 2016; Miles and Thompson, 2016). While one study found no differences in drop-out rates between CPT and PE (Miles and Thompson, 2016), another found that those receiving PE drop out at higher rates than patients receiving CPT (e.g., 45% vs. 33%; Kehle-Forbes et al., 2016). Available data shows that VA patients initiating EBPs attend about 5 to 9 sessions (Kehle-Forbes et al., 2016; Watts et al., 2014), indicating that some patients may drop out of treatment before completing the full 8–12 session protocol. Despite apparent underuse and low completion rates, there is little research on patient and treatment-factors associated with initiating and completing evidence-based psychotherapy (EBP). Such information could better assist with understanding barriers and facilitators to care, as well as guide outreach and retention efforts.

Few studies have examined patient demographic and prior

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treatment factors associated with outpatient EBP treatment initiation and completion, and these studies have examined care at individual sites. In terms of patient demographics, younger veterans tended to initiate EBPs at lower rates than older veterans and were more likely to drop out of treatment at three sites (Mott et al., 2014a; Jeffreys et al., 2014; Kehle-Forbes et al., 2016), whereas age was not significantly associated with treatment discontinuation at a fourth site (Gros et al., 2013). In terms of prior treatment factors, an active area of debate is whether individuals need prior PTSD psychotherapy before starting EBPs (De Jongh et al., 2016). One site examined this question, and those who delayed EBP initiation were more likely to complete treatment (Mott et al., 2014b). In related qualitative work, patients who completed EBPs reported that prior treatment increased confidence in their ability to participate in EBP (Hundt et al., 2015), and that not feeling ready was a common reason for declining EBP (Hundt et al., 2017a).

Implementing EBPs in the VHA has been an ongoing process with refinements along the way. Given that clinicians were gradually trained to use these treatments over the implementation period (Karlin, 2012; Wagner et al., 2011), examining whether year of treatment has an impact on initiating and completing EBPs is also important. A follow up study at one large site indicated increased use of EBPs in individual clinics over time (e.g., Hundt et al., 2017b). However, year of entry into mental health treatment has never been examined on a national level as a potential predictor of initiation and completion of EBPs. Relatedly, while some individuals receive EBPs in the first year of entering treatment, others can take a longer time to initiate care. Other factors that may impact time to treatment include patient readiness and barriers to care (Zubkoff et al., 2016), as well as systemic barriers (Watts et al., 2014). Among a national sample of Iraq and Afghanistan veterans using VHA care, we found that earlier initiation of any treatment after the last deployment was associated with greater improvement in PTSD symptoms (Maguen et al., 2014). Therefore, beyond the general trend in EBP availability within the VA system, there is a need to examine which patient factors were associated with shorter time to receiving EBPs.

Due to challenges in readily identifying CPT and PE use in the VHA national electronic medical records (Shiner et al., 2012), we recently developed an algorithm to identify EBPs through natural language processing (NLP) of psychotherapy notes (please see Maguen et al., 2018). More specifically, using NLP, we developed machine-learning algorithms to classify note text on a large scale in an observational study of Iraq and Afghanistan veterans with PTSD. PTSD visits were linked to 8.1 million psychotherapy notes, and annotators labeled 3467 randomly-selected psychotherapy notes ( $\kappa = 0.88$ ) to indicate receipt of EBP. Our overall classification accuracy was strong (0.991 for PE; 0.965 for CPT individual, and 0.968 for CPT group), indicating that our algorithm correctly identified instances of CPT and PE in the electronic medical records. Due to robust performance metrics of our algorithm, we were able to use it to identify patients' use of EBPs. While CPT was implemented in the VHA in 2006 and PE in 2007, templated notes for these treatments were not implemented until 2015 and are still underused in clinical practice (Shiner et al., 2018), meaning that a NLP approach continues to be the only viable option for longitudinal analysis of CPT and PE use over the entire EBP implementation period. Our goal was to describe uptake and completion of EBPs as well as facilitators and barriers to receiving EBPs in a national healthcare system. Prior studies have been able to elucidate national use and trends, but this is the first time that examining these barriers and facilitators is possible on a national level across a fifteen-year period. Overall, we were interested in examining three groups of veterans who never received any EBPs, those who dropped out of EBPs, and those who completed at least a minimally-adequate course of EBP treatment. In addition, we examined factors associated with timing of EBP receipt.

## 2. Methods

### 2.1. Study population

We identified 308,556 Iraq and Afghanistan war veterans who had a post-deployment PTSD diagnosis from October 2001 to September 2015 at one of 130 VHA facilities. Of those, 265,566 had an initial post-deployment mental health visit and at least one coded psychotherapy visit (with PTSD as the primary or secondary diagnosis) that was linked to a clinical note by June 15th, 2017.

### 2.2. Data sources

We obtained demographic and military service information from the Iraq and Afghanistan War Veterans Roster and the VA Corporate Data Warehouse (CDW), a national repository of VHA clinical and administrative data. We obtained diagnostic, encounter, and pharmacy data from the CDW.

### 2.3. Outcome variables

We measured three hierarchical outcomes related to utilization of PE and CPT (individual or group) during any 24-week period (chosen as a conservative estimate): (1) receipt of eight or more sessions of PE or CPT (defined as PE or CPT completion; Cully et al., 2008; Mott et al., 2014a; Spont et al., 2010); (2) receipt of 1–7 sessions of PE/CPT (defined as early termination); and (3) no PE/CPT treatment. Additionally, we measured time from first mental health visit (defined as index date) to completion of the first full-dose of PE/CPT.

We allowed 24-weeks for the completion of evidence-based psychotherapy and recognize that for some individuals this may represent poor continuity of treatment; however, we wanted to account for the reality of avoidance that manifests in PTSD and did not want to underestimate rates in those receiving these treatments that have significant barriers prohibiting completion in a shorter time frame.

### 2.4. Independent variables

Using ICD-9 and ICD-10 codes, we identified the following outpatient or inpatient diagnoses in the year before the index date: schizophrenia or other psychotic disorder, bipolar disorder, depression, alcohol abuse and/or dependence, drug abuse and/or dependence, pain conditions, traumatic brain injury, and suicide behavior (ideation and attempts). Comorbidities other than suicide ideation or attempt were defined as 2+ diagnoses at outpatient or 1+ diagnosis at inpatient or fee basis settings before 09/12/2015. We used any suicide codes that were captured in the medical record, given that in our experience, ideation that is strong enough to be captured as a diagnosis is often chronic and warrants inclusion, given that this is a rare event. We did not have any exclusion criteria.

We also included trauma exposure variables available in the medical records including military sexual trauma (MST) as well as serving in a combat zone and number of deployments, which served as a proxy for combat exposure. MST is recorded according to a veteran's response to the following: "While you were in the military: (a) Did you receive uninvited and unwanted sexual attention, such as touching, cornering, pressure for sexual favors, or verbal remarks?; (b) Did someone ever use force or threat of force to have sexual contact with you against your will?"

We examined whether taking certain medications in the year prior to or after index date was associated with PE/CPT outcomes. These medications were based on the VA/DoD PTSD treatment guidelines in place for most of the treatment period (Departments of Veterans Affairs and Defense, 2010) and include nine selective serotonin and serotonin-norepinephrine reuptake inhibitors (SSRIs and SNRIs; Desvenlafaxine, Duloxetine, Venlafaxine, Citalopram, Escitalopram, Fluoxetine,

Fluvoxamine, Paroxetine, and Sertraline), two tricyclic antidepressants (TCAs; Amitriptyline and Imipramine), Mirtazapine, and Prazosin. We did not include Nefazadone and Phenylzine, given that these are very rarely prescribed to patients with PTSD in routine VHA clinical practice (Krystal et al., 2017).

To test temporal effects, we examined the association between the year of the first mental health visit (entry year) and PE/CPT outcomes. We created a categorical variable of calendar years, with combined years of 2001–2005 as the reference category, and combined years of 2015–2017 as the last category, due to small numbers of observations in individual years during these periods.

In addition, we considered the following variables as potential covariates: rurality, service connection, and CPT treatment format received (individual, group, or both).

## 2.5. Statistical analysis

To assess whether statistically significant differences exist between groups, we used Kruskal Wallis tests or Mann-Whitney tests for continuous variables and Chi-Square or Fisher's Exact tests for categorical variables. We used log rank tests to compare the survival distributions of different groups.

We conducted regression analyses focused on three outcome variables: (1) ordered logistic regressions for the three-category outcome variable: no EBP, early termination, or EBP completers in any 24 weeks during follow-up; (2) binary logistic regressions for EBP completers vs. early terminators; and (3) Cox proportional hazards regressions for time to completion of the first PE/CPT. Due to multicollinearity, education was not included as a predictor in the models. To control for potential confounding, variables that were significant in bivariate analyses ( $p < 0.05$ ) were entered in the models as covariates. In regression analyses, we considered  $p < 0.001$  as statistically significant. Analyses were completed using SAS 9.4 (SAS Institute, 2013) and StataMP 15 (StataCorp, 2017).

## 3. Results

### 3.1. Evidence-based psychotherapy

Of 265,566 veterans with PTSD receiving mental health care, 24,039 (9.1%) completed an EBP for PTSD, 36,595 (13.8%) were early terminators, and 204,932 (77.2%) received no EBP in any 24 weeks during the study period. More specifically, 5154 (1.9%) completed PE, 12,782 (4.8%) were early terminators, during any 24-week period. Furthermore, 19,067 (7.4%) completed CPT, 29,006 (10.9%) were early terminators, during any 24-week period. Given these differences between PE and CPT receipt, we present results separately for each treatment.

### 3.2. Prolonged exposure therapy

There were many significant differences between the no PE, early termination, and completion groups in this large dataset (Table 1a). In addition to being older and more educated, those who completed PE were more likely to be African-American, Officers, and National Guard or Reservists. The largest differences between those who initiated PE (completed or terminated early) and those who did not were that initiators were more likely to be married and have multiple deployments, military sexual trauma, medications, and a history of pain, TBI, depression, alcohol abuse or dependence, drug abuse or dependence, and suicide ideation or attempt. In addition, those who initiated PE were more likely to live in an urban area, be service connected, and have served in a combat zone. Table 2a shows factors associated with our hierarchical outcome categories (no PE, early termination, completion)

during any 24-week period based on ordered logistic regression. The odds of completing progressively larger numbers of PE treatment sessions were greater for those in their 30s and 40s, African-Americans, married individuals, Reservists, Officers, those serving in a combat zone, those with multiple deployments, those with military sexual trauma, non-smokers or those without schizophrenia or bipolar diagnosis, those with a history of pain, TBI, depression, alcohol abuse or dependence, or suicide ideation or attempt, and those who entered VA mental health treatment after 2005, lived in urban areas, or were service connected.

