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Integrating Mobile Technology and Social Support with Cognitive Behavioral Therapy for Anger in Veterans with PTSD: A Pilot Study

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ABSTRACT

We conducted a pilot study incorporating mobile technology and social support into cognitive behavioral therapy (CBT) for anger in veterans with posttraumatic stress disorder (PTSD). $N=26$ veterans with PTSD were administered standard 12-weekly session CBT for anger. Veterans randomized to an experimental group additionally received an app (“Connectd”) enabling CBT skills use and anger self-assessment while their family/friends received a supporter’s version of the same app providing PTSD resources/psychoeducation. Experimental participants readily used Connectd, found it valuable, and were more likely to practice CBT skills compared to control participants. Findings show feasibility and potential of a novel approach to treating anger in veterans with PTSD.

KEYWORDS

Cognitive-behavioral therapy; anger; posttraumatic stress disorder; veterans

Anger difficulties are a commonly reported problem of veterans, and are associated with numerous negative outcomes such as poor physical health, social and functional impairments, and aggression (Sayer et al., 2010). In a nationally representative survey, 61.2% of U.S. veterans reported experiencing difficulties controlling anger and 23.9% reported experiencing aggressive urges over a 2-year period (Sippel et al., 2016). Recent research has linked anger to suicide (Hawkins et al., 2014), which is a growing problem for military populations and surpasses the suicide rate among demographically-matched civilians (Ursano et al., 2018). Finally, anger is a symptom of posttraumatic stress disorder (PTSD), which has been shown in veterans to be a risk factor for suicide (Doran et al., 2018; LeardMann et al., 2013) and violence (Novaco & Chemtob, 2015). For these reasons, there is a critical need to determine how to effectively treat anger in military veterans with PTSD.

Although there is no single ideal approach for treating all aspects of anger (Edmondson & Conger, 1996), meta-analyses show medium-to-large effect sizes across different treatment modalities for reducing anger problems (Glancy & Saini, 2005) and literature

reviews confirm cognitive behavioral therapy (CBT) is effective for reducing anger (Del Vecchio & O’Leary, 2004; Lee & DiGiuseppe, 2018). With respect to military populations, Gerlock (1994) reported on the effectiveness of an eight-week CBT anger management intervention for veterans and found most veterans improved, although those with psychological trauma from childhood showed less improvement. Thus, CBT techniques reduced anger problems for veterans but moderators of these effects were identified (Gerlock, 1994). A randomized trial of CBT specifically aimed at reducing anger among veterans with PTSD (Chemtob et al., 1997) found significantly reduced anger scores, attesting to the therapeutic benefits of using a structured format to address a range of cognitive, behavioral, and affective aspects of anger. Taken together, these studies suggest CBT can be an effective treatment for veterans with dysregulated anger.

Despite the existence of these evidence-based approaches, many veterans may not fully benefit from them. Some research suggests CBT is more effective when patients are highly engaged (e.g., regularly attend sessions, complete practice assignments). Indeed, treatment engagement is a predictor of good

outcomes for many psychological disorders, including PTSD (Glenn et al., 2013). Unfortunately, studies have revealed that veterans who meet criteria for PTSD and report anger problems have been shown to demonstrate poor treatment engagement (i.e., session attendance, homework compliance) and treatment outcomes (Forbes et al., 2004; Morland et al., 2012; Rosen et al., 2001). For example, the treatment dropout rate for these patients is up to 47% (see Morland et al., 2012). Thus, it appears novel strategies are needed to keep veterans engaged in treatment so they can receive the benefits of evidence-based psychological interventions.

