

# Measuring Use of Evidence Based Psychotherapy for Posttraumatic Stress Disorder

Brian Shiner · Leonard W. D’Avolio · Thien M. Nguyen ·  
Maha H. Zayed · Yinong Young-Xu · Rani A. Desai ·  
Paula P. Schnurr · Louis D. Fiore · Bradley V. Watts

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**Abstract** To improve methods of estimating use of evidence-based psychotherapy for posttraumatic stress disorder in the Veteran’s health administration, we evaluated administrative data and note text for patients newly enrolling in six VHA outpatient PTSD clinics in New England during the 2010 fiscal year ( $n = 1,924$ ). Using natural language processing, we developed machine learning algorithms that mimic human raters in classifying note text. We met our targets for algorithm performance as measured by precision, recall, and F-measure. We found that 6.3 % of our study population received at least one session of evidence-based psychotherapy during the initial 6 months of treatment. Evidence-based psychotherapies appear to be infrequently utilized in VHA outpatient PTSD

clinics in New England. Our method could support efforts to improve use of these treatments.

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

## Introduction

The US Veterans Health Administration (VHA) has invested heavily in efforts to develop and implement effective treatments for posttraumatic stress disorder (PTSD). Development efforts have ranged from basic science (e.g. Yehuda et al. 2010) to multi-site clinical trials (e.g. Krystal et al. 2011). Implementation efforts have included educational interventions to improve use of

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B. Shiner (✉) · M. H. Zayed · B. V. Watts  
VA Medical Center, White River Junction, VT, USA  
e-mail: brian.shiner@va.gov

B. Shiner · B. V. Watts  
VA New England Veterans Engineering Resource Center,  
White River Junction, VT, USA

B. Shiner · R. A. Desai · P. P. Schnurr  
VA National Center for PTSD, White River Junction, VT, USA

B. Shiner · Y. Young-Xu · P. P. Schnurr · B. V. Watts  
Geisel School of Medicine at Dartmouth, Hanover, NH, USA

L. W. D’Avolio · T. M. Nguyen · L. D. Fiore  
VA Boston Health Care System, Jamaica Plain, MA, USA

L. W. D’Avolio · T. M. Nguyen · L. D. Fiore  
Massachusetts Veterans Epidemiology and Information Center,  
Jamaica Plain, MA, USA

L. W. D’Avolio  
Harvard Medical School, Boston, MA, USA

Y. Young-Xu  
VA National Center for Patient Safety,  
White River Junction, VT, USA

R. A. Desai  
VA Northeast Program Evaluation Center,  
West Haven, CT, USA

R. A. Desai  
Yale University Schools of Medicine and Public Health,  
New Haven, CT, USA

L. D. Fiore  
Boston University Schools of Medicine and Public Health,  
Boston, MA, USA

psychotropic medications (e.g. Friedman 2009) and training programs in the use of specific psychotherapy protocols (e.g. Karlin et al. 2010). Two evidence-based psychotherapy protocols have been a focus of these training efforts. Prolonged exposure (PE) consists of weekly 90-min sessions of imaginal and in vivo exposure to trauma-associated stimuli. Cognitive processing therapy (CPT) consists of weekly 60-min sessions of cognitive therapy addressing maladaptive thoughts associated with traumatic events. Both have been extensively tested in veterans, and have demonstrated statistically significant and clinically meaningful improvement in their symptoms (e.g. Monson et al. 2006; Schnurr et al. 2007). Further, these treatments have been successfully implemented as part of routine practice in some VHA settings (Chard et al. 2010; Tuerk et al. 2011; Yoder et al. 2012). In addition to PE and CPT, two other evidence-based psychotherapy protocols for PTSD have received A-level recommendations (strongest evidence) in the Department of Veterans Affairs and Department of Defense Clinical Practice Guideline (VA/DOD CPG; Friedman et al. 2010), but have not been a focus of these training efforts. These include Eye movement desensitization and reprocessing therapy (EMDR; e.g. Davidson and Parker 2001) and stress inoculation therapy (SIT; e.g. Foa et al. 1999).

