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Understanding Preferences for a PTSD Support Technology Among Veterans: A Qualitative Analysis

RESEARCH

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ABSTRACT

Background: Posttraumatic stress disorder is prevalent among combat veterans in the United States. Mobile health-based interventions have the potential to provide non-invasive, discreet support for posttraumatic stress disorder patients. There is a need to understand the design requirements for an evidence-based, user-centered application for such interventions.

Objective: This study sought to identify key expectations and requirements for the design of a veteran-centered, mobile health intervention for veterans with posttraumatic stress disorder.

Methods: Participants (N = 50) with posttraumatic stress disorder were recruited from Project Hero biking events in five locations to participate in semi-structured interviews (n = 39), one focus group (n = 9), and one dyadic interview (n = 2). Qualitative thematic analysis was performed on transcripts by two coders with software facilitation (MAXQDA 12).

Results: Thematic analysis of interviews identified key features including momentary assessment and intervention, periodic assessment and intervention features to help users recover in their long-term daily life, and connectivity.

Conclusion: The information gathered and analyzed can be used to guide development and deployment of a mobile health application for aiding veterans with their daily struggles with posttraumatic stress disorder.

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Combat veterans are susceptible to posttraumatic stress disorder (PTSD) due to exposure to violence, death, and moral situations, with an estimated 23% of United States (U.S.) veterans returning from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) having PTSD (Fulton et al., 2015). This is particularly impactful because PTSD, a mental health disorder that occurs after experiencing a traumatic event, is characterized by four main symptoms that may negatively impact reintegration with civilian society: (1) the intrusion of negative thoughts, (2) avoidance of situations reminiscent of the traumatic event, (3) negative thoughts and feelings, and (4) hyperarousal (i.e., a triggered state; American Psychiatric Association, 2013).

Veterans living with PTSD can face daily challenges in managing triggers—stimuli related to their trauma—and other symptoms (Yarvis & Schiess, 2008). The triggers they experience may be mundane, which adds to the difficulty of living with PTSD. Everyday situations can provoke stress, such as driving, engaging in relationships, sleeping, and regulating health (Plach & Sells, 2013; Punski-Hoogervorst et al., 2023). Emotional challenges, emotional distress, isolation, and living in a volatile environment are common experiences among individuals living with PTSD (Sherman et al., 2008; Vigfusdottir et al., 2025). Furthermore, loneliness and social isolation, in conjunction with mental disorders and physical disabilities, have resulted in an increased rate of suicide among OIF and OEF veterans; veterans' suicide risk is 41%–61% greater than the general U.S. population (U.S. Department of Veterans Affairs [VA], 2019). A timely and effective treatment that focuses on improving veterans' quality of life can mitigate or potentially prevent the worsening of PTSD symptoms.

An accurate diagnosis of PTSD is the first step toward helping veterans seeking treatment manage their symptoms. Currently, psychotherapy and pharmacotherapy are the two main treatment approaches for PTSD (Forbes et al., 2010; Martin et al., 2021). Psychotherapy may involve talking with a clinician or engaging in cognitive behavioral therapy, such as prolonged exposure or cognitive processing therapy (Eftekhari et al., 2013; Forbes et al., 2010). Pharmacotherapy may involve different types of medication that treat comorbid disorders such as anxiety or depression (Friedman & Davidson, 2007; Ravindran & Stein, 2009). Barriers surrounding psychotherapy include unwillingness to talk, time constraints, previously negative experiences, or the stigma associated with receiving therapy (Schaffler et al., 2022; Stecker et al., 2013). Furthermore, therapy session attendance may be affected by geographic, social, financial, and temporal barriers that inhibit the timely treatment of PTSD patients (Buzza et al., 2011; Goins et al., 2005; Hundt et al., 2018).

Barriers associated with pharmacotherapy include unwillingness to take medications, ineffectiveness of medication, or forgetting to take medication (Zullig et al., 2015). Additionally, the effectiveness of existing treatment options for PTSD is largely limited due to the inability to remotely monitor veterans' mental well-being and provide timely interventions, making clinicians reliant on subjective self-assessments (e.g., PTSD Checklist for DSM-5 [PCL-5]). As noted by Bovin et al. (2015), it is critical to continually assess PTSD symptoms, before, during, and after treatment, to verify the effectiveness of an intervention. Therefore, there is a need for a discreet and personalized approach to treatment that is tailored to veterans' needs.