Using binary logistic regression, we examined an additional factor – the number of non-EBP therapy sessions before the first PE session – on the probability of completing PE among patients who ever received any PE (See Appendix Table 1a). Unlike findings based on the ordered logistic regression model, the year in which a patient initiated mental health care was not associated with completing PE, indicating that VA mental health entry year was related to initiation, but not completion of PE. The binary logistic regression results were otherwise similar to the results for the ordered logistic regression.

Of the 5154 patients who completed PE, the mean duration between the first mental health visit and the completion of PE was 3.25 years (SD = 2.66 years). For the rest of the sample who terminated early or did not receive PE ( $n = 260,412$ ), the average follow-up time in VA care was 7.13 years (SD = 2.76 years) until the last follow-up date (June 15th, 2017) or death.

Table 3a shows factors associated with shorter time to completion of PE from VA mental health entry, based on a Cox proportional hazards model. Patients completed PE in less time if they were in their 30's and 40's, African-American, married individuals (relative to the divorced, separated or single), Reservists, Officers, had multiple deployments, experienced military sexual trauma, took medications, had no diagnosis of schizophrenia, had a history of pain, TBI, depression or suicide ideation or attempt, entered VA mental health care after 2005, were service connected or served in a combat zone. Interestingly, whereas PE completion rates did not improve across years (above), time to PE completion improved steadily and dramatically across years.

### 3.3. Cognitive processing therapy

There were many significant differences between the no CPT, early termination, and completion groups in this large dataset (Table 1b). In addition to being older and more educated, those who completed CPT were more likely to be African-American, National Guard or Reservists, and Officers. The largest differences between those who initiated CPT (completed or terminated early) and those who did not were that initiators were more likely to be women, or to report military sexual trauma, or to take medication, or have a history of bipolar, psychosis, pain, TBI, depression, alcohol abuse or dependence, drug abuse or dependence, or suicide ideation or attempt. In addition, patients who initiated CPT were more likely to be service connected or have served in a combat zone. Compared to those who terminated early, those who completed eight or more sessions were more likely to receive both individual and group formats of CPT. Table 2b shows factors associated with achievement of our hierarchical outcome categories (no CPT, early termination, or completion) during any 24-week period based on ordered logistic regression. The odds of completing progressively larger number of CPT treatment sessions were greater for people 30 years or older, non-Hispanics, married individuals, Reserve members, Officers, those who did not take medications, or were service connected, served in a combat zone, or received group format or both individual and group formats of CPT, relative to individual CPT.

Using binary logistic regression, we examined an additional factor – the number of non-EBP therapy sessions before the first CPT session – on the probability of completing CPT among patients who ever received

any CPT (See [Appendix Table 1b](#)). Unlike findings based on the ordered logistic regression model, the year in which a patient initiated mental health care was not associated with CPT completion except for year 2014, relative to years between 2001 and 2005, indicating that VA mental health entry year was significantly related to initiation, but not completion of CPT. The binary logistic regression results were otherwise similar to the results for ordered logistic regression.

Of the 19,607 patients who completed CPT, the mean duration between the first mental health visit and the completion of CPT was 3.49 years (SD: 2.72). For the rest of the sample ( $n = 245,959$ ) who did not receive CPT or terminated early, the average follow-up time was 7.13 years (SD: 2.76) until the last follow-up date (June 15th, 2017) or death.

[Table 3b](#) shows factors associated with faster time to completion of CPT from VA mental health entry, based on a Cox proportional hazards model. Patients completed CPT in less time if they were 30 years or older, non-Hispanic, married, Reservists, Officers, or entered VA mental health care after 2005, served in a combat zone, or received group format or both individual and group formats of CPT, relative to individual format of CPT. 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.

#### 4. Discussion

Over a 15-year period, 308,556 Iraq and Afghanistan war veterans in VHA care were identified as having PTSD and 265,566 veterans with PTSD received mental health care and at least one coded psychotherapy visit. While 22.8% of those veterans initiated an EBP during this period, only 9.1% completed treatment. Significantly more veterans completed CPT than PE, which may reflect a greater number of providers trained in CPT as well as patient and provider treatment preferences ([Hundt et al., 2016](#); [Schumm et al., 2015](#)). Availability of both individual and group modalities of CPT may also account for these differences, allowing for easier delivery and completion. Furthermore, those who completed EBPs did so an average of three years after their initial mental health visit. It is unclear whether this is predominantly due to veterans not being ready for evidence-based PTSD treatment upon initial presentation ([Zubkoff et al., 2016](#); [Hundt et al., 2017a](#)), needing initial treatment for comorbid medical, psychiatric, or substance abuse conditions ([Shiner et al., 2017](#)), needing immediate care to address suicide or other risk issues ([Conner et al., 2014](#)), long wait times in the VA treatment system that may lead patients to receive other psychotherapeutic and pharmacologic modalities before receiving evidence-based treatment ([Watts et al., 2014](#)), or some combination of these and other factors.

Understanding factors associated with timing to and completion of EBP treatments can assist with better engagement and retention. We found many demographic, military and clinical factors associated with completing an adequate dose of EBP, and doing so in a timely manner. Many factors were similar across both CPT and PE, but some were unique to each. Interestingly, military sexual trauma was one of the strongest predictors of completing PE as well as timing of PE, and these associations closely approached clinical significance for CPT. While this may seem surprising due to the shame and stigma associated with MST, prior studies have found that those with MST have higher healthcare utilization rates (e.g., 50% higher than those without MST; [Brignone et al., 2017](#)) and that 76% of veterans with MST receive MST-related care ([Turchik et al., 2012](#)). There may be systemic issues that have facilitated completion and timing of EBPs among those with MST, such as implementation of MST coordinators at each facility who assist with connection to care, and availability of free care to those with documented MST. In addition to MST, combat and number of deployments were also associated with timing and completion of EBPs, which

may serve as a proxy for exposure to potentially traumatic experiences. The potential impact of trauma type and severity on completion of EBPs is critical, and although more work is needed in this area, our findings suggest that these factors are important and need to be examined in more granularity in future studies.

Importantly, calendar year of treatment seemed to make somewhat of a difference in whether individuals completed EBPs, and a very significant difference in the time it took to complete EBPs. In fact, year of veterans' first mental health visit was the factor most strongly associated with timely EBP completion. This likely reflects the significant efforts that VHA has invested in hiring and training more clinicians to provide EBPs, providing patient materials that explain and demystify these treatments, and investing in campaigns to destigmatize EBPs by having veterans who have benefited tell their recovery stories. The fact that the VA has become more efficient when delivering EBPs is also encouraging, given that on average, veterans are receiving EBPs over three years after their first mental health visit.

We also found that engaging in other psychotherapy prior to starting EBP was associated with higher completion of EBPs, compared to early termination. While veterans may be at high-risk when presenting to treatment or have comorbid conditions that need to be treated prior to starting EBPs, there is also evidence that individuals with PTSD may need to gain trust in providers or in the overall system prior to engaging in EBPs (e.g., [Hundt et al., 2015](#); [Hundt et al., 2017a](#)). It may also be that individuals who are more likely to engage in any psychotherapy are more likely to be open to engagement in EBP for PTSD. Veterans may also have competing interests such as family life, school, or work that prohibit initially committing to EBPs, which require weekly attendance and out of session assignments. This finding is an important one that may hold valuable information on how to increase rates of EBPs. It may be that having a few sessions to prepare individuals for EBPs can be helpful in engagement as well as prevention of drop out from EBPs.

There were also notable race differences that varied by treatment. Most notably, African-American veterans were more likely to complete PE, compared to getting none or some PE (only race difference for PE), and once enrolled in EBPs, more likely to complete PE, compared to early termination. African-Americans also received PE more quickly, compared to Whites. Although we need more studies on race to better understand these findings, it is encouraging to see these results. There is a prior study that found that in one VHA clinic, African-Americans showed significantly more improvement than other ethnicities in PE ([Jeffreys et al., 2014](#)), which may help explain some of these findings. This is the first known study that has been able to examine national race and ethnicity EBP differences among multiple groups at this level of granularity due to our large sample size. This is consistent with our prior findings demonstrating different healthcare utilization patterns among veteran racial/ethnic groups ([Koo et al., 2015](#)).

We found that the relationship between gender and EBPs was somewhat complex. While women were more likely to receive more CPT sessions compared to men, being female was not associated with completing PE. Unfortunately, most clinical trials of EBPs either include only one gender or have relatively small numbers of participants, rendering appropriately powered gender comparisons challenging. In the one known study that could examine gender differences in PE at one VA specialty clinic, no gender differences were found with respect to PE treatment completion rates ([Mouilso et al., 2016](#)). This is generally consistent with other studies examining non-EBP PTSD treatment that is most frequently conducted in civilians. One factor that may be key in better understanding EBP completion and timeliness are patient preferences, yet few studies exist in this area. One study that was conducted predominantly with men found that CPT was preferred over other PTSD therapies, including PE ([Schumm et al., 2015](#)). Prior studies have found that matching patients to their preferred treatments is

associated with less likelihood of treatment drop out and demonstrated greater treatment improvements (Swift et al., 2011). Related to patient preferences, having a broader choice of delivery methods may help increase engagement and completion. For example, telehealth or web-based delivery of psychotherapy may assist veterans with busy lives who are trying to balance work and home duties.

Not surprisingly, younger age was associated with lower likelihood of EBP completion, more drop out, and slower time to receipt of EBPs. This is consistent with several studies that have found younger veterans to be less likely to engage in care (Jeffreys et al., 2014; Kehle-Forbes et al., 2016). We have previously found that both younger age and longer time to care were associated with less PTSD symptom improvement (Maguen et al., 2014).

There were several clinical factors that impacted completion and timeliness of care. Comorbid conditions including pain, TBI, depression, alcohol or drug abuse or dependence, and suicide ideation or attempt were associated with receiving more PE sessions and timelier PE; however, they were not associated with receiving more CPT sessions or timelier CPT. In addition, having a schizophrenia diagnosis was negatively associated with receiving more sessions of both PE, and negatively associated with timelier PE. More studies are needed to best understand how to best triage individuals with comorbid mental health disorders in a EBP clinical setting, and who benefits most from which treatment. Existing studies have studied provider perceptions yet there is little clinical guidance based on research. Taking medication in the year before or after index date was associated with timelier PE but not CPT. To best facilitate clinical care, future studies should examine how medications may differentially facilitate engagement in CPT and PE.