Given the high prevalence of PTSD among VHA patients (e.g. Seal et al. 2007), the impairment associated with PTSD (e.g. Schnurr et al. 2009), and the amount of care the VHA provides for PTSD (e.g. Rosenheck and Fontana 2007), it is essential that this care be as effective as possible. To facilitate implementation of evidence-based practices, we need accurate measures of the use of these practices. In the case of psychotherapy, measuring whether patients receive evidence-based treatments presents a challenge. Administrative records indicate whether psychotherapy services were delivered, but do not contain information about the content of those services, such as the specific therapy protocols the therapists followed. This challenge has been especially apparent in recent efforts to determine whether VHA users with new-onset PTSD have received an adequate amount of psychotherapy. These studies have used categorical measures intended to approximate the number and timing of sessions delivered in efficacy trials. Estimates of treatment adequacy in National VHA studies have ranged from ~10 % (Seal et al. 2010) to ~30 % (Spoont et al. 2010), depending on the adequacy and inclusion criteria. Further, if there is systematic miscoding in administrative records, these studies may not accurately estimate the amount of psychotherapy veterans actually receive.

Prior work manually examining treatment notes showed that many encounters administratively coded as psychotherapy sessions were actually other services such as

intakes, case management, and psychological testing (Shiner et al. 2011). Similarly, manual review of note text has revealed that misattribution of administrative codes in VA substance abuse treatment has led to overestimations of the quality of substance abuse treatment (Harris et al. 2010). While scaling up manual review of treatment notes to a regional or national study would be labor-intensive, automated coding of note text using natural language processing is one method that has the potential to efficiently glean important information from this large and unstructured data source (e.g. Meystre et al. 2008).

In this study, we sought to address two limitations of prior research on automated coding of psychotherapy notes for VHA patients with PTSD, namely that this research was conducted on a small sample at a single site, and the method was not used to identify specific types of evidence-based psychotherapy such as PE and CPT (Shiner et al. 2011). We examined care across six sites following extensive training and implementation efforts aimed at increasing the use of evidence-based psychotherapies for PTSD. Our goal was to apply automated coding to a large pool of treatment notes, enabling information capture far beyond what is feasible with manual chart review. Our hypotheses were: (1) that automated coding would be able to discriminate between note text describing psychotherapy and other services when applied to multiple sites; and (2) that automated coding would be able to detect and discriminate between note text describing psychotherapy in general and specific evidence-based psychotherapy protocols for PTSD.

In order to maximize the likelihood of finding examples of the delivery of evidence-based psychotherapy in routine practice, we used a sample of new patients receiving care in the VHA's specialized outpatient PTSD clinics (called PTSD Clinical Teams or PCTs), and used treatment data from 2010, the most recent year available. This allowed for the effects of VA PE and CPT training programs, which began in 2006 (Karlin et al. 2010), and the VA Uniform Mental Health Services Package, which mandated the availability of these treatments in VA clinics beginning in 2008 (Kussman 2008) to be seen. We also included SIT and EMDR as evidence-based psychotherapies as they have received A-level recommendations in the VA/DOD CPGs (Friedman et al. 2010). However, these two treatments were neither included in the 2008 mandate nor were they the subject of national training programs similar to those developed for PE and CPT. While this report describes the application of automated coding to psychotherapy notes in a cross-sectional population, our hope is that this work can contribute to measurement of implementation of evidence-based psychotherapy over time and at multiple levels, supporting improvement efforts both in individual clinics and across the health system.

## Methods

### Subjects

We queried the VA-New England Data Warehouse to identify our study population and to obtain administrative data about service use during the 2010 fiscal year. We identified all patients seen in a PCT clinic by identifying those who had clinic visits indicating outpatient individual or group PCT visits in the first half of the 2010 fiscal year (October 2009 through March 2010). We then removed patients who had any PCT clinic visit in the 2009 fiscal year. This mimics the case identification method recommended to PCT directors to identify “newly admitted” patients for programmatic reporting (Desai et al. 2010). Using this method, we identified 1,928 individual patients. We then used the VHA’s Medical Domain Web Service to obtain note text for all clinical encounters in the 6 months following PCT entry. We obtained a complete set of notes on all but 4 patients (99.8 %). Our final dataset contained 84,561 clinical notes and related administrative data for 1,924 patients.

### Natural Language Processing Method

We used the automated retrieval console (ARC) to analyze the content of clinical notes (D’Avolio et al. 2010, 2011). ARC is publically available software designed to perform automated text coding without the need to develop custom coding or rules. Instead, ARC ‘learns’ from a set of gold standard interpretations made by human chart reviewers and combines natural language processing and machine learning technology to replicate their judgments (Fig. 1).