The ubiquitous nature of mobile devices, coupled with recent advances in mobile devices and on-board sensor technology, has paved the way for mobile health (mHealth)-based interventions that can facilitate non-invasive, discreet technology-based care for patients. While mHealth interventions have demonstrated efficacy in monitoring and treating patients with chronic illnesses (Farias et al., 2020; Franklin et al., 2003; Rami et al., 2006) and lifestyle (Collins et al., 2003; Singh et al., 2024), relatively less attention has been focused on veterans with PTSD. Although the U.S. Department of Veterans Affairs (VA), in partnership with the Department of Defense (DoD), developed 'PTSD Coach', a mobile application that helps manage symptoms of PTSD, to provide Cognitive Behavioral Therapy (CBT)-based interactive tools for veterans (Owen et al., 2015), recent reviews highlighted the need for evidence-based, user-centered designs to engage patients and sustain treatment adherence (Rodriguez-Paras et al., 2017; Sander et al., 2020). To address this gap, this qualitative study aimed to identify key requirements for the design of a veteran-centered, mHealth intervention, focusing on key expectations, requirements, and concerns towards technology-based interventions.

METHODS

PARTICIPANTS

Fifty veterans were recruited for interviews and focus groups. Thirty-nine veterans participated in interviews and nine veterans participated in a focus group and two veterans participated in a dyadic interview. All participants were combat veterans, diagnosed with PTSD, and recruited from bicycle riding events organized by Project Hero, an organization dedicated to helping combat veterans and first responders diagnosed with PTSD. To safeguard the participants' privacy and minimize the risk of deductive disclosure, demographic data were not collected.

STUDY TEAM

The interviews were conducted by three doctoral students and one assistant professor. All the interviewers had been

trained in qualitative research (through graduate level courses and experience in a research-intensive university) and ethics in research (Certified for Responsible Conduct of Research program from the Collaborative Institutional Training Initiative [CITI Program] prior to the study. The study team did not establish a relationship with the participants prior to the study.

PROTOCOL

The interviews and focus groups took place during five bicycle riding events, sponsored by Project Hero, in hotels across California, Florida, Minnesota, Texas, and Washington, DC. The participants were approached, face-to-face, at the Project Hero events and were asked to participate in an interview covering topics of living with PTSD and preferences for self-management technologies. Depending upon interviewee preference, interviews were conducted immediately or in the ensuing days after participation in the bike rides. After debriefing on the interview topic, reviewing the informed consent and gaining participants' consent to audio-record the conversations, the interviews and focus groups began. Semi-structured interview-style questions were used to gain the requirements for PTSD mitigation technology from the participants. The interview protocol contained imagination exercises (i.e., imagine having access to a tool), expectations for the tool, and expectations of what other features for the mitigation should have. Due to the nature of semi-structured interviews, not every interview included every question, and not all participants responded to every question; however, depending on the conversation, additional questions and follow-ups were presented to capture interesting thoughts or ideas shared by participants.

The interviews were conducted in a private area (i.e., rooms or tables apart from others) where only the participants and researchers were present and lasted less than an hour. Upon completion, the participants received a $50 Amazon gift card. There were no follow-up interview sessions, clarifications on content or review of quotes with the participants. The study was approved by the Texas A&M University Institutional Review Board (protocol ID: IRB2017-0108D). This group of participants was also asked a distinct set of interviews and focus group questions related to experiences and challenges of living with PTSD.

QUALITATIVE DATA ANALYSIS

A transcription service, Temi, was used to transcribe the audio-recorded interviews preceding analysis and the transcripts were reviewed and edited, using the original audio to ensure accuracy (Temi, 2019). Thematic analysis of the interviews was conducted by two coders. Thematic analysis was selected due to the construction of the protocol to elicit feedback and thoughts on various topics and allow themes to emerge, rather than clear theories constructed ahead of time (Braun & Clarke, 2006; Guest et al., 2012). The two coders were doctoral students in industrial and systems engineering trained in qualitative methods and analysis, requirement gathering and human factors and systems engineering methods; both coders had three years of experience conducting thematic analysis and user experience methods for exploratory and evaluative techniques as well as previous work involving veterans. The two coders completed the following steps, separately and sequentially, and then met to discuss any discrepancies, taking into account their perceptions regarding design requirements and understanding of PTSD healthcare for veterans: code creation, initial coding, and focused coding.