Although suicidal behavior can be conceptualized on a continuum, and it is important for clinicians to make clinical judgements based on all risk factors evaluated as a whole, prior studies have found that CPT can reduce suicidal ideation among active duty military personnel (Bryan et al., 2016; Gradus et al., 2013). Interestingly, Gradus et al. found that while both EBPs reduced suicidal ideation, CPT was slightly more effective, despite a small magnitude of difference. In patients with TBI, several studies have now shown that EBPs can be conducted effectively with these patients, although timing of treatment may be slower. One study also found that while both EBPs impact PTSD symptoms in those with TBI, veterans completing PE had greater symptom reduction than those completing CPT (Ragsdale et al., 2016). However, others argue that combining EBPs with cognitive rehabilitation may be key, and current trials are underway to test this hypothesis (Jak et al., 2015). In terms of drug dependence, while no known studies have examined CPT in a drug dependent population, one trial using PE combined with concurrent treatment of substance use found reductions in PTSD symptoms (Mills et al., 2012). Finally, although there is some evidence that individuals with severe mental illness (e.g., bipolar disorder and schizophrenia) may benefit from trauma-focused treatments like PE (Grubaugh et al., 2016), completion rates and drop out have not been examined in larger samples; furthermore, clinicians may have concerns about using CPT or PE in those with thought disorder symptoms.

There were several additional findings that deserve further exploration. Not surprisingly, being service connected, and having served in a combat zone were associated with receiving more sessions of PE and CPT. Those in urban areas were more likely to receive more sessions of PE than those in rural areas, and those with group or both individual and group formats of CPT were more likely to receive more sessions of CPT, relative to those receiving individual CPT. Being service connected, and having served in a combat zone were also associated with receiving timelier PE. Having served in a combat zone was associated with receiving timelier CPT, together with group format or

both individual and group formats of CPT, relative to individual CPT.

There are several limitations of our study that should be noted. First, this study was conducted with Iraq and Afghanistan War veterans and may not generalize to veterans of all eras. Second, despite the robust performance of our NLP algorithm (see Maguen et al., 2018), it is important to note that EBP cases may have been missed or misidentified. Related, CPT or PE received through non-VA care or Vet Centers would not be captured in the electronic medical record. Third, although mental health diagnoses were made by medical professionals in the patient's medical records (e.g., two or more instances of outpatient diagnoses, which optimizes positive predictive validity; Frayne et al., 2010 and Gravelly et al., 2011), diagnoses were not confirmed with gold standard assessment tools; furthermore, there is always the possibility of over or under-diagnosis based on issues such as overreporting due to secondary gain or underreporting due to stigma associated with PTSD (or other mental health disorders that may impact the results). Fourth, we were not able to include several variables that may also be associated with our outcomes such as income and region of treatment. Fifth, although we focused on PTSD concordant medications for this study, future studies may want to examine augmenting medications for PTSD (e.g., antipsychotics) or those that are used to reduce anxiety symptoms, but not recommended (e.g., benzodiazepines). An important area for future investigation is including provider-level predictors that may impact receipt of evidence-based psychotherapies. For example, providers may have beliefs about patient readiness, be reluctant to administer these treatments, or may not be trained in these treatment modalities. All of these variables may impact receipt and completion of these psychotherapies.

We found that while 22.8% Iraq and Afghanistan veterans with PTSD receiving psychotherapy in the VHA initiated EBP during the study period, only 9.1% completed treatment, and those who completed EBPs did so an average of three years after their initial mental health visit. Furthermore, significantly more veterans completed CPT than PE, and there were a number of factors that were associated with completion of EBPs, including history of MST, older age, gender, race/ethnicity, multiple deployments, and comorbid conditions including pain, TBI, depression, suicide ideation or attempt. Psychotherapy sessions prior to first EBP were associated with EBP completion, compared to early termination. Finally, year of engagement in mental health was most strongly associated with timing of care, with those engaging in later years receiving more timely care. This demonstrates that the VHA has made strides in providing timely EBPs due to several programs and initiatives. Future efforts can continue to focus on how to ensure that engaged veterans stay in treatment and complete an adequate dose of EBPs, with efforts targeted at retaining veterans who are most at risk. Future research can also use comparative effectiveness research on a larger scale to advance our understanding of group differences in EBP improvement, given that clinical trials have not had enough power to look at these differences. Some of these differences may account for some of the differential engagement and completion results, which will be important to elucidate in future studies.

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## Appendix

Table 1a

Patient characteristics by PE status (N = 265,566).

|                                           | No PE (n = 247,630, 93.3%) | 1–7 PE Sessions (n = 12,782, 4.8%) | 8+ PE Sessions (n = 5154, 1.9%) | P      |
|-------------------------------------------|----------------------------|------------------------------------|---------------------------------|--------|
| <b>Baseline age</b>                       | 32.0 (8.6)                 | 32.0 (8.3)                         | 33.6 (8.9)                      | <0.001 |
| <b>Baseline age categories</b>            |                            |                                    |                                 | <0.001 |
| <30                                       | 133,820 (54.0%)            | 6714 (52.5%)                       | 2307 (44.8%)                    |        |
| 30–39                                     | 65,605 (26.5%)             | 3621 (28.3%)                       | 1516 (29.4%)                    |        |
| 40–49                                     | 37,767 (15.3%)             | 1999 (15.6%)                       | 1063 (20.6%)                    |        |
| 50–59                                     | 9507 (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%)                          |        |
| <b>Gender</b>                             |                            |                                    |                                 | 0.918  |
| Male                                      | 221,398 (89.4%)            | 11,401 (89.2%)                     | 4606 (89.4%)                    |        |
| Female                                    | 26,227 (10.6%)             | 1381 (10.8%)                       | 548 (10.6%)                     |        |
| Missing                                   | 5 (0%)                     | 0(0%)                              | 0(0%)                           |        |
| <b>Race</b>                               |                            |                                    |                                 | <0.001 |
| White                                     | 176,405 (71.2%)            | 9086 (71.1%)                       | 3480 (67.5%)                    |        |
| Black or African American                 | 42,037 (17.0%)             | 2175 (17.0%)                       | 1092 (21.2%)                    |        |
| American Indian or Alaska Native          | 2942 (1.2%)                | 169 (1.3%)                         | 59 (1.1%)                       |        |
| Asian                                     | 3958 (1.6%)                | 212 (1.7%)                         | 94 (1.8%)                       |        |
| Native Hawaiian or Other Pacific Islander | 2946 (1.2%)                | 166 (1.3%)                         | 56 (1.1%)                       |        |
| Multi-races                               | 2988 (1.2%)                | 152 (1.2%)                         | 69 (1.3%)                       |        |
| Missing                                   | 16,354 (6.6%)              | 822 (6.4%)                         | 304 (5.9%)                      |        |
| <b>Ethnicity</b>                          |                            |                                    |                                 | <0.001 |
| Hispanic or Latino                        | 30,325 (12.3%)             | 1725 (13.5%)                       | 686 (13.3%)                     |        |
| Not Hispanic or Latino                    | 205,317 (82.9%)            | 10,544 (82.5%)                     | 4256 (82.6%)                    |        |
| Other                                     | 8028 (3.2%)                | 330 (2.6%)                         | 144 (2.8%)                      |        |
| Missing                                   | 3960 (1.6%)                | 183 (1.4%)                         | 68 (1.3%)                       |        |
| <b>Marital status</b>                     |                            |                                    |                                 | <0.001 |
| Married                                   | 121,414 (49.0%)            | 6654 (52.1%)                       | 2766 (53.7%)                    |        |
| Never married                             | 63,257 (25.5%)             | 2935 (23.0%)                       | 1190 (23.1%)                    |        |
| Divorced/separated/single                 | 57,767 (23.3%)             | 2950 (23.1%)                       | 1095 (21.3%)                    |        |
| Widow/Widower/widowed                     | 745 (0.3%)                 | 28 (0.2%)                          | 19 (0.4%)                       |        |
| Missing                                   | 4447 (1.8%)                | 215 (1.7%)                         | 84 (1.6%)                       |        |
| <b>Rurality</b>                           |                            |                                    |                                 | <0.001 |
| Highly rural                              | 2404 (1.0%)                | 131 (1.0%)                         | 43 (0.8%)                       |        |
| Rural                                     | 77,683 (31.4%)             | 3856 (30.2%)                       | 1490 (28.9%)                    |        |
| Urban                                     | 166,747 (67.3%)            | 8763 (68.6%)                       | 3611 (70.1%)                    |        |
| Missing                                   | 796 (0.3%)                 | 32 (0.3%)                          | 10 (0.2%)                       |        |
| <b>Education</b>                          |                            |                                    |                                 | <0.001 |
| <HS diploma                               | 3434 (1.4%)                | 145 (1.1%)                         | 58 (1.1%)                       |        |
| HS diploma                                | 207,813 (83.9%)            | 10,686 (83.6%)                     | 4128 (80.1%)                    |        |
| Some college                              | 18,684 (7.6%)              | 997 (7.8%)                         | 451 (8.8%)                      |        |
| Baccalaureate                             | 11,625 (4.7%)              | 666 (5.2%)                         | 343 (6.7%)                      |        |
| Post Baccalaureate                        | 2957 (1.2%)                | 155 (1.2%)                         | 110 (2.1%)                      |        |
| Unknown                                   | 3117 (1.3%)                | 133 (1.0%)                         | 64 (1.2%)                       |        |
| <b>Service branch</b>                     |                            |                                    |                                 | 0.026  |
| Air Force                                 | 13,612 (5.5%)              | 718 (5.6%)                         | 302 (5.9%)                      |        |
| Army                                      | 175,803 (71.0%)            | 9082 (71.1%)                       | 3633 (70.5%)                    |        |
| Coast Guard                               | 140 (0.1%)                 | 6 (0.1%)                           | 0 (0%)                          |        |
| Marine                                    | 41,335 (16.7%)             | 2198 (17.2%)                       | 844 (16.4%)                     |        |
| Navy                                      | 16,740 (6.8%)              | 778 (6.1%)                         | 375 (7.3%)                      |        |
| <b>Component</b>                          |                            |                                    |                                 | <0.001 |
| Active Duty                               | 165,576 (66.9%)            | 8558 (67.0%)                       | 3202 (62.1%)                    |        |
| Guard                                     | 52,599 (21.2%)             | 2639 (20.7%)                       | 1173 (22.8%)                    |        |
| Reserve                                   | 29,455 (11.9%)             | 1585 (12.4%)                       | 779 (15.1%)                     |        |
| <b>Rank</b>                               |                            |                                    |                                 | <0.001 |
| Enlisted                                  | 238,580 (96.4%)            | 12,252 (95.9%)                     | 4878 (94.6%)                    |        |
| Officer                                   | 7726 (3.1%)                | 471 (3.7%)                         | 252 (4.9%)                      |        |
| Warrant                                   | 1324 (0.5%)                | 59 (0.5%)                          | 24 (0.5%)                       |        |
| <b>Number of deployments</b>              |                            |                                    |                                 | <0.001 |
| Single deployment                         | 136,303 (55.0%)            | 6723 (52.6%)                       | 2645 (51.3%)                    |        |
| Multiple deployments                      | 110,431 (44.6%)            | 6017 (47.1%)                       | 2493 (48.4%)                    |        |
| Missing                                   | 896 (0.4%)                 | 42 (0.3%)                          | 16 (0.3%)                       |        |
| <b>Served in a combat zone</b>            |                            |                                    |                                 | <0.001 |
| No                                        | 110,777 (44.7%)            | 5689 (44.5%)                       | 2126 (41.3%)                    |        |
| Yes                                       | 63,244 (25.5%)             | 3425 (26.8%)                       | 1549 (30.1%)                    |        |
| Missing                                   | 73,609 (29.7%)             | 3668 (28.7%)                       | 1479 (28.7%)                    |        |
| <b>Military sexual trauma</b>             | 15,917 (6.4%)              | 963 (7.5%)                         | 422 (8.2%)                      | <0.001 |
| <b>Service connected</b>                  |                            |                                    |                                 | <0.001 |
| No                                        | 17,240 (7.0%)              | 468 (3.7%)                         | 122 (2.4%)                      |        |
| Yes                                       | 230,389 (93.0%)            | 12,314 (96.3%)                     | 5032 (97.6%)                    |        |