To remediate low treatment engagement in this patient population, studies have shown treatment incorporating technology, including electronic computer guidance, videoconferencing, and in-person anger management augmented by a mobile application is typically equivalent to traditional treatment modalities, suggesting these alternate modes of delivery do not diminish treatment outcomes (Mackintosh et al., 2017; Morland et al., 2017; Van Ameringen et al., 2017). Further, there may be some benefit to including technology in treatment as it can make treatment more accessible and engaging. Mackintosh et al. (2017) offered in-person anger management training with and without an adjunctive mobile application that facilitated practicing the skills learned in treatment, provided feedback through physiological sensors, and supported communication with the therapist. These researchers found patients who received the technology component were less likely to drop out of treatment, although this result did not reach statistical significance. This result is nevertheless promising; it suggests the addition of technology did not adversely impact treatment engagement in any significant way.

One way technology might further enhance treatment engagement is by tracking symptoms and prompting patients to practice CBT skills outside of session. For traditional CBT conducted in a clinical setting, clinicians rely on their patients to remember to practice skills and to complete homework from the in-person session. Further, when patients return to the clinic, clinicians rely heavily on broad, subjective, and potentially imprecise patient recall. Time between sessions can be significant, particularly given lower engagement among veterans with PTSD and anger (Forbes et al., 2004), so it can be difficult to get an accurate view of the patient's functioning and for the patient to consistently practice skills learned. Because daily therapy sessions are not feasible, mobile technology could enable more frequent and systematic

tracking of symptoms and enable prompting of CBT skill practice, both of which would enhance the treatment process. To our knowledge, there is no research examining the effects of including such mobile technology to specifically track symptoms in CBT for anger; therefore, the utility of mobile applications that facilitate ongoing monitoring warrants further investigation.

Another method to improve treatment engagement is to involve a patient's social support network. This is not typically done in CBT, but is relevant because anger management problems often manifest with family members and friends. Indeed, research indicates veterans' social support networks can increase engagement in mental health treatment (Graziano & Elbogen, 2017). Social support has also been shown in veterans to relate to reduced violence (Van Voorhees et al., 2018) and suicide (Wilks et al., 2019). Thus, technology that provides relevant psychoeducation and connects social supporters to information about a patient's mental health problem would be correspondingly beneficial, particularly in the context of their achieving greater understanding of PTSD and anger. To the best of our knowledge, no studies have integrated technology and social support into anger treatment for veterans with PTSD.

Taken together, it follows that CBT for anger in veterans with PTSD could be enhanced by using mobile technology to encourage CBT skills use and symptom recording and also by involving social support. Accordingly, the primary goal of the current study was to conduct a pilot study testing the feasibility and acceptability of incorporating mobile technology and involving social support into CBT for anger in veterans with PTSD. We hypothesized veterans would find the technology to be an acceptable addition to treatment. Exploratory aims of this pilot study were to compare treatment engagement (e.g., treatment retention or skill use) and symptoms of PTSD and anger between participants with and without access to the technology to specifically facilitate CBT skills.

Method

Participants

For this pilot study, all procedures were approved by the Institutional Review Board at a university medical center. Participants were recruited through veterans' health facilities and organizations in the Southeastern Region of the United States. Inclusion criteria for veterans were: (1) served in one of the military branches

(Army, Navy, Marines, Air Force, or Coast Guard) since September 11, 2001; (2) met criteria for current PTSD on the Clinician Administered PTSD Scale for DSM-5 (CAPS-5; Weathers et al., 2018); (3) reported at least one episode of anger or irritability in the past week; (4) reported regular use of an iOS or Android smartphone; and (5) could identify a family member/friend over the age of 18 who regularly used an iOS or Android smartphone. Inclusion criteria for era of service was selected because anger has been identified as one of the most prevalent post-deployment adjustment problems among post-9/11 veterans (Sayer et al., 2010) particularly among those with PTSD (Novaco & Chemtob, 2015). Veterans were also informed this study involved anger management treatment and were excluded if they were currently in anger management treatment elsewhere.

