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Integration of mCare and T2 Mood Tracker: Illustrating mHealth Usability Testing

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Abstract

Military operational requirements potentially limit access to behavioral health care for service members. Although mobile technology solutions are increasingly viable, a secure method for mobile data exchange between patients and providers has yet to be adopted in military health care. Usability testing is the industry standard prior to implementing new technology. This paper demonstrates usability testing on a secure data exchange system between mCare and T2 Mood Tracker. Sixteen civilian providers in an outpatient behavioral health clinic tested the mCare Provider Portal, and nine uniformed proxy patients tested the Mood Tracker app. The System Usability Scale (SUS) was used as an outcome measure, which is composed of usability and learnability sub-factors. Proxy patients rated the mobile app as acceptable on the SUS, with average usability and above average learnability. Providers had less favorable views of the mCare Provider Portal, which they rated as marginal across all domains. Participants expressed enthusiasm about the potential of the provider web portal/patient smartphone app system, but had concerns about technical difficulties and ethical issues when exchanging data electronically. The results suggest a willingness to use technology to share data between patients and providers, but also a need for refinement of system usability before full-scale implementation.

Keywords Usability testing · Behavioral health · Military · Mobile app · Telehealth

In military environments with high operational tempo, mission-essential tasks often take priority over medical care, in turn impacting treatment-seeking behaviors by service members (Dolan et al. 2005). Given this context, it is important to explore alternative ways to provide access to care without impacting the mission. Recent technology advances have made it possible for providers and patients to connect across settings and circumstances (Fiordelli et al. 2013). However, the military has been slow to adopt such technology due to concerns about secure data exchange (Department of Defense [DoD] 2014). Meanwhile, the field of mobile health is burgeoning, with increasingly high patient and provider acceptance and use of accessible and portable technology interfaces (Bush et al. 2014). Patients can access content by mobile device at their convenience, enabling self-paced and repeated use of resources over time (Armstrong et al. 2017).

The National Defense Authorization Act (NDAA) for Fiscal Year 2017 required improved telehealth capability across the Military Health System (MHS) by leveraging mobile health technology (National Defense Authorization Act for Fiscal Year 2017 2016). In response to this mandate, the DoD National Center for Telehealth & Technology (T2; Tacoma, WA, USA) partnered with the U.S. Army Telemedicine and Advanced Technology Research Center (TATRC; Fort Detrick, MD, USA) to develop and test a system that employs both the user interface of an existing mobile app (T2 Mood Tracker) and data exchange between patients and providers using TATRC's mCare application. This study assessed the usability of an interface of this kind in the MHS.

This study was conducted under an exemption from the Institutional Review Board at Madigan Army Medical Center.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the U.S. Government, the Department of Defense, the Department of the Army, or the Defense Health Agency.

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Usability Testing

Usability testing is an industry standard in technology development, the purpose of which is twofold. Usability testing is designed to improve the utility of a product, and to improve the design and development process of products (Dumas and Redish 1999). The driving factor in usability testing is to detect problems with a product early in the development process, by having end-users engage in real-world exercises using the product (Dumas and Redish 1999). The usability of a system must be assessed in the context of its intended end use, including who is using the system, for what purpose, and in what environment (International Organization for Standardization 1998). Usability testing of mobile health applications is standard practice to assess ease of use, functionality, and user satisfaction (Zapata et al. 2015). Unlike traditional statistical methods, usability testing does not require large sample sizes; themes can emerge about the features of a particular new technology from the feedback of a relatively few users (Virzi 1992).

Usability testing, unlike research, does not investigate the presence of some phenomenon among test subjects; rather, participants are the evaluators or assessors of the product, and the product itself is the subject of interest (Dumas and Redish 1999). A primary purpose of the current report is to illustrate usability testing for behavioral health technology. Whereas, usability testing is quite commonplace in technology and business fields, health care professionals who are using technology in their practices may be unaware of usability testing. Furthermore, to avoid spending taxpayer dollars on unusable systems, it will be imperative to incorporate usability testing prior to implementing technology in the MHS as required by the National Defense Authorization Act for Fiscal Year 2017 (2016). This study illustrated usability testing with an existing mobile application, T2 Mood Tracker, as integrated with a secure data exchange system, mCare.

T2 Mood Tracker

The T2 Mood Tracker mobile app helps users to rate and track moods over time. Users can monitor their emotional experiences associated with military-related behavioral health issues (Bush et al. 2014). Use of T2 Mood Tracker to electronically record, self-monitor, store, and display health information through portable touch-screen technology can mitigate the problems of traditional paper health diaries. When patients forget to bring paper diaries to appointments or fail to routinely record their experiences, it potentially skews analysis and interpretation of their emotional functioning; these difficulties are dramatically reduced when similar diaries are recorded on mobile devices (Dale and Hagen 2007).