Code creation consisted of reading through the semi-structured interview guide and creating codes related to the prompts, along with memos describing the expected content for each code; the coders then discussed the names and concepts behind the codes, ending with one set of initial codes. Initial coding consisted of coding each interview separately within the initial codes and then discussing coding process and merging the projects to have a cohesive complete initial coded set. The focused coding consisted of granularizing each of the initial codes to contain the most basic level of information in a sub-code, or focused code; these individually coded sections were discussed and merged for a unified focused code set. The thematic coding process entailed a deeper discussion of the themes and constructs that emerged from the analysis. Initial codes and focus codes were grouped together based on thematically similar features relating to technology preferences. As this process was done with both coders, all definitions were agreed upon during thematic coding sessions and a final set was determined. After coming to a consensus, the themes were discussed among the other authors, and changes were made as necessary, including renaming of themes and definitions of the constructs. MAXQDA 12 software was used to complete the analysis (VERBI Software, 2018).

RESULTS

Four themes were identified from the thematic analysis. Table 1 displays the themes, subthemes, number of participants voicing the theme and definitions of the subthemes. Counts presented for themes, subthemes, and other factors are presented using n = #, with # signifying the number of participants who shared a thought relating to that construct. Quotes supporting the subthemes were deidentified to preserve anonymity. Participants did not revise their transcripts or quotes and did not provide feedback on these findings.

THEME	SUBTHEMES	COUNT	SUBTHEME DEFINITION
Momentary assessment and intervention	Alarm	36	An indication that veterans are triggered and should use a mitigation technique
	Heart rate	21	The use of heart rate to see if veterans are triggered or not
	Mitigation techniques	21	The use of a variety of techniques to help veterans cope during the triggered state
Periodic assessment and intervention	Tracking	26	The collecting of physiological and self-report data to provide context for triggered states
	Early prediction	23	An algorithm that can predict the onset of the triggered state and recommend actions to take to calm down
	Memory aids	18	Reminders about daily activities and health care practices to improve quality of life
	Additional help	18	A virtual coach or companion to help veterans with their activities
	Teaching	11	The ability to teach veterans about how to improve their wellbeing through verified methods
Connectivity	Contacts list	30	A list of close contacts that veterans can reach out to in an emergency
	Clinician	26	The ability to connect with veteran's clinician when needed
	Social platform	26	A social platform that allows veterans to connect with each other and their health care providers
	Communication	22	The ability to communicate through various methods
Other preferences	Easy to use	31	The tool should be easy to use for all
	Wearable	19	The tool should be worn on the body
	Commands	17	The tool will tell veterans what to do when triggered
	Customizable	14	The tool should have customizable features
	Discreet	14	The tool should not appear to be a unique device for veterans with PTSD

Table 1 Themes and Subthemes Identified from the Thematic Analysis.

MOMENTARY ASSESSMENT AND INTERVENTION

Some participants mentioned features of the technology that would aid them momentarily (to prepare for and overcome triggered states). These features address particular moments in time in which assistance for or recognition of their hype-aroused or triggered state is needed to take next steps to return to their previously nominal state.

Alarm

Participants had many preferences for the type of alarm they would receive from such technology when they were in a stressful moment or triggered state. For the modality of the alarm, the participants mentioned three main categories which included vibrations or buzzes (n = 24), audio (n = 13), or visual (n = 9) as well as a combination of any of the three (n = 5). Beyond the modality of the alarm, some participants mentioned certain characteristics of the alarm that they expected from the technology. The alert should have the characteristics of a notification (n = 13), in the sense that it gains their attention and brings relevant information about the nature of the alert to their awareness. Further, they want the alert to come in early (n = 9). Also, they want the alert to be personal and discreet (n = 7), so that they were the only ones aware of the alert. Overall, participants want an effective alerting method in which they are made aware of their state in a discreet manner.

Heart Rate

Many of the participants (n = 21) expressed their desire for the technology to measure their heart rate. They want to be able to always see their heart rate in a continuously monitored manner. Because they believed that their heart rate is a good indication of their state, triggered or not, a technology that detects their heart rate can alert them of their triggered state.

Mitigation Techniques

Some participants (n = 21) stated that they want the technology to have mitigation techniques that will help them to cope when in a triggered state. Some participants

(*n* = 17) mentioned their desire for a relaxation feature to help mitigate their PTSD symptoms. Some of the relaxation techniques included breathing exercises, meditation, and yoga. They want these relaxation techniques to be readily available and viewable on the technology. Other participants (*n* = 12) stated they want a feature on the technology to help them recenter and focus on reality during a stressful moment. While this is a technique that some participants had been working on improving, they thought adding it to the technology would be helpful. It was stated that a focusing tool would help to bring them back to reality and focus on the present, thus alleviating some of the negative consequences of PTSD, at least momentarily.