Procedure

Data collection occurred from March 2017 to March 2018. Potential participants first responded to recruitment flyers by calling over the phone. After obtaining verbal consent, research staff provided information about the study and asked initial screening questions. If a veteran was interested in participating and met inclusion criteria, he/she selected a trusted family member or friend to participate in the study. The research coordinator then contacted the family member/friend to inform them about the study and inquire about their interest in participating. If both veteran and family/friend consented, an appointment was scheduled at clinic offices. There, veterans and family/friends provided written informed consent. Veterans were then evaluated by interview for PTSD using the CAPS under supervision of a licensed psychologist, and if they met inclusion criteria, completed assessment and self-report measures. Family/friends completed questionnaires about the veterans' behaviors. Veterans and family/friends were compensated for interviews.

After the baseline interview, participants were randomized to experimental or active control study conditions. Both conditions lasted 3 months and all participants received 12-sessions of CBT for Anger Management from the manual published by Substance Abuse and Mental Health Services Administration (SAMHSA; Reilly & Shopshire, 2002) which focuses on teaching relaxation, cognitive, and communication skills in order to develop individualized plans to help patients manage dysregulated anger. In the current study, individual one-on-one treatment sessions lasted

approximately 60-75 minutes and were conducted by masters or doctoral level clinicians who were supervised by a licensed clinical psychologist. Sessions were audiotaped to assess fidelity to the intervention; 10% of the sessions were randomly selected and reviewed by the supervising psychologist who provided weekly feedback to clinicians in order to ensure treatment adherence.

The two study conditions differed only in the mobile application (app) installed on their smartphones, which was one of two versions of a mobile app with the same title "Connectd." Veteran-family/friend dyads randomized to the control group ($N = 15$ dyads) received a version of the app that contained pointers to traditional outside health resources such as contact information for support groups and the VA (hereafter called the "control group").

In contrast, veteran/family-friend dyads randomized to the experimental condition ($N = 11$ dyads) received the full version of Connectd (hereafter called the "Connectd group") which allowed veterans to browse a set of curated online tools/resources and track their progress across a variety of relevant outcomes (e.g., anger levels). The data collected from all respondents focused on current emotional state (e.g., stressed vs. calm, happy vs. sad, etc.), general review of behavior in the past day (ate well/poorly, slept good/bad, active/inactive, etc.), and levels of stress related to others (e.g., coworkers, spouse, etc.). Connectd regularly prompted veterans with a small number of these questions, which were then aggregated and organized for access in a provider portal. Additionally, the application provided videos, audio recordings, and documents that facilitated the use of CBT skills. For family/friends, their mobile application provided resources and links to psychoeducation about PTSD and also prompted questions about themselves and the veterans.

The Connectd app was personalized in several ways. First, veterans were initially asked questions based on demographic characteristics or goals they expressed (e.g., do you have children, are you employed). Based on these answers, Connectd would ask suitable questions and present customized resources and content. Second, the app allowed participants to declare goals (e.g., physical fitness, improving relationships, etc.). Based on these goals, the app prompted the participants more/less frequently for updates about those subjects, so progress could be measured more efficiently. Third, Connectd personalized the timing of its data collection prompts, based on historical response times from each participant. After collecting an initial sample of data,

Connectd used machine learning techniques to gradually deduce which time periods yielded the most rapid responses and then gradually tuned its notifications to occur during those times, to maximize engagement potential.

Information gathered by Connectd from participants was securely routed to a cloud-based service that deposited the results for access by clinicians in the clinical portal. The Connectd cloud-based service parsed raw data from the participant into a more structured form, coded it as needed, and stored it in a database that the clinician could access via a clinical portal. Data in the clinical portal were shown on one main page, per veteran, to streamline clinical review time. Recent events (e.g., high levels of stress by a participant) were displayed, as well as graphs of each variable over time, with trend lines.

Measures

Demographics

At baseline, data on demographics of veteran participants were collected including gender, marital status, race/ethnicity, education, and military branch.