(continued on next page)

Table 1a (continued)

|                                                                  | No PE (n = 247,630, 93.3%) | 1–7 PE Sessions (n = 12,782, 4.8%) | 8+ PE Sessions (n = 5154, 1.9%) | P      |
|------------------------------------------------------------------|----------------------------|------------------------------------|---------------------------------|--------|
| Missing                                                          | 1 (0%)                     | 0 (0%)                             | 0 (0%)                          |        |
| Smoking in yr before index date                                  | 24,159 (9.8%)              | 1092 (8.5%)                        | 417 (8.1%)                      | <0.001 |
| Medication                                                       | 160,215 (64.7%)            | 8658 (67.7%)                       | 3570 (69.3%)                    | <0.001 |
| # Comorbidities                                                  | 2.5 (1.8)                  | 2.9 (1.9)                          | 2.8 (1.9)                       | <0.001 |
| Comorbidities                                                    |                            |                                    |                                 |        |
| Schizophrenia                                                    | 3627 (1.5%)                | 125 (1.0%)                         | 39 (0.8%)                       | <0.001 |
| Bipolar                                                          | 32,250 (13.0%)             | 1760 (13.8%)                       | 654 (12.7%)                     | 0.037  |
| Psychosis                                                        | 7479 (3.0%)                | 384 (3.0%)                         | 131 (2.5%)                      | 0.138  |
| Pain                                                             | 184,021 (74.3%)            | 10,420 (81.5%)                     | 4310 (83.6%)                    | <0.001 |
| TBI                                                              | 36,647 (14.8%)             | 2766 (21.6%)                       | 1161 (22.5%)                    | <0.001 |
| Depression                                                       | 156,713 (63.3%)            | 9197 (72.0%)                       | 3670 (71.2%)                    | <0.001 |
| Alcohol abuse                                                    | 55,164 (22.3%)             | 3409 (26.7%)                       | 1308 (25.4%)                    | <0.001 |
| Alcohol dependence                                               | 41,545 (16.8%)             | 2623 (20.5%)                       | 1017 (19.7%)                    | <0.001 |
| Drug abuse                                                       | 34,731 (14.0%)             | 2042 (16.0%)                       | 792 (15.4%)                     | <0.001 |
| Drug dependence                                                  | 28,052 (11.3%)             | 1681 (13.2%)                       | 641 (12.4%)                     | <0.001 |
| Suicide ideation or attempt                                      | 28,605 (11.6%)             | 2084 (16.3%)                       | 760 (14.8%)                     | <0.001 |
| # Other therapies before 1st PE                                  | N/A                        | 12.1 (21.5)                        | 13.8 (24.2)                     | <0.001 |
| # Other therapies before 1st PE, excluding those with no therapy | N/A                        | (n = 11,141)<br>13.8 (22.5)        | (n = 4528)<br>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.

Medication: Took any of 13 PTSD medications in the one year before or after index date.

Comorbidities other than suicide ideation or attempt were defined as 2+ diagnoses at outpatient or 1+ diagnosis at inpatient or fee basis settings before 09/12/2015 (the last date for PTSD diagnosis for this cohort); suicide ideation or attempt was defined as any diagnosis at any setting before 09/12/2015.

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      |
|-------------------------------------------|-----------------------------|--------------------------------------|------------------------------------|--------|
| Baseline age                              | 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%)                       | 9148 (46.7%)                       |        |
| 30–39                                     | 57,088 (26.3%)              | 8144 (28.1%)                         | 5510 (28.1%)                       |        |
| 40–49                                     | 32,532 (15.0%)              | 4456 (15.4%)                         | 3841 (19.6%)                       |        |
| 50–59                                     | 8176 (3.8%)                 | 982 (3.4%)                           | 1006 (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%)              | 3652 (12.6%)                         | 2629 (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%)              | 4843 (16.7%)                         | 3734 (19.0%)                       |        |
| American Indian or Alaska Native          | 2490 (1.2%)                 | 386 (1.3%)                           | 294 (1.5%)                         |        |
| Asian                                     | 3553 (1.6%)                 | 396 (1.4%)                           | 315 (1.6%)                         |        |
| Native Hawaiian or Other Pacific Islander | 2532 (1.2%)                 | 394 (1.4%)                           | 242 (1.2%)                         |        |
| Multi-races                               | 2583 (1.2%)                 | 376 (1.3%)                           | 250 (1.3%)                         |        |
| Missing                                   | 14,801 (6.8%)               | 1690 (5.8%)                          | 989 (5.0%)                         |        |
| Ethnicity                                 |                             |                                      |                                    | <0.001 |
| Hispanic or Latino                        | 26,666 (12.3%)              | 3778 (13.0%)                         | 2292 (11.7%)                       |        |
| Not Hispanic or Latino                    | 179,679 (82.8%)             | 23,971 (82.6%)                       | 16,467 (84.0%)                     |        |
| Other                                     | 7082 (3.3%)                 | 857 (3.0%)                           | 563 (2.9%)                         |        |
| Missing                                   | 3526 (1.6%)                 | 400 (1.4%)                           | 285 (1.5%)                         |        |
| Marital status                            |                             |                                      |                                    | <0.001 |
| Married                                   | 106,420 (49.1%)             | 14,474 (49.9%)                       | 9940 (50.7%)                       |        |
| Never married                             | 55,733 (25.7%)              | 6940 (23.9%)                         | 4709 (24.0%)                       |        |
| Divorced/separated/single                 | 50,197 (23.1%)              | 7026 (24.2%)                         | 4589 (23.4%)                       |        |
| Widow/Widower/widowed                     | 642 (0.3%)                  | 92 (0.3%)                            | 58 (0.3%)                          |        |
| Missing                                   | 3961 (1.83%)                | 474 (1.6%)                           | 311 (1.6%)                         |        |
| Rurality                                  |                             |                                      |                                    | <0.001 |
| Highly rural                              | 2042 (0.9%)                 | 317 (1.1%)                           | 219 (1.1%)                         |        |
| Rural                                     | 67,527 (31.1%)              | 9312 (32.1%)                         | 6190 (31.6%)                       |        |
| Urban                                     | 146,693 (67.6%)             | 19,280 (66.5%)                       | 13,148 (67.1%)                     |        |
| Missing                                   | 691 (0.3%)                  | 97 (0.3%)                            | 50 (0.3%)                          |        |
| Education                                 |                             |                                      |                                    | <0.001 |
| <HS diploma                               | 3059 (1.4%)                 | 362 (1.3%)                           | 216 (1.1%)                         |        |
| HS diploma                                | 182,649 (84.2%)             | 24,302 (83.8%)                       | 15,676 (80.0%)                     |        |
| Some college                              | 16,108 (7.4%)               | 2262 (7.8%)                          | 1762 (9.0%)                        |        |
| Baccalaureate                             | 9893 (4.6%)                 | 1405 (4.8%)                          | 1336 (6.8%)                        |        |

(continued on next page)

Table 1b (continued)