Some participants (*n* = 8) mentioned distractions such as games, challenging activities or puzzles, and stressors for desensitization that might help them overcome the triggered state. A few participants mentioned other features that might be helpful, including uplifting quotes. One participant stated:

> That's kinda [sic] the way I would do it. It was kind of a tiered approach, you know, hey, get you in touch with a medical professional for lack of a better term, a specific term anyway, and then your, your peers and buddies. Because if it's really an issue of life or limb health, you want the healthcare person first. If it's a hey, you're just having a rough day, that's, that would be the next order (Participant 036).

PERIODIC ASSESSMENT AND INTERVENTION

Some participants mentioned several periodic assessments and intervention features that would aid them in their long-term care; these features were focused on longer periods of time and referenceable when wanted, as opposed to needed in a particular moment, contrasting the momentary assessments and interventions theme. These features also address overall health from a higher viewpoint, rather than granular information for a specific need. By considering their preferences for features that may have a long-term impact on their health, they were planning for the future and were hopeful in the recovery process.

Tracking

One component of the early prediction subthemes was the technology's ability to track the participants' activities. Some participants (*n* = 26) believed that if the technology was tracking, collecting, and analyzing the data with "good intentions" and the purpose to help them improve their health, it was a good thing to do. Further, some participants thought that the technology should track every component of their life so that the predictive measures can be more accurate and helpful for them. They also believed the technology should send the data to their clinicians so that clinicians have a better idea of how their time has been since the last visit and provide better recommendations for improving their health.

Some participants thought that everything should be tracked; for example, thoughts, feelings, emotions, sleep, activity, eating, nutrition, breathing, panic attacks, reactions, symptoms, blood pressure, sweat, heart rate, and any other physiological data. While all of these tracked measures can be combined into an accurate model for predictive health, each component on its own can be analyzed and improved by the veterans by viewing the measures, recognizing the context surrounding the measures and planning for future actions to account for the situations that may arise. Some participants thought that they could talk to their clinician about these tracked measures and work on ways to improve their situation.

Early Prediction

This subtheme captures some participants' *(n* = 23) desire to have a primary feature for early prediction. They want the technology to be able to recognize or predict when they are having a hyperarousal event. They believed that by having an early alarm, they could learn from the technology and from their physiological signals, which would allow them to intervene before a stress moment brings them to a triggered state. Further, some participants stated that to be effective, the technology would need to know some of the contextual factors surrounding their life such as their activity, location, schedule, and symptoms. One participant mentioned:

> But maybe if this [tool] would give me advanced warning…maybe my heart rate kicks up to 90 out there while I'm waiting but if it tells me that when I hit like 75 or 78 or whatever when I haven't quite started to notice it yet, then giving me advanced warning, then I can work on calming myself down prior to the point where I start getting worked up and having these huge conversations in my head (Participant 010).

Memory Aids

Memory aids were mentioned (*n* = 18) to help them better remember their daily struggles and problems, which they can then report to their clinician. Specifically, they want the technology to record voice memos for retrospective listening. Additionally, they hoped that the memory aids would help improve their ability to remember certain tasks

or items over time. This feature would help provide more or better feedback to their healthcare provider and progress more quickly in their recovery. One of the participants shared their thoughts on memory aids, stating:

> Honestly if I see my mental health guy once or twice a month. I may or may not remember everything that happens in between sessions. So, if something is triggering me and this (the device) helped me with it. Now you have a way to monitor the activities I have done and what my heart rate is. This would be a way to have an accurate picture of that (Participant 026).

Additional Help

Aside from the above, some participants want the technology to have features that help with day-to-day life in general (*n* = 18)—for example, coaching, being a companion, assisting in personal health care, resting, and maintaining situation awareness. They mentioned that they want to rely more on technology than other people in managing their PTSD, as stated by this participant:

> ...the watch...I hate to say it this way...but the watch would basically become a crutch for those who haven't yet developed the ability to take that pause. And trust me it took me a lot of years to get to that point, so I don't mean that as degrading them in needing a crutch. Sometimes you need a crutch until you can build up the strength on your own (Participant 011).

Some participants want the technology to act as an aid and helper in their coping with PTSD, however it manifests.