Feasibility

Participants answered questions regarding feasibility (e.g., “Connectd was easy to use”), acceptability (“Connectd reminders about upcoming sessions were helpful to me”), and usability (“When I was angry or stressed, the resources and tools that Connectd recommended helped me manage those feelings”) of the mobile application at post-treatment. Veterans were prompted to answer these using the following response options: Disagree, Strongly Disagree, Neither, Don’t Know, and I didn’t use.

Treatment engagement

Veterans were queried about their independent use of specific CBT skills (Anger Meter, Identifying Clues to Triggers, Deep Breathing, Progressive Muscle Relaxation, Thought Stopping, ABCD Model of Cognitive Restructuring, Assertive Responding and Behavior, Conflict Resolution Model, and Anger Control Plan). They were prompted to answer these using the following response options: “Never” = 0, “Once” = 1, “2-3 times” = 2.5, “3-4 times” = 3.5, “More than 4 times” = 5, “Don’t know/can’t recall” = 0. The total number of times skills were used was approximated by adding these response values across all specific skills queried. Additionally, after the study was complete, session progress notes were examined

to gather qualitative and quantitative data on how the Connectd app was used during sessions of the CBT for Anger protocol. Clinicians documented each CBT session where they gathered qualitative data on participants’ use of the Connectd app.

Clinical outcomes

At baseline and post-treatment the CAPS was administered by interviewers blind to participants’ study condition to measure frequency and intensity of PTSD symptoms. Additionally, anger was measured by the Dimensions of Anger Reactions (DAR) (Forbes et al., 2004), a self-report measure of anger disposition directed toward other people designed for and validated in combat veterans with PTSD.

Working alliance

At post-treatment, the Working Alliance Inventory–Short Revised (WAI-SR; Munder et al., 2010), a 12-item scale validated in outpatients to document perceptions of the quality of the therapist-client relationship, was administered to participants and therapists.

Statistical analyses

All analyses were conducted using SAS version 9.4. Demographic characteristics of the sample were described using frequencies and percentages. Chi-square and Fisher exact tests were conducted to identify potential differences in demographic characteristics between veterans who did and did not complete a post-treatment assessment and between veterans in the control and experimental groups among those who completed a post-treatment assessment.

To examine feasibility/acceptability/usability of Connectd, frequencies and percentages of participants’ responding “Agree” or “Strongly Agree” to items assessing the utility of Connectd were calculated. Statistical comparisons between groups were conducted using Fisher’s exact tests.

For treatment engagement measures including completing the CBT protocol and veteran-reported use of specific CBT techniques outside of sessions, means, standard deviations, medians, and interquartile ranges (IQRs) were calculated. WAI scores were also examined at post-treatment. Statistical comparisons between experimental and control groups on these continuous measures were accomplished using non-parametric exact Wilcoxon two-sample t-tests appropriate for small samples.

For clinical outcomes, CAPS-5 and DAR scores were compared between the control and experimental

Table 1. Demographic characteristics of veteran participants.

	Sample	
	Total (<i>N</i> = 26)	
	<i>n</i>	%
Veteran patients		
Gender		
Female	5	19.2
Male	21	80.8
Marital status		
Unmarried	3	11.5
Married	19	73.1
Married, but separated	2	7.7
Divorced	2	7.7
Race/ethnicity		
White, not Hispanic	18	69.2
Black, not Hispanic	5	19.2
Hispanic, White	1	3.8
More than one race	2	7.7
Highest education		
High School Graduate/G.E.D.	3	11.5
Associate's Degree/Partial College	13	50.0
Technical School	2	7.7
Bachelor's Degree	7	26.9
Graduate Degree	1	3.8
Military branch		
Army	15	57.7
Army Reserve	1	3.8
Army National Guard	3	11.5
Air National Guard	1	3.8
Navy	1	3.8
Air Force	1	3.8
Marines	4	15.4

groups at baseline, post-treatment, and reduction in score from baseline to post-treatment. Mean, SDs, median, and interquartile ranges (IQRs) were calculated for these measures and nonparametric exact Wilcoxon two-sample *t* tests conducted. A nonparametric Wilcoxon signed rank test was implemented to verify overall effectiveness through reduction on these measures from baseline to post-treatment among the combined sample.