### Annotation of a Reference Standard

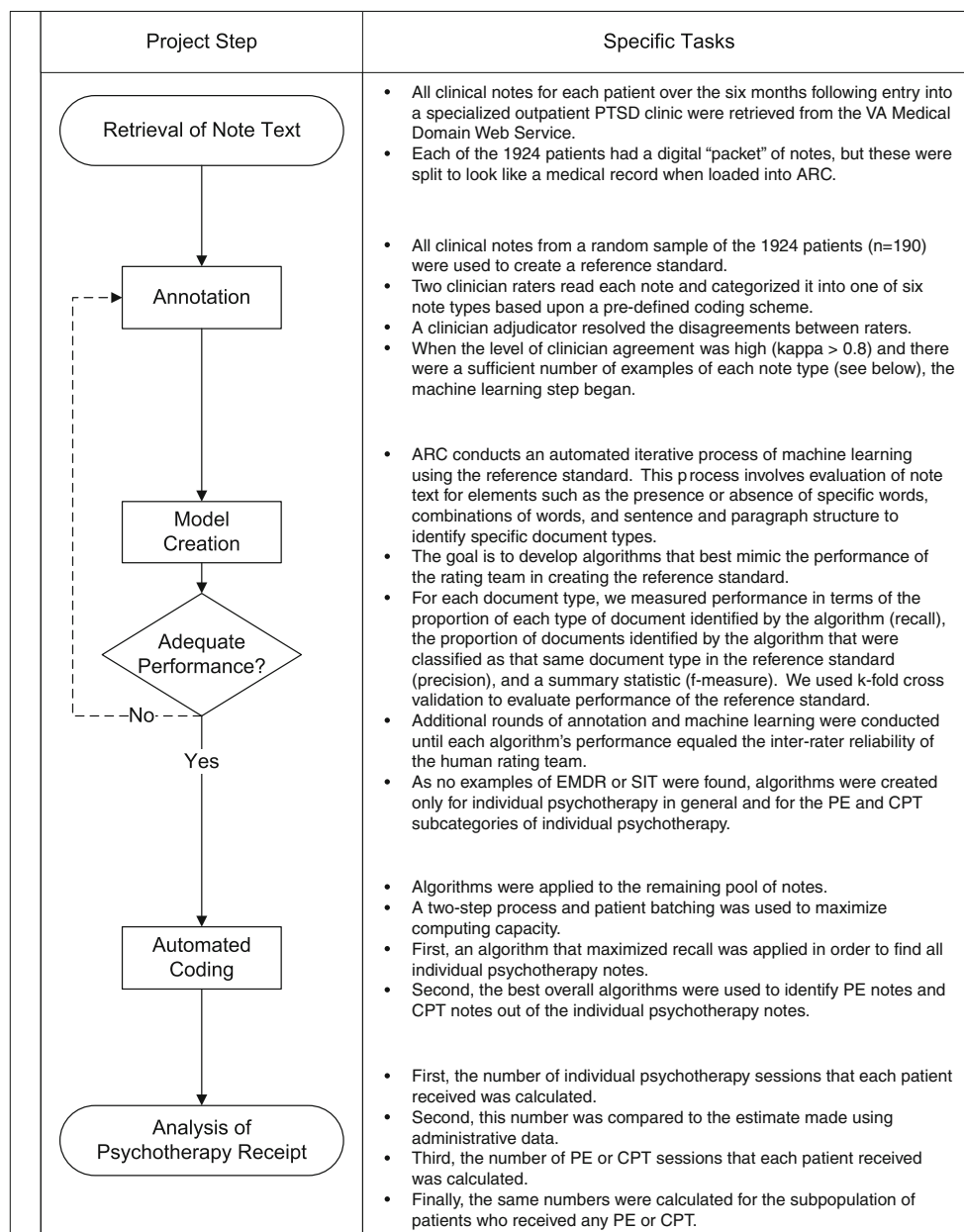
The first step in using ARC is annotation, the assignment of labels to notes so ARC can learn what to target. Annotation is simply a chart review in which raters review notes using a pre-determined coding scheme and label each note with a code that indicates their judgment. We modified an existing chart review protocol (Dieperink et al. 2005) to guide our annotation step. The original protocol included rules to classify mental health notes into five categories: individual psychotherapy, group psychotherapy, case management, medication management, and other mental health visits. As we were interested in the four individual psychotherapies recommended for PTSD in the VA/DOD CPGs (PE, CPT, EMDR, SIT), we maintained individual psychotherapy category in order to identify candidate evidence-based psychotherapy notes. The VA/DoD CPGs do not include A-level recommendations for PTSD psychotherapies delivered in a group format. Individual psychotherapy

notes that did not describe the use of one of the four evidence-based psychotherapies of interest were called “other individual psychotherapy.” The remaining categories were combined into a group called “not individual psychotherapy,” which also included non-mental health notes. Thus, all notes were coded as CPT, PE, EMDR, SIT, other individual psychotherapy, or not individual psychotherapy based on the clinician’s written description. Psychotherapy notes were still counted if they also addressed another service in addition to psychotherapy such as medication management or case management.