Teaching

Some participants (*n* = 11) want to be aided by the technology and to learn from it to improve their condition on their own, ultimately relying less on the technology over time. Specifically, they want to be taught explicitly how to recognize their stressful moments or triggered states rather than just receive help in managing their PTSD. While the main focus of additional help is for the technology to serve as a helping force in overcoming their difficulties with PTSD, this subtheme focuses explicitly on the participants' desire to gradually become completely independent in their PTSD care. One participant stated, "Maybe I can learn to notice what, what my triggers are and what's the best way to counter that trigger" (Participant 040).

CONNECTIVITY

Some participants mentioned their desire for features that allowed them to connect with others through technology, both through commonly found features across mobile communication devices but also with features that exist in social media platforms and remote patient monitoring.

Contacts List

While a social platform may not be the best option for some veterans, most participants thought including a list of contacts was beneficial. Some participants (*n* = 30) mentioned a wide variety of contacts to include in their technology. Emergency services (e.g., 911, suicide hotlines) were mentioned as possible contacts for extreme circumstances. Professional services (e.g., social worker, personal clinician) were mentioned as possible contacts for help with health issues. However, the professional would need to have an established rapport with the veteran for the veteran to find the advice helpful. Including family members and friends on a list of contacts would be helpful because veterans can stay in contact with them through a stressful situation.

Clinician

Some participants (*n* = 26) want to have an extra feature to share information and needs specifically with a clinician. Aside from mentioning the ability to contact their clinician, these participants want to send their physiological data, homework, other assignments or measures of their health to the clinician. They thought that sending more information and having greater communication with their clinicians outside of their sessions would help the clinicians treat them more effectively.

However, they did not want the relationship to be one-sided and mentioned that the clinicians also needed to be proactive in providing care and treatment to them. Specifically, it was stated that the clinicians should do some of the following to be effective and active in their treatment process: (1) send more activities in between sessions, (2) call the veterans periodically, either by phone or video, (3) personalize the treatment, especially if the veterans are sending more information, (4) provide a coaching interaction, and (5) make recommendations based off analysis of the data they receive. One participant shared their sentiment:

> It would almost make a better relationship between us and our doctor because they almost kind of personalize it, like if they call us if we have too many hits. I like to feel like somebody cares, so if somebody were to call and ask if you are okay, it

> feels more like someone is actually out there who cares (Participant 030).

Not all participants like the idea of sharing more information with clinicians. Some (*n* = 6) thought sharing their information with the clinician may be damaging because of health insurance changes or loss of privacy. They believed that if the clinician, and in turn insurance, has too much information concerning their health, their cost of health care may increase. One participant shared this concern:

> For example, I have private health care and I have VA health care. Certain things I use VA for. Certain things I use my health insurance for…. The healthcare, which does everything it can to help you, and the claims to benefit, which if your guide is working on a claim, to try and get an increase or get rated for something, they will use everything they can against you. I don't know if this would cause that but I want the ability to determine whether the VA has access to it or not…. I want to have that control because I always think the claims to benefit side will try to screw me and I don't want to give them any opportunity (Participant 026).

As for privacy, some participants mentioned that they would be wary of sending all their information to the clinician and would like to be able to choose how much of their data the clinician is able to see. Overall, connecting to a clinician was seen as beneficial even if there were some concerns regarding care and privacy.

Social Platform

Aside from individual communication techniques, some participants (*n* = 26) stated their preference for a social platform where they could communicate with other veterans or a group of their family and friends. They believed that this would be beneficial for them because they would be able to talk to and share experiences with others who are experiencing similar afflictions. They thought that an online community might help them in a similar way as in-person group therapy does, as stated by one participant:

> I think that both would work. I mean, especially in this environment, in this big social group, a lot of us going through the same stuff, so you know, it'd be easy to be able to talk to one of them who's going through the same thing, but also your families the next closest to you. So being able to talk to them or have them go through it would benefit both (Participant 001).

Some participants (*n* = 7) thought that the social platform would work if it had some privacy features. For instance, they thought that anonymity, limited public forums, no family members, and limited participation to only veterans with PTSD would make a better platform. Not all participants liked the idea of a social platform; some participants (*n* = 6) mentioned that they do not have a base of friends to rely on for help and so a social platform would not help them. Still, others mentioned that they would not be comfortable speaking to strangers about their struggles and problems. There needs to be certain limits and features for a social platform contained in the technology.