Despite the number of statistical tests conducted, no correction for multiple comparisons was implemented due to the small sample size and exploratory nature of the study. Results presented should be interpreted with the understanding that *p* values displayed may not be directly compared to a desired alpha level to maintain the corresponding type 1 error rate. Nevertheless, we use the uncorrected $p < 0.05$ threshold for evaluating statistical significance to guide our discussion of the results.

Results

Table 1 shows characteristics of the entire sample. Of the $N = 26$ who enrolled initially in the pilot study, sixteen veterans completed the post-treatment assessment, including nine veterans in the control group (60%) and seven veterans in the experimental group (64%). Demographics did not differ significantly

between those who completed and did not complete the post-treatment assessment. Among the sample of veterans who completed the post-treatment assessment, the majority were between the ages of 30–39 years, 88% were male, and 56% identified Army as their military branch. Three-quarters of veterans identified themselves as White (not Hispanic). Seven of the nine veterans in the control group (78%) and four of the seven veterans in the experimental group (57%) reported being married. Although not statistically significant, mean age among veterans who completed the post-treatment assessment was slightly higher than mean age among veterans who did not complete ($M = 41.38$, $SD = 9.26$ versus $M = 34.60$, $SD = 6.65$, $p = 0.06$).

Table 2 shows that relative to veterans in the control group, a significantly higher percentage of veterans in the experimental group agreed with statements regarding the utility of Connectd resources and tools. All veterans in the experimental group agreed the resources provided by Connectd were helpful to them, relative to only three (33%) of the veterans in the control group ($p = 0.01$). Veterans in the experimental group also agreed to a significantly greater extent with statements about the helpfulness of specific features including reminders about upcoming sessions, progress reporting, and goal-tracking features. A higher percentage of veterans in the experimental group agreed that Connectd responded to their emotional state with appropriate resource and tool recommendations.

Table 3 shows overall use of the specific components of the Connectd app in the experimental group. Deep breathing, progressive muscle relaxation, and listening to relaxing sounds were the most often used tools. Assertive communication and better communication skills were followed by cognitive restructuring and thought stopping. Other PTSD psychoeducational material was also accessed (e.g., get better sleep, therapies/methods, medication).

Although Connectd permitted use of CBT skills only for the experimental group, we asked all participants to estimate utilization of specific CBT techniques at home outside of clinical sessions. We found that veterans in the experimental group were significantly more likely to independently practice CBT skills at home ($p = 0.037$), indicating a mean of 31.78 times among the control group versus 39.50 times among the experimental group during the course of CBT for anger treatment.

We analyzed therapist- and veteran-reported score statistics among the control and experimental groups

Table 2. Feasibility, acceptability, and usability of Connectd responses from veterans who completed the post-treatment assessment by experimental/control status.^b

Percentage responding "agree" or "strongly agree" ^a	Control (N = 9)		Experimental (N = 7)		p Value ¹
	n	%	n	%	
The resources provided by Connectd were helpful to me.	3	33.3	7	100.0	0.0114
The Connectd goal tracking feature was helpful to me.	2	22.2	7	100.0	0.0032
Connectd responded to my emotional state appropriately, recommending resources or tools when I needed them.	2	22.2	7	100.0	0.0032
When I was angry or stressed, the resources and tools that Connectd recommended helped me manage those feelings.	1	11.1	7	100.0	0.0014
Connectd was easy to use.	6	66.7	6	85.7	0.5846
Connectd introduced me to new resources I didn't know about before the study.	4	44.4	7	100.0	0.0337
Connectd local/national resources were useful to me.	3	33.3	6	85.7	0.0601
Connectd resources were interesting to me.	3	33.3	7	100.0	0.0114
Connectd reminded me about my upcoming weekly sessions.	1	11.1	7	100.0	0.0014
Connectd reminders about upcoming sessions were helpful to me.	1	11.1	7	100.0	0.0014
Connectd progress reporting helped me understand how my emotions and behavior change over time.	1	11.1	7	100.0	0.0014
I felt confident about the security of the personal information I provided through Connectd.	3	33.3	5	71.4	0.3147

^aOther response options include: Disagree, Strongly Disagree, Neither, Don't Know, and I Didn't use Connectd.