|                                                                   | 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      |
|-------------------------------------------------------------------|------------------------------|--------------------------------------|------------------------------------|--------|
| Post Baccalaureate                                                | 2540 (1.2%)                  | 321 (1.1%)                           | 361 (1.8%)                         |        |
| Unknown                                                           | 2704 (1.3%)                  | 354 (1.2%)                           | 256 (1.3%)                         |        |
| <b>Service branch</b>                                             |                              |                                      |                                    | <0.001 |
| Air Force                                                         | 11,818 (5.5%)                | 1580 (5.5%)                          | 1234 (6.3%)                        |        |
| Army                                                              | 153,728 (70.9%)              | 20,737 (71.5%)                       | 14,053 (71.7%)                     |        |
| Coast Guard                                                       | 129 (0.1%)                   | 11 (0.04%)                           | 6 (0.03%)                          |        |
| Marine                                                            | 36,658 (16.9%)               | 4743 (16.4%)                         | 2976 (15.2%)                       |        |
| Navy                                                              | 14,620 (6.7%)                | 1935 (6.7%)                          | 1338 (6.8%)                        |        |
| <b>Component</b>                                                  |                              |                                      |                                    | <0.001 |
| Active Duty                                                       | 145,732 (67.2%)              | 19,260 (66.4%)                       | 12,344 (63.0%)                     |        |
| Guard                                                             | 45,567 (21.0%)               | 6285 (21.7%)                         | 4559 (23.3%)                       |        |
| Reserve                                                           | 25,654 (11.8%)               | 3461 (11.9%)                         | 2704 (13.8%)                       |        |
| <b>Rank</b>                                                       |                              |                                      |                                    | <0.001 |
| Enlisted                                                          | 209,204 (96.4%)              | 27,956 (96.4%)                       | 18,550 (94.6%)                     |        |
| Officer                                                           | 6594 (3.0%)                  | 911 (3.1%)                           | 944 (4.8%)                         |        |
| Warrant                                                           | 1155 (0.5%)                  | 139 (0.5%)                           | 113 (0.6%)                         |        |
| <b>Number of deployments</b>                                      |                              |                                      |                                    | <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%)                       | 9161 (46.7%)                       |        |
| Missing                                                           | 757 (0.4%)                   | 106 (0.4%)                           | 91 (0.5%)                          |        |
| <b>Served in a combat zone</b>                                    |                              |                                      |                                    | <0.001 |
| No                                                                | 96,927 (44.7%)               | 12,976 (44.7%)                       | 8689 (44.3%)                       |        |
| Yes                                                               | 55,339 (25.5%)               | 7534 (26.0%)                         | 5345 (27.3%)                       |        |
| Missing                                                           | 64,687 (29.8%)               | 8496 (29.3%)                         | 5573 (28.4%)                       |        |
| <b>Military sexual trauma</b>                                     | 12,750 (5.9%)                | 2543 (8.8%)                          | 2009 (10.3%)                       | <0.001 |
| <b>Service connected</b>                                          |                              |                                      |                                    | <0.001 |
| No                                                                | 16,193 (7.5%)                | 1126 (3.9%)                          | 511 (2.6%)                         |        |
| Yes                                                               | 200,759 (92.5%)              | 27,880 (96.1%)                       | 19,096 (97.4%)                     |        |
| Missing                                                           | 1 (0%)                       | 0 (0%)                               | 0 (0%)                             |        |
| <b>CPT format ever received</b>                                   |                              |                                      |                                    | <0.001 |
| Individual only                                                   | N/A                          | 19,956 (68.8%)                       | 9294 (47.4%)                       |        |
| Group only                                                        | N/A                          | 6409 (22.1%)                         | 3818 (19.5%)                       |        |
| Both individual and group                                         | N/A                          | 2618 (9.0%)                          | 6495 (33.1%)                       |        |
| Missing                                                           | N/A                          | 23 (0.1%)                            | 0 (0%)                             |        |
| <b>Smoking yr before index date</b>                               | 21,319 (9.8%)                | 2710 (9.3%)                          | 1639 (8.4%)                        | <0.001 |
| <b>Medication</b>                                                 | 139,601 (64.4%)              | 19,542 (67.4%)                       | 13,300 (67.8%)                     | <0.001 |
| <b># Comorbidities</b>                                            | 2.4 (1.8)                    | 2.9 (2.0)                            | 3.2 (2.1)                          | <0.001 |
| <b>Comorbidities</b>                                              |                              |                                      |                                    |        |
| Schizophrenia                                                     | 3148 (1.5%)                  | 366 (1.3%)                           | 277 (1.4%)                         | 0.038  |
| Bipolar                                                           | 26,749 (12.3%)               | 4561 (15.7%)                         | 3354 (17.1%)                       | <0.001 |
| Psychosis                                                         | 6245 (2.9%)                  | 996 (3.4%)                           | 753 (3.8%)                         | <0.001 |
| Pain                                                              | 159,145 (73.4%)              | 23,443 (80.8%)                       | 16,163 (82.4%)                     | <0.001 |
| TBI                                                               | 30,899 (14.2%)               | 5663 (19.5%)                         | 4012 (20.5%)                       | <0.001 |
| Depression                                                        | 134,134 (61.8%)              | 20,727 (71.5%)                       | 14,719 (75.1%)                     | <0.001 |
| Alcohol abuse                                                     | 45,929 (21.2%)               | 7920 (27.3%)                         | 6032 (30.8%)                       | <0.001 |
| Alcohol dependence                                                | 33,600 (15.5%)               | 6357 (21.9%)                         | 5228 (26.7%)                       | <0.001 |
| Drug abuse                                                        | 28,149 (13.0%)               | 5288 (18.2%)                         | 4128 (21.1%)                       | <0.001 |
| Drug dependence                                                   | 22,482 (10.4%)               | 4354 (15.0%)                         | 3538 (18.0%)                       | <0.001 |
| Suicide ideation or attempt                                       | 22,842 (10.5%)               | 4779 (16.5%)                         | 3828 (19.5%)                       | <0.001 |
| # Other therapies before 1st CPT                                  | N/A                          | 10.8 (20.5)                          | 12.7 (20.6)                        | <0.001 |
| # Other therapies before 1st CPT, excluding those with no therapy | N/A                          | (n = 23,965)                         | (n = 16,701)                       | <0.001 |
|                                                                   |                              | 13.1 (21.9)                          | 14.9 (21.6)                        |        |

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.

Medication: Took any of 13 PTSD medications in the year before or after index date.

Comorbidities other than suicide ideation or attempt were defined as 2+ diagnoses at outpatient or 1+ diagnosis at inpatient or fee basis settings before 09/12/2015 (the last date for PTSD diagnosis for this cohort); suicide ideation or attempt was defined as any diagnosis at any setting before 09/12/2015.

Table 2a

Ordered logistic regression predicting likelihood of No PE sessions, Partial dose (1–7 sessions), and Full dose (8+ sessions) by patient characteristics.

|                              | Odds ratio (95% CI) | P      |
|------------------------------|---------------------|--------|
| <b>Baseline age category</b> |                     |        |
| <30                          | Ref                 |        |
| 30–39                        | 1.11 (1.06–1.15)    | <0.001 |
| 40–49                        | 1.10 (1.05–1.16)    | <0.001 |
| 50–59                        | 0.93 (0.85–1.01)    | 0.097  |
| 60+ *                        | 0.89 (0.68–1.17)    | 0.412  |
| <b>Gender</b>                |                     |        |
| Male                         | Ref                 |        |
| Female                       | 0.93 (0.88–0.99)    | 0.017  |

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Table 2a (continued)

|                                           | Odds ratio (95% CI) | P      |
|-------------------------------------------|---------------------|--------|
| <b>Race</b>                               |                     |        |
| White                                     | Ref                 |        |
| Black /African American                   | 1.09 (1.04–1.13)    | <0.001 |
| American Indian or Alaska Native          | 1.06 (0.92–1.21)    | 0.441  |
| Asian                                     | 1.10 (0.97–1.24)    | 0.130  |
| Native Hawaiian or Other Pacific Islander | 1.03 (0.89–1.18)    | 0.685  |
| Multi-races                               | 1.02 (0.88–1.17)    | 0.828  |
| Missing                                   | 1.02 (0.95–1.09)    | 0.553  |
| <b>Ethnicity</b>                          |                     |        |
| Hispanic or Latino                        | Ref                 |        |
| Not Hispanic or Latino                    | 0.93 (0.89–0.98)    | 0.005  |
| Other                                     | 0.78 (0.70–0.87)    | <0.001 |
| Missing                                   | 0.83 (0.72–0.95)    | 0.007  |
| <b>Marital status</b>                     |                     |        |
| Married                                   | Ref                 |        |
| Never married                             | 0.89 (0.85–0.92)    | <0.001 |
| Divorced/separated/single                 | 0.88 (0.84–0.91)    | <0.001 |
| Widow/Widower/widowed                     | 0.80 (0.59–1.07)    | 0.133  |
| Missing                                   | 0.99 (0.87–1.12)    | 0.896  |
| <b>Service branch</b>                     |                     |        |
| Air force                                 | Ref                 |        |
| Army                                      | 0.96 (0.90–1.03)    | 0.249  |
| Coast Guard                               | 0.56 (0.25–1.28)    | 0.173  |
| Marine                                    | 1.03 (0.95–1.11)    | 0.524  |
| Navy                                      | 0.90 (0.82–0.98)    | 0.016  |
| <b>Component</b>                          |                     |        |
| Active Duty (regular)                     | Ref                 |        |
| Guard                                     | 1.05 (1.01–1.09)    | 0.027  |
| Reserve                                   | 1.16 (1.11–1.22)    | <0.001 |
| <b>Rank</b>                               |                     |        |
| Enlisted                                  | Ref                 |        |
| Officer                                   | 1.31 (1.21–1.42)    | <0.001 |
| Warrant                                   | 0.86 (0.69–1.08)    | 0.204  |
| <b>Number of deployments</b>              |                     |        |
| Single deployment                         | Ref                 |        |
| Multiple deployments                      | 1.11 (1.07–1.14)    | <0.001 |
| Missing                                   | 0.90 (0.68–1.18)    | 0.458  |
| <b>Military sexual trauma</b>             | 1.26 (1.18–1.35)    | <0.001 |
| <b>Smoking</b>                            | 0.86 (0.82–0.91)    | <0.001 |
| <b>Medication</b>                         | 1.06 (1.02–1.09)    | 0.001  |
| <b>Schizophrenia</b>                      | 0.54 (0.46–0.63)    | <0.001 |
| <b>Bipolar</b>                            | 0.90 (0.86–0.95)    | <0.001 |
| <b>Pain</b>                               | 1.37 (1.31–1.42)    | <0.001 |
| <b>TBI</b>                                | 1.45 (1.40–1.51)    | <0.001 |
| <b>Depression</b>                         | 1.31 (1.27–1.36)    | <0.001 |
| <b>Alcohol abuse</b>                      | 1.12 (1.07–1.17)    | <0.001 |
| <b>Alcohol dependence</b>                 | 1.12 (1.07–1.17)    | <0.001 |
| <b>Drug abuse</b>                         | 0.98 (0.93–1.04)    | 0.500  |
| <b>Drug dependence</b>                    | 1.01 (0.95–1.07)    | 0.728  |
| <b>Suicide ideation or attempt</b>        | 1.28 (1.22–1.34)    | <0.001 |
| <b>Year of 1st mental health visit</b>    |                     |        |
| 2001–2005                                 | Ref                 |        |
| 2006                                      | 1.17 (1.07–1.27)    | <0.001 |
| 2007                                      | 1.15 (1.07–1.25)    | <0.001 |
| 2008                                      | 1.29 (1.19–1.39)    | <0.001 |
| 2009                                      | 1.35 (1.25–1.45)    | <0.001 |
| 2010                                      | 1.31 (1.21–1.41)    | <0.001 |
| 2011                                      | 1.24 (1.15–1.34)    | <0.001 |
| 2012                                      | 1.28 (1.18–1.38)    | <0.001 |
| 2013                                      | 1.28 (1.18–1.38)    | <0.001 |
| 2014                                      | 1.27 (1.17–1.39)    | <0.001 |
| 2015–2017                                 | 1.31 (1.12–1.52)    | <0.001 |
| <b>Rurality</b>                           |                     |        |
| Urban                                     | Ref                 |        |
| Rural                                     | 0.93 (0.90–0.96)    | <0.001 |
| Highly rural                              | 0.97 (0.83–1.13)    | 0.694  |
| Missing                                   | 0.67 (0.49–0.92)    | 0.013  |
| <b>Service connected</b>                  |                     |        |
| No                                        | Ref                 |        |
| Yes                                       | 1.82 (1.67–1.98)    | <0.001 |
| <b>Served in a combat zone</b>            |                     |        |
| No                                        | Ref                 |        |
| Yes                                       | 1.14 (1.10–1.18)    | <0.001 |

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**Table 2b**

Ordered logistic regression predicting likelihood of No CPT sessions, Partial dose (1–7 sessions), and Full dose (8+ sessions) by patient characteristics.