Coding was performed by a psychologist previously trained in the evidence-based psychotherapies and one of two psychiatrists with extensive knowledge of the therapies. For our initial round of annotation, two coders independently reviewed all notes for randomly-selected patients. The third coder independently adjudicated documents where the two primary coders disagreed ( $n = 116$  documents; 3.5 %). The coding team met to discuss adjudicated documents. At the end of the group coding round, there was an insufficient number of examples of PE and CPT documents for ARC to create a reliable model. As agreement was high ( $\kappa > 0.8$ ) in the group coding round, the psychologist coder independently completed annotation of all documents for an additional round of 100 randomly-selected patients, with the goal of finding additional PE and CPT documents.

### Model Creation

After an annotated note set has been supplied, ARC automatically iterates through various combinations of features and classifiers, evaluating the performance of each using 10-fold cross validation and the supplied reference set. Our goal in the machine learning step was to achieve performance that equaled the manual coding team’s performance (Hripcsak and Wilcox 2002), which in this case was measured with the kappa statistic. Machine learning algorithm performance is measured in terms of recall, precision, and F-measure. Recall is the proportion of each type of document identified by the algorithm. Precision is the proportion of documents identified by the algorithm that were classified as that same document type by the manual reviewers. F-measure is a weighted average of the recall and precision. Having achieved our performance goals based on an evaluation using the supplied reference set, the final step in the process is application of the ARC model to the larger set of documents not included in the reference set. We used a two-step classification to maximize computing capacity. We first separated all individual psychotherapy notes from the entire document set. We then classified evidence-based psychotherapy notes from this smaller document set.



**Fig. 1** Using the automated retrieval console to code psychotherapy notes

### Analysis of Psychotherapy Receipt

Once the automated coding process was complete, we performed analyses comparing various methods for assessing psychotherapy delivered. For each patient, we calculated psychotherapy received over their initial 6 months of treatment in the PCT in three ways: (1) we determined the mean number of individual psychotherapy sessions using individual psychotherapy current procedural technology codes as per Cully et al. (2008), (2) we determined the mean number of individual psychotherapy sessions using automated classification of all documents, and (3) we determined the mean

number of sessions of each evidence-based psychotherapy using automated coding of individual psychotherapy documents. We repeated these analyses for the subpopulation of patients who received any evidence-based psychotherapy. All statistical analyses were completed in STATA, Version 10.0 (StataCorp, College Station, TX).

### Results

The coders had a high level of agreement in the initial round of annotation of 3,306 documents for 90 randomly-

**Table 1** Reference set annotation

Classification	Round 1			Round 2			
	Coder 1 ( <i>n</i> = 3,306)	Coder 2 ( <i>n</i> = 3,306)	$\kappa$	Adjudicator ( <i>n</i> = 116)	Final group coding set ( <i>n</i> = 3,306)	Coder 1 ( <i>n</i> = 4240)	Aggregated reference set ( <i>n</i> = 7,546)
PE	18	19	0.88	0	18	40	58
CPT	50	51		1	51	55	106
SIT	0	0		0	0	0	0
EMDR	0	0		0	0	0	0
Other individual psychotherapy	486	463		48	465	597	1,062
Not individual psychotherapy	2,752	2,773		67	2,772	3,549	6,321

*PE* prolonged exposure, *CPT* cognitive processing therapy, *SIT* stress inoculation therapy, *EMDR* eye movement desensitization and reprocessing, Round 1 = group coding round, Round 2 = individual coding round

selected patients ( $\kappa$  0.88, Table 1). They did not find any examples of the use of EMDR or SIT, but did find sufficient examples of PE and CPT to perform an initial test of machine learning. The best performing model for identifying psychotherapy notes from the rest of the document set achieved our measurement targets using a combination of canonical forms of words (rule-based word forms), named entities, concept identifiers and negated unique concept identifiers (words or phrases that reliably indicate our target therapies were not used). However, using our initial document set, we could not devise a model to separate PE notes or CPT notes from the rest of the psychotherapy notes with a recall that matched our manual coding team's performance (Table 2).