^bFisher's exact test.

Table 3. Utilization of Connectd app components in the experimental group.

Strategy	Total taps by veterans	Count of veterans who tapped at least once
Deep breathing	56	9
Listening to relaxing sounds	40	6
Progressive muscle relaxation	39	8
Get better sleep	27	6
Therapies/methods	22	5
Assertive communication	17	7
Better communication skills	17	6
Cognitive restructuring	17	9
Other strategies	14	7
Take a timeout	14	8
Be grateful	13	4
Conflict resolution	12	6
Be inspired by others	8	4
Eat healthier	7	3
Medication	7	5
Be more active	6	3
Thought stopping	6	4

at baseline, post-treatment, and the reduction from baseline to post-treatment. CAPS-5 and DAR score reductions from baseline to post-treatment were observed for both groups, suggesting overall effectiveness of CBT treatment ($p = 0.02$ for both measures). CAPS-5 scores decreased from baseline ($M = 50$, $SD = 15.3$) to follow-up ($M = 44$, $SD = 18.2$) in the experimental group and from baseline ($M = 49.3$, $SD = 9.9$) to follow-up ($M = 34.5$, $SD = 15.0$) in the control group; however this change was not significantly different between experimental and control groups ($p = 0.4460$). Correspondingly, DAR scores decreased from baseline ($M = 36.9$, $SD = 16.8$) to

follow-up ($M = 32.7$, $SD = 19.9$) in the experimental group and from baseline ($M = 43.3$, $SD = 7.3$) to follow-up ($M = 27.6$, $SD = 15.0$) in the control group; however this change was not significantly different between experimental and control groups ($p = 0.2626$). Working alliance as measured by veteran and clinician did not differ between the groups. Number of sessions and drop out also did not differ: median count of sessions completed was 9.0 (IQR = 9.0) among participants randomized to the control group and 10.0 (IQR = 9.0) among participants randomized to the experimental group ($p = 0.58$).

Table 4 describes how the Connectd app was used by veterans. Several themes emerged including its use in session, for symptom management, psychoeducation, interventions, relationship building, and tracking non-adherence. Therapists documented checking the Connectd clinical portal 86% of the time before seeing the veteran to review data collected by the app about the participant. Therapists and veterans explicitly discussed the app in 40% of sessions and reviewed the clinical portal together in 30% of sessions. The therapist suggested a resource for the veteran in the app in about one-third (32%) of all sessions.

Discussion

The primary goal of this pilot study was to test the feasibility and acceptability of incorporating mobile technology and involving enhanced social support into CBT for anger in veterans with PTSD. Results suggest the mobile application (Connectd) was

Table 4. Qualitative data on Connectd app used in CBT for anger.