Communication

When discussing their desire to connect with others, some participants (*n* = 22) stated they want the ability to talk to someone. They hope this conversation will help them alleviate some of their problems, calm them down or just provide an outlet for them to relax and talk freely. Further, some participants want to be the ones to initiate contact with others. One participant shared, "There were some dark times in my life that if the tools are there, you know how much relief you get with the simple fact that you can talk to somebody" (Participant 031).

While some participants want to initiate contact with friends or family, others want to be able to be contacted easily. They thought that someone should contact them when they are feeling stressed or in a triggered state. Similarly, other participants also believed that the technology should be monitoring them and sending that information to a select group of people, such as family members, close friends, and clinicians. This would allow the people involved in the veteran's life to intervene and make sure they are doing well. Another participant mentioned a feature that progresses sequentially based on the severity of symptoms. For example, calling a friend and then calling 911 if they were still in a triggered state. Another participant mentioned alerting their spouse and, if conditions worsened, their clinician. They want mitigations that were commensurate to their condition; however, mitigation techniques should be appropriate to the condition of each individual. One participant shared:

> I think the best scenario is somebody contacts me; somebody contacts that because we are the worst at reaching out for help. And when we're in anxiety or depression these last days, weeks, even months. So, if a watch can see that you've been sleeping 18 hours a day for three weeks, you're not going to call anybody, and you're not necessarily in crisis, but somebody should call you or come knock on your door (Participant 041).

OTHER PREFERENCES

Participants also mentioned technological requirements that could be tailored to their individual preferences, focusing on specific and customizable aspects that may not meet general needs or expectations. The features of the technology listed would be personal to the veterans and meet their expectations as a tool made for them. Thus, this theme tends to be more focused on external characteristics that impact the way the veteran uses the technology.

Easy to Use

Many of the participants ($n = 31$) stated that the technology should be easy to use. While general in its nature, this subtheme is important because if veterans cannot use the technology, then it will not help them cope with their PTSD. Some participants mentioned some items to consider in the technology's usability: (1) proven through studies or personal use, (2) appropriate training, (3) symbols need to be easy to recognize, (4) good aesthetics, (5) usable by those with physical challenges (e.g., arm amputation) and generally accessible by all, and (6) attractive to those who are closed-minded to the use of technology.

Wearable

Some participants ($n = 19$) mentioned that the technology should be wearable. They want the technology to take the form of other popular technologies such as a wrist-worn fitness tracker or smartwatch. Others mentioned that wearing the technology on the ankle would be useful for veterans with amputated limbs. Further, the participants want it wearable because it could blend in with what others are using and wearing and not draw attention to itself. Other specific features of the technology tended towards its mobility—the technology should be small and able to fit on a person.

Commanding

Some participants ($n = 17$) mentioned their desire for a technology that gives them clear and concise directions and actions to take when in a triggered state. They want the technology to not only provide mitigation techniques, but also give explicit commands to follow, as shared by one participant, "It could know what those triggers are and then tell me, 'Alright breathe.' Or mitigate, leave, or something; those types of things" (Participant 027).

Additionally, some participants mentioned that the commands should give only one recommended action so that they do not waste time choosing between actions. They want the technology to "think" for them so they can fall back into their military training of obedience and follow the commands.

Customizable

Some participants ($n = 14$) want to personalize the technology in a variety of ways (e.g., color, alerting methods, military branch insignia or colors) in addition to other applications or technological features. Aside from the aesthetics, they also want the technology to be personalized to how their PTSD is detected and mitigation techniques. Overall, the participants want a technology that they could make their own through customization.

Discreet

Building upon the desire for wearable technology, the participants ($n = 14$) mentioned that the technology should be discreet both in terms of hardware and software. They expressed their desire to appear "normal" among others and not have an obvious tool that draws attention to themselves. Specifically, some participants mentioned that the technology should not contain or display the following information: suicide hotline phone number or PTSD/medical status. They did not want a loud alert or salient image, such as a stop sign, to appear on the screen of the device. Rather, an acceptable alert would be a vibration, and a notification should look like other notifications on a phone screen or smartwatch.

Further, they also want the information on their device to be private and secure, not accessible by anyone whom they do not explicitly give permission to view their data. An example of this expectation of discreetness was shared by one participant who stated, "It's not just something that by wearing it somebody in the community might [say], 'Oh, I wonder what's wrong with that guy that he needs something special'. ...You'd never know it was doing something else for me" (Participant 014). Overall, they want a technology that would allow them to approach life without being noticed or stigmatized if they do use the technology.