Therefore, we reviewed and annotated all notes for 100 patients selected randomly out of the remaining pool of 1,834 patients. In this set of 4,240 documents, we again did not find any examples of the use of EMDR or SIT, but did find additional examples of the use of PE and CPT (Table 2). The best-performing model for separating all psychotherapy notes from the rest of the document set achieved our measurement targets using a combination of

word tokens (specific words), and the canonical forms of words plus contextual annotation. However, given our two-step process of initially identifying candidate individual psychotherapy notes from which to identify PE and CPT notes, we chose the model with the highest recall, which relied on sentence structure (Table 2). We achieved our performance targets for PE (recall of 0.90, precision of 1.00, and F-measure of 0.94) using a combination of word tokens and the canonical forms of words plus word tokens and achieved our performance targets for CPT (recall of 0.91, precision of 1.00, and F-measure of 0.95) using a combination of word tokens and the canonical forms of words plus verbs (Table 3).

In total, the automated coding process identified 12,762 individual psychotherapy notes, including 169 PE notes and 580 CPT notes. A total of 5 notes were coded as both PE and CPT after automated coding. Upon dual, independent, manual review, these notes were determined to be PE notes ( $\kappa = 1$ ). In this case, the therapist was clearly performing the PE protocol, but referred to difficulties performing specific CPT techniques with the same patient at an earlier date. As we moved from analytic methods reliant

**Table 2** Performance of machine learning algorithms in psychotherapy note classification

Study A: 3,306 documents for 90 patients				
Differentiation of:		Recall	Precision	F-measure
1	Psychotherapy notes from all clinical notes	0.92	0.92	0.92
2	PE Notes from all psychotherapy notes	0.72	0.93	0.81
3	CPT Notes from all psychotherapy notes	0.86	0.98	0.91
Study B: 7,546 documents for 190 patients (aggregated reference set)				
Differentiation of:		Recall	Precision	F-measure
1	Psychotherapy notes from all clinical notes	0.95	0.86	0.90
2	PE notes from all psychotherapy notes	0.90	1.00	0.94
3	CPT notes from all psychotherapy notes	0.91	1.00	0.95

*PE* prolonged exposure, *CPT* cognitive processing therapy



**Table 3** Comparing methods to estimate use of PE and CPT

	Estimated mean number of sessions among the total pool of patients M (95 % CI) <i>n</i> = 1,924	Estimated mean number of sessions among the pool of patients receiving one session of PE or CPT M (95 % CI) <i>n</i>
Administrative data—individual psychotherapy	9.1 (8.8, 9.4)	16.3 (14.9, 17.7) <i>n</i> = 121
NLP-any individual psychotherapy	6.6 (6.3, 6.9)	14.4 (13.1, 15.8) <i>n</i> = 121
NLP-CPT and/or PE	0.4 (0.3, 0.5)	6.1 (5.3, 7.0) <i>n</i> = 121
NLP-CPT	0.3 (0.2, 0.4)	6.1 (5.1, 7.1) <i>n</i> = 94
NLP-PE	0.1 (0.0, 0.1)	5.8 (4.1, 7.5) <i>n</i> = 29

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

on current procedural technology coding to methods reliant on automated coding of note text, our estimates of the use of evidence-based psychotherapy decreased (Table 3). Using administrative coding, it appears that patients received an average of 9.1 sessions of psychotherapy over the 6 months of care examined, whereas using automated review of note text it appears that patients received 6.6 sessions. This means that some services administratively coded as psychotherapy appeared to be other services when the notes were reviewed. A total of 121 patients (6.3 %) received at least one session of PE or CPT, and 2 of these patients received both PE and CPT. These 121 patients received an average of 6.1 sessions of evidence-based psychotherapy, although they had a total of 14.4 individual psychotherapy sessions. This means that patients who received evidence-based psychotherapy for PTSD also received an equal or greater number of sessions of other forms of individual psychotherapy as part of their course of treatment.

## Discussion

We demonstrated that automated coding of note text can identify psychotherapy notes and classify the type of therapy performed in a session as reliably as human raters, confirming our hypotheses. Our method performed well even when evaluating notes from multiple sites. Furthermore, we were able to apply this method to a large pool of treatment notes after initial development using a randomly-selected coding set. Using this method, we were able to make an estimate of the degree to which the VHA-endorsed PTSD treatment methods are being delivered. We see this project as an important first step in using NLP to determine whether psychotherapy occurred during a treatment encounter. Our hope is that this method will allow for

important analyses on the use of particular forms of psychotherapy without manual chart review.