Use	Qualitative findings
In-session	<ul style="list-style-type: none"> • Reviewed data over the past 3 months together in session, to see the progress he made. • The portal showed a spike in anger and stress a couple of days before the appointment, which was discussed during the appointment. • Discussed stress/anger correlation, .95 and talked about how general stress management tools would be helpful in anger control plan. • We looked at portal together, this time w/focus on ratings since study beginning. While all averages 3 or lower (to good) – first 6 weeks more fluctuation in anger and stress, and they followed each other in pattern. Now, anger remains low even when stress fluctuates.
Monitoring symptoms	<ul style="list-style-type: none"> • Veteran reported that even though it's repetitive (surveys), "it makes me aware of what I'm feeling, and then I think about where it's coming from."
Psycho-education	<ul style="list-style-type: none"> • Veteran found app most helpful in beginning to see videos of others "you know you're not the only one." • Particularly likes family meeting/assertiveness video, PTSD video, breathing exercises, and progressive muscle relaxation.
Self-administered interventions	<ul style="list-style-type: none"> • Veteran stated he likes using app to "wind down" with one of the progressive muscle relaxation exercises. • Veteran stated he has used videos of other veterans discussing PTSD, and breathing exercises. • Veteran likes beach/wave recording, cited as reason he was late.
Relationship building	<ul style="list-style-type: none"> • Veteran stated that participating in study with his sister has had effect of increasing communication between two and improving relationship.
Tracking non-adherence	<ul style="list-style-type: none"> • Appears that the veteran has not been using the features of the app to practice deep breathing. • It was clear that the veteran had not been using it much in the past two weeks. He had only accessed it twice in a 10-day period to do surveys. He stated that he has been very busy and stressed out because his uncle passed away.
Feedback to improve app	<ul style="list-style-type: none"> • Veteran did not like the video for "improving relationships" because content involved family meeting "which is not my situation." • Veteran reported she wished there was more of a "forced" push to do a meditation or relaxation exercise. Also she didn't like family meeting video, wished there was something for single people on improving communication with family not living with. • Veteran mentioned that he has benefited from the suggestions after he takes the surveys. He noted that the app made him more apt to be honest in his responses so he could get the right suggestions to help him in that moment.

acceptable and feasible to both veterans and their families. Compared to the control group, significantly more participants in the experimental group indicated Connectd enhanced their weekly therapy sessions and added value to treatment. Additionally, participants in the experimental condition reported significantly greater use of CBT skills than participants in the control condition. However, there was no difference in reduction of PTSD or anger symptoms between the two study groups. This result is not surprising since both groups received CBT for Anger and strong evidence supports the efficacy of CBT treatments for anger and PTSD (Hofmann & Smits, 2008; Lee & DiGiuseppe, 2018).

Measures of working alliance and treatment engagement—number of sessions attended and drop out—did not differ between groups. This is relevant because it could be argued adding a mobile app to the CBT for anger protocol might detract from implementing the therapeutic protocol as originally designed. Put differently, time spent discussing findings from the Connectd app could take away time from other components involving back and forth interaction between therapist and client as well as engagement in treatment. However, neither veterans nor clinicians in this study reported any differences between the two study conditions on working alliance and treatment attendance, suggesting that adding

mobile technology did not markedly interfere with implementing the protocol. As seen in Table 4, at least some veterans appeared to benefit directly from taking time to discuss data collected in Connectd. For this reason, the study contributes to growing literature suggesting that introducing mobile technology to CBT protocols does not adversely impact the therapeutic alliance or process.

A benefit of the Connectd application appeared to be its prompting frequent data collection. Psychotherapy is limited to a client remembering thoughts, feelings, and experiences which are vulnerable to inaccurate or incomplete recall whereas the application involved in this study could help psychotherapy clients collect tremendous amounts of data "in vivo" which can be accurately summarized for the therapy session. Qualitative data from the current study suggested participants and therapists found the data collection feature of the application helpful. Indeed, they noted the data allowed for identification of anger triggers and improved participant insight into the causes and consequences of anger. Seminal work (Skinner, 1974) acknowledges the importance of increased awareness in order to produce behavior change, therefore this improved insight may have helped participants improve their anger regulation. Future research might examine the relationship between this awareness and improved anger specifically in veterans with PTSD.

Additionally, qualitative data show benefits that would not be attained from in-person psychotherapy but instead from mobile technology used. First, the clinical portal allowed participants to visualize the progress they made based on their self-assessments of anger made on the Connectd app; such depiction of progress is not standard for CBT and would be cumbersome to attain with paper and pencil. Second, the Connectd app enabled participants to implement CBT outside the traditional clinic as well as to monitor symptoms at home, both of which have been absent from in-person CBT. Third, the mobile app helped address treatment adherence and engagement by both providing reminders to participants and providing clinicians with information about app use, which were raised in session. These multiple unique ingredients of Connectd all have potential to enhance CBT.