|                                           | Odds ratio (95% CI) | P      |
|-------------------------------------------|---------------------|--------|
| <b>Baseline age category</b>              |                     |        |
| <30                                       | Ref                 |        |
| 30–39                                     | 1.11 (1.06–1.16)    | <0.001 |
| 40–49                                     | 1.35 (1.27–1.43)    | <0.001 |
| 50–59                                     | 1.58 (1.42–1.75)    | <0.001 |
| 60+                                       | 2.14 (1.55–2.95)    | <0.001 |
| <b>Gender</b>                             |                     |        |
| Male                                      | Ref                 |        |
| Female                                    | 1.04 (0.96–1.12)    | 0.351  |
| <b>Race</b>                               |                     |        |
| White                                     | Ref                 |        |
| Black /African American                   | 1.02 (0.97–1.08)    | 0.456  |
| American Indian or Alaska Native          | 1.06 (0.90–1.25)    | 0.457  |
| Asian                                     | 1.11 (0.95–1.30)    | 0.206  |
| Native Hawaiian or Other Pacific Islander | 0.90 (0.76–1.08)    | 0.266  |
| Multi-races                               | 0.95 (0.80–1.13)    | 0.568  |
| Missing                                   | 0.94 (0.86–1.03)    | 0.182  |
| <b>Ethnicity</b>                          |                     |        |
| Hispanic or Latino                        | Ref                 |        |
| Not Hispanic or Latino                    | 1.15 (1.08–1.22)    | <0.001 |
| Other                                     | 1.07 (0.94–1.22)    | 0.294  |
| Missing                                   | 1.13 (0.95–1.35)    | 0.167  |
| <b>Marital status</b>                     |                     |        |
| Married                                   | Ref                 |        |
| Never married                             | 1.05 (1.00–1.11)    | 0.045  |
| Divorced/separated/single                 | 0.91 (0.87–0.96)    | <0.001 |
| Widow/Widower/widowed                     | 0.73 (0.51–1.04)    | 0.079  |
| Missing                                   | 0.94 (0.80–1.11)    | 0.483  |
| <b>Service branch</b>                     |                     |        |
| Air force                                 | Ref                 |        |
| Army                                      | 0.92 (0.85–1.00)    | 0.063  |
| Coast Guard                               | 0.67 (0.23–1.95)    | 0.468  |
| Marine                                    | 0.97 (0.88–1.07)    | 0.550  |
| Navy                                      | 0.93 (0.83–1.03)    | 0.171  |
| <b>Component</b>                          |                     |        |
| Active Duty (regular)                     | Ref                 |        |
| Guard                                     | 1.08 (1.03–1.14)    | 0.003  |
| Reserve                                   | 1.14 (1.08–1.22)    | <0.001 |
| <b>Rank</b>                               |                     |        |
| Enlisted                                  | Ref                 |        |
| Officer                                   | 1.43 (1.29–1.58)    | <0.001 |
| Warrant                                   | 1.02 (0.79–1.34)    | 0.856  |
| <b>Number of deployments</b>              |                     |        |
| Single deployment                         | Ref                 |        |
| Multiple deployments                      | 1.03 (0.99–1.08)    | 0.090  |
| Missing                                   | 1.20 (0.89–1.62)    | 0.227  |
| <b>Military sexual trauma</b>             | 1.15 (1.06–1.25)    | 0.001  |
| <b>Smoking</b>                            | 0.91 (0.85–0.97)    | 0.005  |
| <b>Medication</b>                         | 0.93 (0.89–0.97)    | <0.001 |
| <b>Schizophrenia</b>                      | 1.04 (0.87–1.25)    | 0.659  |
| <b>Bipolar</b>                            | 0.96 (0.91–1.02)    | 0.153  |
| <b>Psychosis</b>                          | 0.95 (0.85–1.07)    | 0.401  |
| <b>Pain</b>                               | 1.00 (0.95–1.05)    | 0.977  |
| <b>TBI</b>                                | 1.03 (0.98–1.08)    | 0.266  |
| <b>Depression</b>                         | 1.06 (1.02–1.12)    | 0.008  |
| <b>Alcohol abuse</b>                      | 1.03 (0.98–1.09)    | 0.233  |
| <b>Alcohol dependence</b>                 | 1.10 (1.04–1.16)    | 0.001  |
| <b>Drug abuse</b>                         | 0.97 (0.90–1.03)    | 0.324  |
| <b>Drug dependence</b>                    | 1.04 (0.96–1.11)    | 0.340  |
| <b>Suicide ideation or attempt</b>        | 1.03 (0.97–1.09)    | 0.388  |
| <b>Year of 1st mental health visit</b>    |                     |        |
| 2001–2005                                 | Ref                 |        |
| 2006                                      | 0.95 (0.86–1.05)    | 0.308  |
| 2007                                      | 0.92 (0.84–1.01)    | 0.089  |
| 2008                                      | 0.95 (0.87–1.04)    | 0.293  |
| 2009                                      | 1.00 (0.91–1.10)    | 0.999  |
| 2010                                      | 1.01 (0.92–1.11)    | 0.807  |
| 2011                                      | 1.06 (0.97–1.17)    | 0.203  |
| 2012                                      | 1.08 (0.98–1.19)    | 0.105  |
| 2013                                      | 1.09 (0.99–1.20)    | 0.085  |
| 2014                                      | 1.21 (1.08–1.34)    | 0.001  |
| 2015–2017                                 | 1.14 (0.94–1.38)    | 0.187  |
| <b>Rurality</b>                           |                     |        |

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Table 2b (continued)

|                                 | Odds ratio (95% CI) | P      |
|---------------------------------|---------------------|--------|
| Urban                           | Ref                 |        |
| Rural                           | 0.99 (0.95–1.03)    | 0.632  |
| Highly rural                    | 0.94 (0.78–1.13)    | 0.503  |
| Missing                         | 0.70 (0.48–1.02)    | 0.066  |
| <b>Service connected</b>        |                     |        |
| No                              | Ref                 |        |
| Yes                             | 1.32 (1.18–1.48)    | <0.001 |
| <b>Served in a combat zone</b>  |                     |        |
| No                              | Ref                 |        |
| Yes                             | 1.10 (1.05–1.15)    | <0.001 |
| missing                         | 1.01 (0.96–1.06)    | 0.715  |
| <b>CPT format ever received</b> |                     |        |
| Individual                      | Ref                 |        |
| Group                           | 1.25 (1.19–1.32)    | <0.001 |
| Both individual and group       | 5.30 (5.02–5.59)    | <0.001 |

Table 3a

Cox proportional hazards regression for completion of first PE.

|                                           | Hazard Ratio (95% CI) | P      |
|-------------------------------------------|-----------------------|--------|
| <b>Baseline age category</b>              |                       |        |
| <30                                       | Ref                   |        |
| 30–39                                     | 1.26 (1.18–1.35)      | <0.001 |
| 40–49                                     | 1.43 (1.31–1.55)      | <0.001 |
| 50–59                                     | 1.29 (1.11–1.48)      | 0.001  |
| 60 +                                      | 1.31 (0.86–1.48)      | 0.205  |
| <b>Gender</b>                             |                       |        |
| Male                                      | Ref                   |        |
| Female                                    | 0.84 (0.75–0.94)      | 0.002  |
| <b>Race</b>                               |                       |        |
| White                                     | Ref                   |        |
| Black or African American                 | 1.24 (1.15–1.33)      | <0.001 |
| American Indian or Alaska Native          | 0.99 (0.77–1.29)      | 0.961  |
| Asian                                     | 1.16 (0.94–1.42)      | 0.172  |
| Native Hawaiian or Other Pacific Islander | 0.92 (0.71–1.20)      | 0.549  |
| Multi-races                               | 1.14 (0.90–1.45)      | 0.286  |
| Missing                                   | 0.98 (0.87–1.11)      | 0.786  |
| <b>Ethnicity</b>                          |                       |        |
| Hispanic or Latino                        | Ref                   |        |
| Not Hispanic or Latino                    | 0.93 (0.85–1.01)      | 0.083  |
| Other                                     | 0.83 (0.69–1.00)      | 0.050  |
| Missing                                   | 0.76 (0.59–0.99)      | 0.038  |
| <b>Marital status</b>                     |                       |        |
| Married                                   | Ref                   |        |
| Never married                             | 0.97 (0.90–1.04)      | 0.399  |
| Divorced/separated/single                 | 0.85 (0.79–0.91)      | <0.001 |
| Widow/Widower/widowed                     | 1.04 (0.66–1.63)      | 0.869  |
| Missing                                   | 0.94 (0.75–1.18)      | 0.589  |
| <b>Service branch</b>                     |                       |        |
| Air force                                 | Ref                   |        |
| Army                                      | 0.94 (0.84–1.06)      | 0.332  |
| Coast Guard                               | –*                    | –*     |
| Marine                                    | 1.06 (0.93–1.22)      | 0.382  |
| Navy                                      | 1.01 (0.86–1.17)      | 0.948  |
| <b>Component</b>                          |                       |        |
| Active Duty (regular)                     | Ref                   |        |
| Guard                                     | 1.12 (1.04–1.21)      | 0.002  |
| Reserve                                   | 1.27 (1.17–1.38)      | <0.001 |
| <b>Rank</b>                               |                       |        |
| Enlisted                                  | Ref                   |        |
| Officer                                   | 1.39 (1.22–1.59)      | <0.001 |
| Warrant                                   | 0.77 (0.51–1.15)      | 0.195  |
| <b>Number of deployments</b>              |                       |        |
| Single deployment                         | Ref                   |        |
| Multiple deployments                      | 1.13 (1.07–1.19)      | <0.001 |
| Missing                                   | 0.78 (0.48–1.28)      | 0.329  |
| <b>Military sexual trauma</b>             | 1.39 (1.24–1.57)      | <0.001 |
| <b>Smoking</b>                            | 0.85 (0.76–0.94)      | 0.001  |
| <b>Medication</b>                         | 1.13 (1.06–1.20)      | <0.001 |
| <b>Schizophrenia</b>                      | 0.53 (0.38–0.74)      | <0.001 |

(continued on next page)