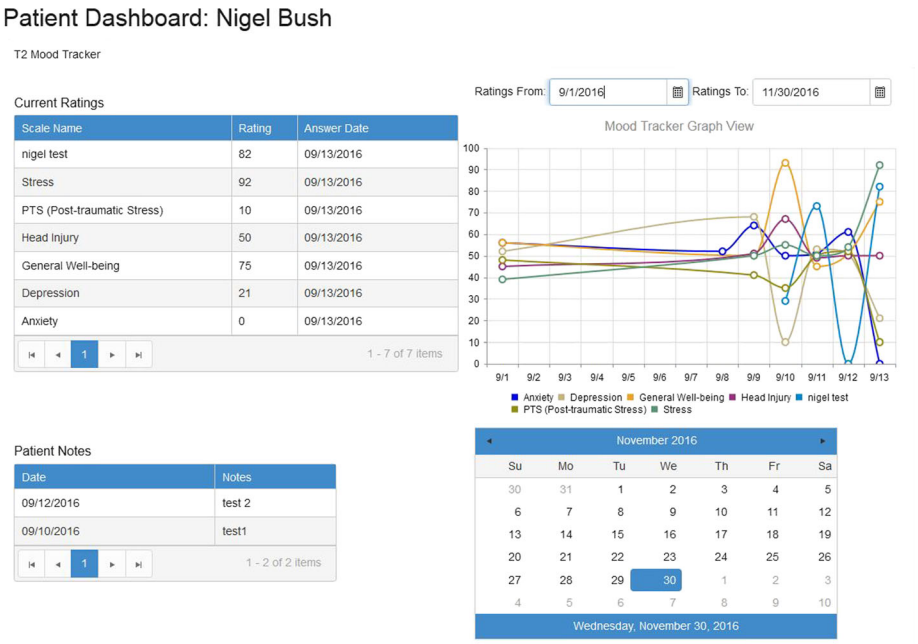

Fig. 1 Screenshot of mCare provider portal

The mCare Platform

The mCare platform is an internal DoD system that allows geographically distributed service members to communicate securely with their care teams through mobile technology (Poropatich et al. 2014). The mCare system includes a patient-facing mobile platform allowed users to enter their own data, as well as a provider portal that displays patient-generated data and can send health-related tips or reminder texts to patients. Thus, providers are able to receive mobile communication from patients in disparate locations, and can push information directly to the patient's mobile phone. This increased engagement between patient and provider can be leveraged to provide coping skill recommendations, health education information, appointment reminders, and other shared clinical information. Access to these resources may be particularly useful for geographically dispersed patients, such as during field training or deployment (Poropatich et al. 2014).

Before military-wide implementation of such a data exchange system, usability testing should determine its utility and operating capability for both service members and providers. In the current study, we integrated T2 Mood Tracker with the mCare platform and evaluated the combined system for usability. The test system included two parts: (1) a secure mobile app for proxy patients to input mood tracking data and (2) a provider portal for health care teams to review the data. Examples of the mobile app and provider portal are provided in Figs. 1 and 2. The resulting system allowed data from the mood tracking app to be available for sharing with providers directly through the portal. Our study tested whether this system would be acceptable to both patients and providers for use within the MHS.

Methods

Proxy Patient mCare Plus Mood Tracker Smartphone App

Typical usability testing requires that the product be tested by the intended group who will use the product (Dumas and Redish 1999). For the purpose of this small-scale usability test, we aimed to illustrate usability testing with behavioral health applications for the military. We used participatory design methods (Kensing and Blomberg 1998) to engage both focus group and individual system evaluators in the identification of confusing elements and desired improvements. To test the mobile interface between T2 Mood Tracker and the mCare Provider Portal, nine army interns and residents of a clinical psychology training program at a large military installation were recruited to serve as proxy patients (Table 1). Psychology trainees were junior army officers between the ranks of first lieutenant and captain (O-2 to O-3). Prospective proxy patient participants met privately with the researchers to obtain informed consent, confirm that the participant's mobile phone was compatible with the software, and explain usability testing procedures.