The pilot study's results should be understood in the context of its limitations. First, the sample size was small, limiting both statistical power and generalizability of the results. Second, while it appears Connectd was associated with improved treatment engagement in some ways (i.e., increased skill use) drop out did not differ between treatment groups. The presence of dysregulated anger is a predictor of dropout in many psychological disorders, including PTSD (e.g., Cassiello-Robbins & Barlow, 2016), and almost half of the participants in this study did not complete treatment. Therefore, more research is needed to identify factors predicting attrition and develop effective interventions aimed at improving retention. Third, all of the symptom outcome data was collected across two time points. Therefore, it is possible one condition improved more quickly than the other, but the data collected do not allow for an assessment of treatment trajectories. Fourth, the follow-up rate was low, with 60% of the control group and 64% of the experimental group completing the post-treatment assessment. Previous studies of anger treatment for veterans also show low rates of treatment completion, ranging from 53% to 82% (Morland et al., 2012). The completion rate in this study does not appear substantially different from other anger-focused treatment studies. Fifth, while PTSD symptoms were assessed as a clinical outcome, participants excluded only if they were receiving concurrent anger treatment but were not excluded if they were receiving PTSD treatment. Finally, there was no follow-up period post-treatment, which restricted assessment of how well gains were maintained in each treatment group.

Future research can work to address some of these limitations by replicating results with a larger sample and including a follow-up period after the end of treatment. Additionally, this technology is likely applicable to a wide array of other mental health conditions. For example, it could be modified to help patients with schizophrenia monitor hallucinations or patients with bipolar disorder monitor their symptoms in order to intervene early when experiencing manic symptoms. Indeed, growing literature suggests mobile applications for disorders including bipolar and major depressive disorder can reduce symptoms (Depp et al., 2015). The Connectd application we used, which was built upon a more general mHealth app framework, was customized specifically for veterans and their friends/family, setting it apart from many applications in the extant literature and thus future research regarding its utility for other psychological disorders in veterans is of interest.

The Connectd app contained multiple components. For example, the active Connectd application contained symptom monitoring, reminders to use CBT skills, and instructional videos. Dismantling research aimed at identifying which of these components was the most meaningful for patients could help improve the efficiency of treatment in the future (Kazdin, 2011). Further, the unique effects of having a mobile platform that included support into the treatment process, and provided supporters with relevant and timely resources should be explored in future research. While beyond the scope of this report, this enhanced social support leveraging a "family-centered" framework provides an innovative model for caregiver/supporter engagement described previously (Barish et al., 2014, 2019). The intent of Connected was to involve social support in the anger treatment process for veterans with PTSD and to strengthen supporter resources. The qualitative data suggests that social support may have been improved with the Connectd app. Future research is needed to examine ways to optimize outcomes for both veterans and their social support networks.

Overall, the ubiquity of mobile technology, affordability of sensors, and opportunity to leverage cutting edge data analytics presents an opening to revolutionize care monitoring in a number of aspects. The results of this pilot study support growing literature suggesting this technology is acceptable and feasible for patients seeking treatment for psychological disorders, in this case veterans with PTSD. There is a tremendous opportunity to automate the collection of more data, on a more regular basis, for the ultimate

benefit of focusing care and delivering treatment more efficiently and responsively.

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Clinical trial registration

ClinicalTrials.gov identifier NCT02954146.

Disclosure statement

Drs. Elbogen, Aralis, Lester, and Saltzman and Ms. Cassiello-Robbins have no specific financial interests and relationships and affiliations relevant to the subject of this manuscript. Dr. Barish is Chief Technology Officer at InferLink Corporation which developed the mobile application used in the current manuscript.

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