Table 3a (continued)

|                                        | Hazard Ratio (95% CI) | P      |
|----------------------------------------|-----------------------|--------|
| <b>Bipolar</b>                         | 0.89 (0.82–0.97)      | 0.009  |
| <b>Psychosis</b>                       | 0.81 (0.68–0.98)      | 0.029  |
| <b>Pain</b>                            | 1.43 (1.33–1.55)      | <0.001 |
| <b>TBI</b>                             | 1.50 (1.40–1.60)      | <0.001 |
| <b>Depression</b>                      | 1.22 (1.14–1.30)      | <0.001 |
| <b>Alcohol abuse</b>                   | 1.09 (1.02–1.17)      | 0.018  |
| <b>Alcohol dependence</b>              | 1.12 (1.03–1.21)      | 0.005  |
| <b>Suicide ideation or attempt</b>     | 1.21 (1.11–1.32)      | <0.001 |
| <b>Year of 1st mental health visit</b> |                       |        |
| 2001–2005                              | Ref                   |        |
| 2006                                   | 1.41 (1.21–1.64)      | <0.001 |
| 2007                                   | 1.43 (1.23–1.65)      | <0.001 |
| 2008                                   | 1.77 (1.54–2.05)      | <0.001 |
| 2009                                   | 2.08 (1.80–2.40)      | <0.001 |
| 2010                                   | 2.34 (2.02–2.70)      | <0.001 |
| 2011                                   | 2.38 (2.06–2.76)      | <0.001 |
| 2012                                   | 2.83 (2.44–3.28)      | <0.001 |
| 2013                                   | 2.88 (2.46–3.36)      | <0.001 |
| 2014                                   | 4.25 (3.60–5.01)      | <0.001 |
| 2015–2017                              | 6.08 (4.70–7.88)      | <0.001 |
| <b>Rurality</b>                        |                       |        |
| Urban                                  | Ref                   |        |
| Rural                                  | 0.91 (0.85–0.97)      | 0.003  |
| Highly rural                           | 0.85 (0.63–1.14)      | 0.277  |
| Missing                                | 0.56 (0.30–1.04)      | 0.068  |
| <b>Service connected</b>               |                       |        |
| No                                     | Ref                   |        |
| Yes                                    | 2.35 (1.96–2.81)      | <0.001 |
| <b>Served in a combat zone</b>         |                       |        |
| No                                     | Ref                   |        |
| Yes                                    | 1.26 (1.18–1.35)      | <0.001 |
| missing                                | 1.05 (0.98–1.13)      | 0.130  |

\* Coast guard group had no observation of outcome (full-dose PE), so no estimate of HR.

Table 3b

Cox proportional hazards regression for completion of first CPT.

|                                  | Hazard Ratio (95% CI) | P      |
|----------------------------------|-----------------------|--------|
| <b>Baseline age category</b>     |                       |        |
| <30                              | Ref                   |        |
| 30–39                            | 1.11 (1.07–1.15)      | <0.001 |
| 40–49                            | 1.29 (1.23–1.35)      | <0.001 |
| 50–59                            | 1.45 (1.35–1.56)      | <0.001 |
| 60 +                             | 1.92 (1.57–2.34)      | <0.001 |
| <b>Gender</b>                    |                       |        |
| Male                             | Ref                   |        |
| Female                           | 1.03 (0.98–1.09)      | 0.272  |
| <b>Race</b>                      |                       |        |
| White                            | Ref                   |        |
| Black or African American        | 0.99 (0.95–1.03)      | 0.625  |
| American Indian or Alaska Native | 1.06 (0.95–1.19)      | 0.304  |
| Asian                            | 1.07 (0.95–1.19)      | 0.273  |
| Native Hawaiian or Other Pacific | 0.93 (0.82–1.06)      | 0.304  |
| <b>Islander</b>                  |                       |        |
| Multi-races                      | 0.94 (0.83–1.06)      | 0.309  |
| Missing                          | 0.97 (0.90–1.03)      | 0.325  |
| <b>Ethnicity</b>                 |                       |        |
| Hispanic or Latino               | Ref                   |        |
| Not Hispanic or Latino           | 1.13 (1.08–1.18)      | <0.001 |
| Other                            | 1.08 (0.98–1.19)      | 0.131  |
| Missing                          | 1.14 (1.00–1.29)      | 0.045  |
| <b>Marital status</b>            |                       |        |
| Married                          | Ref                   |        |
| Never married                    | 1.04 (1.00–1.08)      | 0.028  |
| Divorced/separated/single        | 0.93 (0.90–0.96)      | <0.001 |
| Widow/Widower/widowed            | 0.72 (0.56–0.93)      | 0.013  |
| Missing                          | 0.99 (0.88–1.12)      | 0.915  |
| <b>Service branch</b>            |                       |        |
| Air force                        | Ref                   |        |
| Army                             | 0.94 (0.89–1.00)      | 0.060  |

(continued on next page)

Table 3b (continued)

|                                        | Hazard Ratio (95% CI) | P      |
|----------------------------------------|-----------------------|--------|
| Coast Guard                            | 0.83 (0.37–1.86)      | 0.652  |
| Marine                                 | 0.99 (0.92–1.06)      | 0.691  |
| Navy                                   | 0.96 (0.89–1.04)      | 0.311  |
| <b>Component</b>                       |                       |        |
| Active Duty (regular)                  | Ref                   |        |
| Guard                                  | 1.05 (1.01–1.09)      | 0.009  |
| Reserve                                | 1.09 (1.04–1.14)      | <0.001 |
| <b>Rank</b>                            |                       |        |
| Enlisted                               | Ref                   |        |
| Officer                                | 1.32 (1.23–1.41)      | <0.001 |
| Warrant                                | 1.01 (0.83–1.22)      | 0.940  |
| <b>Number of deployments</b>           |                       |        |
| Single deployment                      | Ref                   |        |
| Multiple deployments                   | 1.02 (0.99–1.05)      | 0.122  |
| Missing                                | 1.21 (0.98–1.49)      | 0.077  |
| <b>Military sexual trauma</b>          | 1.09 (1.03–1.16)      | 0.003  |
| <b>Smoking</b>                         | 0.93 (0.88–0.98)      | 0.006  |
| <b>Medication</b>                      | 0.99 (0.96–1.02)      | 0.551  |
| <b>Schizophrenia</b>                   | 1.01 (0.89–1.14)      | 0.898  |
| <b>Bipolar</b>                         | 0.98 (0.94–1.02)      | 0.395  |
| <b>Psychosis</b>                       | 0.98 (0.91–1.06)      | 0.608  |
| <b>Pain</b>                            | 1.00 (0.96–1.04)      | 0.859  |
| <b>TBI</b>                             | 1.03 (0.99–1.07)      | 0.096  |
| <b>Depression</b>                      | 1.05 (1.01–1.09)      | 0.007  |
| <b>Alcohol abuse</b>                   | 1.02 (0.98–1.06)      | 0.283  |
| <b>Alcohol dependence</b>              | 1.06 (1.02–1.11)      | 0.005  |
| <b>Drug abuse</b>                      | 0.97 (0.92–1.02)      | 0.204  |
| <b>Drug dependence</b>                 | 1.02 (0.97–1.07)      | 0.538  |
| <b>Suicide ideation or attempt</b>     | 1.02 (0.98–1.06)      | 0.363  |
| <b>Year of 1st mental health visit</b> |                       |        |
| 2001–2005                              | Ref                   |        |
| 2006                                   | 1.20 (1.11–1.29)      | <0.001 |
| 2007                                   | 1.38 (1.28–1.48)      | <0.001 |
| 2008                                   | 1.68 (1.56–1.80)      | <0.001 |
| 2009                                   | 2.09 (1.95–2.25)      | <0.001 |
| 2010                                   | 2.51 (2.33–2.70)      | <0.001 |
| 2011                                   | 3.15 (2.92–3.39)      | <0.001 |
| 2012                                   | 3.94 (3.65–4.24)      | <0.001 |
| 2013                                   | 4.99 (4.62–5.40)      | <0.001 |
| 2014                                   | 7.30 (6.69–7.95)      | <0.001 |
| 2015–2017                              | 9.62 (8.30–11.16)     | <0.001 |
| <b>Rurality</b>                        |                       |        |
| Urban                                  | Ref                   |        |
| Rural                                  | 0.99 (0.96–1.03)      | 0.704  |
| Highly rural                           | 0.97 (0.85–1.11)      | 0.683  |
| Missing                                | 0.80 (0.60–1.07)      | 0.133  |
| <b>Service connected</b>               |                       |        |
| No                                     | Ref                   |        |
| Yes                                    | 1.15 (1.06–1.26)      | 0.002  |
| <b>Served in a combat zone</b>         |                       |        |
| No                                     | Ref                   |        |
| Yes                                    | 1.06 (1.03–1.10)      | <0.001 |
| missing                                | 1.01 (0.97–1.04)      | 0.690  |
| <b>CPT format ever received</b>        |                       |        |
| Individual                             | Ref                   |        |
| Group                                  | 1.21 (1.16–1.25)      | <0.001 |
| Both individual and group              | 3.07 (2.97–3.17)      | <0.001 |

Table 1a

Logistic regression (comparing PE completers and early terminators).

|                              | Odds ratio (95% CI) | P      |
|------------------------------|---------------------|--------|
| <b>Baseline age category</b> |                     |        |
| <30                          | Ref                 |        |
| 30–39                        | 1.20 (1.10–1.30)    | <0.001 |
| 40–49                        | 1.45 (1.31–1.61)    | <0.001 |
| 50–59                        | 1.57 (1.31–1.88)    | <0.001 |
| 60+                          | 1.69 (0.99–2.89)    | 0.055  |
| <b>Gender</b>                |                     |        |
| Male                         | Ref                 |        |
| Female                       | 0.87 (0.76–0.99)    | 0.038  |

(continued on next page)