DISCUSSION

This study sought to gather the design requirements veterans had for a tool that could help them cope with PTSD. The themes identified illustrate the broad requirements that some veterans have for the technology and the subthemes identify the specifics. Each of these design requirements has barriers and enablers that contribute to the feasibility of implementing them with technology. Participants expressed the need for a technology-based tool that could provide momentary help in terms of monitoring their heart rate, predictive alerts/alarms to warn them of an impending hyperarousal event, and mitigation techniques that would help them calm down from a hyper-aroused state. Of the

three momentary help features, some participants were particularly keen on being able to monitor their heart rate.

Although previous work has not identified this specific feature, heart rate has been found to be an accurate predictor for PTSD hyperarousal (Orr et al., 2003; Sadeghi et al., 2020). Heart rate information could be used to facilitate biofeedback—a method to modify physiological activity to improve health and performance—to reduce anxiety among veterans (Alneyadi et al., 2021; Ratanasiripong et al., 2012; Schuman & Killian, 2019). Additionally, tracking heart rate could be used to initiate various mindfulness exercises or other therapeutic features to mitigate impending hyperarousal events.

Similar to heart rate monitoring, an alarm for triggers is a desired feature for a PTSD tool. Previous research has not investigated veterans' acceptance of this feature, but alarms and notifications have been found to be helpful and acceptable in other mobile technologies (Flakk Nordang & Halvorsen, 2022; Garzonis et al., 2008; Mehrotra et al., 2015). This feature would help veterans know when they are in a triggered state and allow them to seek help, either from their own mitigation techniques or from mitigation techniques provided to them by the tool itself. However, caution should be exercised when designing alarms/alerts for veteran populations, considering that hyperarousal can be triggered by unexpected sounds (Brewin et al., 2010). Along with Whealin et al. (2015), who found that veterans were open to the possibility of computer-based interventions, the participants' desire for mitigation techniques to be a part of a PTSD tool, beyond computer-based interventions, suggest that the interventions should be available on personal devices such as a smartphone or smartwatch. These smart devices could deliver discreet yet effective interventions for PTSD hyperarousal.

Some participants mentioned design requirements that would provide long-term help such as reminders, tracking, predictive features, and educational content (i.e., teaching). The findings highlight the importance of reminders for veterans so that they can remember and accomplish important tasks throughout their day. This finding is congruent with those of other studies that identified veterans' preferences about health care and appointment-related reminders (Nazi, 2010; Woods et al., 2013). These reminders would be helpful for veterans, as veterans with PTSD often face memory problems (Johnsen & Asbjørnsen, 2008; Zogas, 2020) so they do not forget important events and information. In addition, participants would like to track their daily activity. Similar studies have shown the benefits of activity tracking for patients with mental illnesses, which include the ability to see what they had done during the day, as well as motivation to continue staying active (Naslund et al., 2015; Naslund et al. 2016).

Beyond the ability to see the events and activities leading up to a hyperarousal event, participants also expressed the desire for a tool to predict the onset of a hyperarousal event. The prediction of health issues has been studied from the health care provider's point of view in other domains such as diabetes (Saravanakumar & Sabibullah, 2020) and gynecology (Erekson & Iglesia, 2015) and has been studied among PTSD patients for sleep problems (Seo et al., 2019); a recent study has shown the possibility of detecting PTSD triggers with up to 67% accuracy (McDonald et al., 2019). Additionally, the findings suggest the need for a veteran-centric tool that not only helps them manage their PTSD symptoms, but also provides them with personalized guidance on daily tasks. Previous research confirms that veterans are open to receiving personalized messages that help them manage their PTSD more effectively (Whealin et al., 2015) and that they desire greater access to their healthcare records, educational programs, and medication management (Chen et al., 2021; Nazi, 2010). We posit that providing persuasive design features (e.g., tailored motivational messages) may help veterans more effectively manage their PTSD in the long term.

Some participants also felt the need to connect with their peers and with society in general. Specifically, they mentioned the need for a design that would facilitate connectivity through a variety of means including a social feature for interacting with others, access to contacts for quick needs, general communication with others, and contact with a clinician for medical needs. These findings highlight the participants desire for a social feature that would allow them to communicate with other veterans. This echoes previous work, which suggests veterans are open to social networking with their peer group (Gettings et al., 2022; Whealin et al., 2015). Beyond the available social media platforms, the creation of a veteran-specific tool may alleviate some of their concerns regarding privacy and discreetness. The data also found that veterans seek support from family and friends and would like to communicate with them quickly in a time of need. These findings align with previous work that has shown that veterans seek support from friends, family, and members of the military (Rodriguez-Paras & Sasangohar, 2017).