ARC's performance in identifying and subtyping psychotherapy notes was comparable to or better than in its original applications of extracting information from colorectal, prostate, and lung cancer reports (D'Avolio et al. 2010). This work builds on recent successes using natural language processing to measure important quality and safety processes in the VHA (e.g. Murff et al. 2011). That our method uses a clinician-friendly interface, does not require custom programming, and is freely available to others may expand the generalizability to other disease states and other healthcare settings (Chapman et al. 2011).

Our estimate of the use of psychotherapy based on automated coding of note text was lower than the estimates based on administrative data. If this finding is replicated in national samples, prior studies may have overestimated psychotherapy receipt using administrative data (Cully et al. 2008; Harpaz-Rotem and Rosenheck 2011; Seal et al. 2010; Spont et al. 2010). Evidence-based therapies appear to be infrequently utilized. However, it is currently not possible to determine what the standard should be for VHA clinics delivering evidence-based psychotherapies for PTSD. This relates both to how frequently these treatments should be used and to the minimum number of sessions required to consider a course of treatment "adequate." Understanding the appropriate or even ideal use of these therapies remains to be determined and should be the focus of future work. This work would involve developing a better understanding of patient needs and preferences for treatment as well as determining the minimum number of sessions needed to produce a meaningful and sustained response. As outcomes were not routinely collected in a standardized manner across sites, our work cannot suggest an appropriate adequacy threshold. Additionally, longer

periods of observation are indicated as it is possible that patients begin evidence-based psychotherapy after the initial 6 months of participation in specialized outpatient PTSD clinics or may receive these treatments in other settings before being referred to specialized clinics.

There are several important limitations to this work. The first is that, as noted above, we do not know what the appropriate rate of the use of these treatments is. We are unaware of patient preferences regarding these treatments, or their relative preference for other evidence based treatments. For example, it is possible that patients in this study were receiving other evidence-based treatments, such as pharmacotherapy. Examination of pharmacy records was beyond the scope and focus of this work, but could be contemporaneously explored using previously-established methods (e.g. Mohamed and Rosenheck 2008). The second major limitation is that we have examined care only for veterans in New England receiving treatment in specialized PTSD clinics. Ultimately, our methods should be expanded to all Veterans receiving PTSD care at all VHA facilities. Third, we planned to examine use of SIT and EMDR, two other evidence based psychotherapies recommended for use in the VHA. We were unable to find examples in the notes we reviewed. It is possible this reflects low use of these treatments in New England or in the VHA nationally. Applying NLP to these SIT and EMDR should be the focus of future work. If it is true that these treatments are rarely used, one strategy would be to develop text searches to find possible examples and then to annotate the candidate documents for use in machine learning.

The last major limitation is that we looked only at a cross section of treatment. While this sample was adequate for testing ARC's performance, clinical measurement and improvement applications would require longitudinal data, the development methods to identify changes in performance over time (e.g. Benneyan et al. 2003), and the development of feedback displays (e.g. Curran et al. 2008) that are relevant and actionable at the clinic level and at the health system level. These efforts should be guided by a more nuanced qualitative understanding (e.g. Whitley and Crawford 2005) of individual settings not addressed in this initial work on measurement. Although a measure has been developed we have no current evidence regarding the utility of the measure to drive change or usability of the measure by mental health providers.

Despite these limitations, our findings suggest that automated coding is a promising method to identify use of evidence-based psychotherapies. To our knowledge, this is the first large-scale application of automated coding to the review of psychotherapy notes. Currently, it is technically possible to expand this work to all VHA settings where PTSD is treated, and to provide ongoing regular feedback to individual clinics about their use of these treatments.

This would allow clinicians to have a better understanding of their aggregate practices and local and national leaders to understand the effects of various implementation efforts, and ultimately improve care.

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**Ethical Standard** This work was approved by the White River Junction VA Medical Center Research and Development Committee and was granted a waiver of informed consent by the Dartmouth Committee for the Protection of Human Subjects (CPHS 22440).

**Disclaimer** The views expressed in this manuscript do not necessarily represent the views of the Department of Veterans Affairs or the United States Government. Dr. Shiner had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the results.

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