Table 1a (continued)

|                                           | Odds ratio (95% CI) | P      |
|-------------------------------------------|---------------------|--------|
| <b>Race</b>                               |                     |        |
| White                                     | Ref                 |        |
| Black /African American                   | 1.20 (1.10–1.31)    | <0.001 |
| American Indian or Alaska Native          | 0.91 (0.67–1.23)    | 0.546  |
| Asian                                     | 1.08 (0.84–1.38)    | 0.561  |
| Native Hawaiian or Other Pacific Islander | 0.85 (0.63–1.16)    | 0.317  |
| Multi-races                               | 1.14 (0.86–1.53)    | 0.364  |
| Missing                                   | 0.94 (0.81–1.09)    | 0.423  |
| <b>Ethnicity</b>                          |                     |        |
| Hispanic or Latino                        | Ref                 |        |
| Not Hispanic or Latino                    | 0.98 (0.89–1.09)    | 0.769  |
| Other                                     | 1.08 (0.86–1.35)    | 0.528  |
| Missing                                   | 0.86 (0.64–1.17)    | 0.345  |
| <b>Marital status</b>                     |                     |        |
| Married                                   | Ref                 |        |
| Never married                             | 1.11 (1.02–1.21)    | 0.019  |
| Divorced/separated/single                 | 0.92 (0.85–1.00)    | 0.060  |
| Widow/Widower/widowed                     | 1.48 (0.82–2.68)    | 0.197  |
| Missing                                   | 0.90 (0.68–1.18)    | 0.441  |
| <b>Service branch</b>                     |                     |        |
| Air Force                                 | Ref                 |        |
| Army                                      | 0.97 (0.84–1.12)    | 0.670  |
| Coast Guard                               | (no observation)    | –      |
| Marine                                    | 1.06 (0.90–1.25)    | 0.496  |
| Navy                                      | 1.16 (0.96–1.40)    | 0.123  |
| <b>Component</b>                          |                     |        |
| Active Duty                               | Ref                 |        |
| Guard                                     | 1.11 (1.01–1.21)    | 0.023  |
| Reserve                                   | 1.18 (1.07–1.31)    | 0.001  |
| <b>Rank</b>                               |                     |        |
| Enlisted                                  | Ref                 |        |
| Officer                                   | 1.16 (0.98–1.36)    | 0.084  |
| Warrant                                   | 0.86 (0.53–1.39)    | 0.540  |
| <b>Number of deployments</b>              |                     |        |
| Single deployment                         | Ref                 |        |
| Multiple deployments                      | 1.05 (0.98–1.12)    | 0.160  |
| Missing                                   | 0.84 (0.47–1.53)    | 0.576  |
| <b>Military sexual trauma</b>             | 1.19 (1.02–1.38)    | 0.023  |
| <b>Smoking</b>                            | 0.97 (0.86–1.10)    | 0.673  |
| <b>Medication</b>                         | 1.09 (1.01–1.17)    | 0.021  |
| <b>Schizophrenia</b>                      | 0.81 (0.56–1.17)    | 0.263  |
| <b>Bipolar</b>                            | 0.94 (0.84–1.04)    | 0.208  |
| <b>Pain</b>                               | 1.11 (1.01–1.22)    | 0.024  |
| <b>TBI</b>                                | 1.07 (0.99–1.16)    | 0.089  |
| <b>Depression</b>                         | 0.91 (0.84–0.98)    | 0.014  |
| <b>Alcohol abuse</b>                      | 0.96 (0.88–1.05)    | 0.330  |
| <b>Alcohol dependence</b>                 | 0.98 (0.88–1.05)    | 0.631  |
| <b>Drug abuse</b>                         | 1.08 (0.96–1.23)    | 0.195  |
| <b>Drug dependence</b>                    | 1.00 (0.88–1.15)    | 0.948  |
| <b>Suicide ideation or attempt</b>        | 0.90 (0.81–1.00)    | 0.053  |
| <b># Other therapies before 1st PE</b>    | 1.00 (1.00–1.01)    | <0.001 |
| <b>Year of 1st mental health visit</b>    |                     |        |
| 2001–2005                                 | Ref                 |        |
| 2006                                      | 1.15 (0.96–1.37)    | 0.133  |
| 2007                                      | 1.05 (0.89–1.25)    | 0.538  |
| 2008                                      | 1.07 (0.90–1.25)    | 0.447  |
| 2009                                      | 1.06 (0.90–1.25)    | 0.452  |
| 2010                                      | 1.12 (0.95–1.32)    | 0.165  |
| 2011                                      | 1.06 (0.90–1.25)    | 0.502  |
| 2012                                      | 1.06 (0.90–1.26)    | 0.474  |
| 2013                                      | 0.87 (0.73–1.04)    | 0.118  |
| 2014                                      | 1.15 (0.95–1.39)    | 0.158  |
| 2015–2017                                 | 1.32 (0.96–1.80)    | 0.083  |
| <b>Rurality</b>                           |                     |        |
| Urban                                     | Ref                 |        |
| Rural                                     | 0.95 (0.88–1.02)    | 0.172  |
| Highly rural                              | 0.84 (0.59–1.19)    | 0.322  |
| Missing                                   | 0.73 (0.35–1.51)    | 0.399  |
| <b>Service connected</b>                  |                     |        |
| No                                        | Ref                 |        |
| Yes                                       | 1.47 (1.20–1.81)    | <0.001 |
| <b>Served in a combat zone</b>            |                     |        |
| No                                        | Ref                 |        |
| Yes                                       | 1.19 (1.09–1.29)    | <0.001 |
| Missing                                   | 1.08 (1.00–1.17)    | 0.050  |

**Table 1b**  
Logistic regression (comparing CPT completers and early terminators).

|                                           | Odd ratio (95% CI) | P      |
|-------------------------------------------|--------------------|--------|
| <b>Baseline age category</b>              |                    |        |
| <30                                       | Ref                |        |
| 30–39                                     | 1.11 (1.05–1.16)   | <0.001 |
| 40–49                                     | 1.34 (1.26–1.42)   | <0.001 |
| 50–59                                     | 1.56 (1.41–1.73)   | <0.001 |
| 60+                                       | 2.11 (1.53–2.92)   | <0.001 |
| <b>Gender</b>                             |                    |        |
| Male                                      | Ref                |        |
| Female                                    | 1.03 (0.96–1.11)   | 0.382  |
| <b>Race</b>                               |                    |        |
| White                                     | Ref                |        |
| Black /African American                   | 1.02 (0.97–1.08)   | 0.404  |
| American Indian or Alaska Native          | 1.07 (0.90–1.25)   | 0.449  |
| Asian                                     | 1.11 (0.95–1.30)   | 0.195  |
| Native Hawaiian or Other Pacific Islander | 0.90 (0.76–1.08)   | 0.259  |
| Multi-races                               | 0.94 (0.79–1.12)   | 0.501  |
| Missing                                   | 0.94 (0.86–1.03)   | 0.172  |
| <b>Ethnicity</b>                          |                    |        |
| Hispanic or Latino                        | Ref                |        |
| Not Hispanic or Latino                    | 1.15 (1.08–1.22)   | <0.001 |
| Other                                     | 1.07 (0.94–1.22)   | 0.305  |
| Missing                                   | 1.13 (0.95–1.34)   | 0.174  |
| <b>Marital status</b>                     |                    |        |
| Married                                   | Ref                |        |
| Never married                             | 1.05 (1.00–1.11)   | 0.047  |
| Divorced/separated/single                 | 0.91 (0.87–0.96)   | <0.001 |
| Widow/Widower/widowed                     | 0.73 (0.51–1.04)   | 0.078  |
| Missing                                   | 0.95 (0.80–1.11)   | 0.505  |
| <b>Service branch</b>                     |                    |        |
| Air Force                                 | Ref                |        |
| Army                                      | 0.92 (0.84–1.00)   | 0.050  |
| Coast Guard                               | 0.66 (0.23–1.92)   | 0.448  |
| Marine                                    | 0.97 (0.88–1.07)   | 0.535  |
| Navy                                      | 0.93 (0.83–1.03)   | 0.163  |
| <b>Component</b>                          |                    |        |
| Active Duty                               | Ref                |        |
| Guard                                     | 1.08 (1.03–1.14)   | 0.003  |
| Reserve                                   | 1.14 (1.07–1.22)   | <0.001 |
| <b>Rank</b>                               |                    |        |
| Enlisted                                  | Ref                |        |
| Officer                                   | 1.43 (1.29–1.58)   | <0.001 |
| Warrant                                   | 1.01 (0.78–1.32)   | 0.929  |
| <b>Number of deployments</b>              |                    |        |
| Single deployment                         | Ref                |        |
| Multiple deployments                      | 1.03 (0.99–1.08)   | 0.091  |
| Missing                                   | 1.21 (0.89–1.62)   | 0.220  |
| <b>Military sexual trauma</b>             | 1.15 (1.06–1.25)   | 0.001  |
| <b>Smoking</b>                            | 0.91 (0.85–0.97)   | 0.007  |
| <b>Medication</b>                         | 0.92 (0.88–0.96)   | <0.001 |
| <b>Schizophrenia</b>                      | 1.02 (0.85–1.22)   | 0.828  |
| <b>Bipolar</b>                            | 0.96 (0.90–1.01)   | 0.121  |
| <b>Psychosis</b>                          | 0.94 (0.84–1.06)   | 0.311  |
| <b>Pain</b>                               | 1.00 (0.95–1.05)   | 0.892  |
| <b>TBI</b>                                | 1.03 (0.98–1.08)   | 0.315  |
| <b>Depression</b>                         | 1.06 (1.01–1.11)   | 0.010  |
| <b>Alcohol abuse</b>                      | 1.03 (0.98–1.08)   | 0.292  |
| <b>Alcohol dependence</b>                 | 1.09 (1.03–1.16)   | 0.003  |
| <b>Drug abuse</b>                         | 0.96 (0.90–1.03)   | 0.232  |
| <b>Drug dependence</b>                    | 1.03 (0.96–1.11)   | 0.358  |
| <b>Suicide ideation or attempt</b>        | 1.02 (0.96–1.08)   | 0.542  |
| <b># Other therapies before 1st CPT</b>   | 1.00 (1.00–1.01)   | <0.001 |
| <b>Year of 1st mental health visit</b>    |                    |        |
| 2001–2005                                 | Ref                |        |
| 2006                                      | 0.96 (0.87–1.06)   | 0.433  |
| 2007                                      | 0.94 (0.85–1.03)   | 0.201  |
| 2008                                      | 0.97 (0.89–1.07)   | 0.580  |
| 2009                                      | 1.02 (0.93–1.13)   | 0.609  |
| 2010                                      | 1.04 (0.95–1.15)   | 0.396  |
| 2011                                      | 1.10 (1.00–1.21)   | 0.056  |
| 2012                                      | 1.11 (1.01–1.23)   | 0.025  |
| 2013                                      | 1.13 (1.02–1.24)   | 0.019  |
| 2014                                      | 1.25 (1.12–1.39)   | <0.001 |
| 2015–2017                                 | 1.18 (0.97–1.43)   | 0.096  |

(continued on next page)

Table 1b (continued)

|                                 | Odd ratio (95% CI) | P      |
|---------------------------------|--------------------|--------|
| <b>Rurality</b>                 |                    |        |
| Urban                           | Ref                |        |
| Rural                           | 0.99 (0.95–1.03)   | 0.672  |
| Highly rural                    | 0.94 (0.78–1.13)   | 0.526  |
| Missing                         | 0.68 (0.47–1.00)   | 0.048  |
| <b>Service connected</b>        |                    |        |
| No                              | Ref                |        |
| Yes                             | 1.32 (1.18–1.47)   | <0.001 |
| <b>Served in a combat zone</b>  |                    |        |
| No                              | Ref                |        |
| Yes                             | 1.10 (1.05–1.15)   | <0.001 |
| missing                         | 1.01 (0.96–1.06)   | 0.743  |
| <b>CPT format ever received</b> |                    |        |
| Individual                      | Ref                |        |
| Group                           | 1.25 (1.19–1.31)   | <0.001 |
| Both individual and group       | 5.29 (5.01–5.58)   | <0.001 |

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.psychres.2019.02.027](https://doi.org/10.1016/j.psychres.2019.02.027).

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