In addition to seeking support from family and friends, previous work has also shown that veterans would like more connectivity to clinicians outside of the clinic and in between sessions (Whealin et al., 2015). Specifically, Whealin et al. (2015) found that veterans were willing to participate in telephone calls and video conferences with their health care provider. Nazi (2010) found that veterans would like online, secure communication with their doctor; Haun et al. (2017) found that veterans would like to communicate with their providers electronically;

and Chen et al. (2021, p. 159) found that veterans find it "very important" to see their provider through telehealth video. While in line with this previous work, this study's findings also suggest that beyond the scheduled sessions, greater access to a clinician between sessions would meet veterans' expectations, which would allow for better care. Access to these social features would greatly help veterans overcome their isolation and anti-social tendencies.

Some participants expressed multiple other preferences (i.e., ease of use, customizability, protection of privacy, ability to be worn, and dictation of commands to the veteran). These findings highlight the overall desire for usability and personalization of the tool which aligns with Haun et al. (2017). Haun et al. (2017) found that veterans would like a tool that is standardized across devices, intuitive and easy to use, with easy navigation, and with training for better and more efficient use. This study's findings suggest that veterans would like the PTSD tool to be discreet and private. This aligns with Kumari et al. (2013) and Murmann (2019) whose work shows a preference for privacy in health care matters. This would allow the users to not to be identified as a veteran with PTSD while using the tool and to avoid the stigma associated with mental illness.

Participants desired a PTSD tool that was wearable. These findings align with previous research that noted the importance of device placement while still gathering data (Kumari et al., 2013). This is especially important for veterans who may have lost limbs in combat. The findings suggest that the tool should tell the veterans what to do when they are in a triggered state. This is solidified by previous research that shows voice notifications are easy to understand and overall acceptable to users (Garzonis et al., 2008). Although the nature of these notifications might result in a momentary loss of privacy, they would nonetheless assist a veteran during a stressful situation.

One facet of PTSD care focuses on long-term improvement and trying to an individual return to a level of normalcy similar to their pre-trauma state. However, as many veterans experience difficulty in reintegration into society, and considering this study's findings, there might not be a one-size-fits-all solution (Sayer et al., 2010). Participants in this study showed diverse and sometimes contradictory requirements for the technology. For example, some participants expressed the need for social features while others found such features to be non-beneficial or even repulsive. Similarly, some want the technology to be able to track data and share it with healthcare providers, while some were concerned with privacy issues. The different needs and preferences may or may not be satisfied with customization within one tool. Therefore, further work needs to be done when designing such tools.

STRENGTHS AND LIMITATIONS

To our knowledge, this is the first study documenting a veterans-centered design process to document requirements for PTSD monitoring and self-management. The contextualization of veteran preferences with existing technologies and forward-looking advancements allows for an understanding of the feasibility of such preferences and direction for future work.

Despite the promising findings from this study, there are several noteworthy limitations. Participants were recruited from organized bike riding events and may overrepresent veterans who are physically active and involved in PTSD health management. Also, some of the participants had prior experience with a PTSD tool (e.g., PTSD Coach), which may have primed them or provided them with a mental model for a PTSD tool. Future work should elicit requirements from a broader range of veterans with different activity patterns and demographics. In addition, qualitative analysis might have been subject to several biases inherent to the coding process, such as pre-conceived notions of such PTSD technologies and lack of personal experience of PTSD. Despite these limitations, the findings indicate design requirements for a tool that can facilitate remote monitoring of physiological attributes, while also providing a discreet platform for momentary and periodic self-management.

CONCLUSION

This study documents findings from interviews with veterans to understand their preferences for technology to aid them with their PTSD management. These preferences hold practical implications for their use and implementation and provide guidance in the design of PTSD technology. Future work may evaluate and expand these general guidelines with a larger sample of veterans. More work is also warranted to elicit feedback from other stakeholders such as provides, family members, and care takers. Following the creation of design requirements, the creation of the technology and usability testing and eventual naturalistic testing can take place to iteratively design and improve the technology. Funding for this work may be sought from federal grants.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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