After consenting, we helped each proxy patient participant download the mCare Plus Mood Tracker app, allow participants to explore the app, and answer questions as needed. We provided proxy patients a user guide, which included annotated screenshots of different features of the app to facilitate independent use. To protect anonymity, we advised proxy patients to use a pseudonym for a login username, and informed them they did not need to rate their actual mood but could instead choose to submit dummy ratings indicative of a particular behavioral health disorder. Proxy patients were asked to use the mCare Plus Mood Tracker app at least once daily for 1 week. After the testing period, one of the first two authors met individually with each proxy patient participant to capture feedback on the app in a semi-structured interview and to administer usability questionnaires. This feedback was captured in interview notes and subsequently content analyzed by authors utilizing the participatory design framework to identify "pain points" for the end user. These pain points also drove

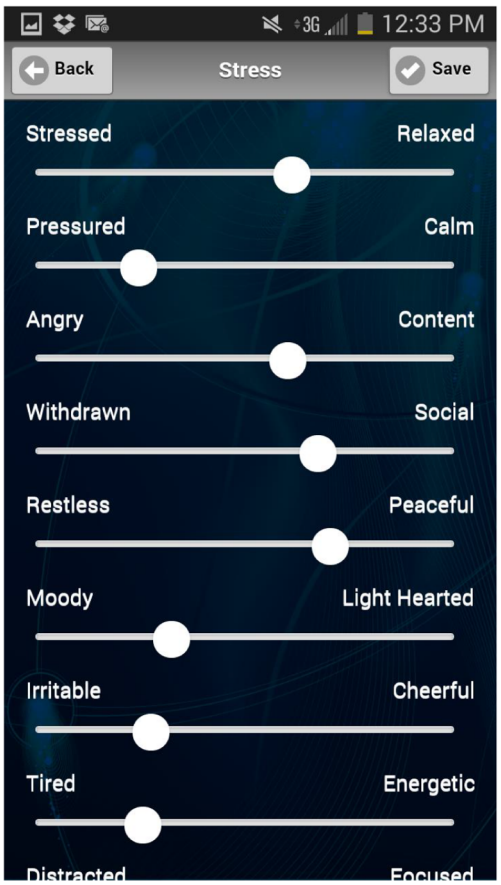

Fig. 2 Screenshot of Mobile App Interface

the identification of recommended changes to the system as responses were categorized based on severity and priority (Kensing and Blomberg 1998).

mCare Provider Portal

Sixteen behavioral health clinicians and paraprofessionals (eight clinical psychologists, four social workers, two licensed professional counselors, one social services assistant, and one nurse case manager) at one embedded behavioral health (EBH) clinic evaluated the mCare Provider Portal in a single-session focus group (Krueger and Casey 2015). Provider demographics are shown in Table 1. EBH clinics provide behavioral health services to active duty, select National Guard, and Active Guard Reserve or activated Reserve service members in a specific unit or set of units (Hoyt et al. 2015). The 30-min focus group was conducted during a routine staff meeting, and was facilitated by two psychology residents (the first and second authors) with post-doctoral training in facilitating usability testing at the T2 Usability Lab. Attendee participation in the evaluation was voluntary (no clinic personnel declined to participate) and their responses were anonymized.

To test the provider portal, the facilitator led the provider participants in a structured walkthrough exercise (Krug 2010). We guided the provider participants through audio-visual demonstration of the major features of the portal, such as how patient mood scales would be displayed, and how to view notes submitted by patients. The provider portal was projected on a large screen to be visible to all participants, with an initial demonstration, a structured walkthrough of patient examples, and additional guided exploration of the portal in response to participant questions. The focus group consisted of approximately 20 min of demonstration and discussion of the portal itself, with each provider participant completing usability questionnaires. Ten minutes of the focus group was set aside to allow provider participants to voice opinions about the portal and recommendations to improve the system (Krueger and Casey 2015). Feedback in the focus group sessions was recorded both on free response forms by participants and through detailed notes captured by facilitators. This feedback then was similarly content analyzed by authors utilizing the participatory design framework to identify "pain points" for the end user (Kensing and Blomberg 1998).

Outcome Measures

System Usability Scale (SUS) The System Usability Scale (SUS; Brooke 1996) is a ten-item Likert-type-scale assessing subjective usability. The SUS is widely used in the evaluation of technology systems, and has produced normative data that allows SUS ratings to be compared with other systems. The SUS consists of one overall main score (SUS main, range 0–100) and two sub-scores: Usability (eight items) and Learnability (two items; Lewis and Sauro 2009). The validated SUS has been standardized such that scores may be given adjective ratings ("Best Imaginable" to "Worst Imaginable,") which correspond to collegiate grade scales of A through F (Bangor et al. 2009). The overall SUS score determines a conventional letter grade based on published baseline data for mobile technologies, and helps assess the acceptable range for usability (Bangor et al. 2009). Across 3500 surveys in 273

Table 1 Participant demographics

Demographic	Proxy patients ($n = 9$)	Providers ($n = 16$)
Gender		
Male	3 (33.3%)	6 (37.5%)
Female	6 (66.7%)	10 (62.5%)
Age range		
20–29	3 (33.3%)	0 (0.0%)
30–39	4 (44.4%)	7 (43.8%)
40–49	1 (11.1%)	3 (18.8%)
50–59	0 (0.0%)	0 (0.0%)
60–69	0 (0.0%)	3 (18.8%)
No answer	0 (0.0%)	3 (18.8%)
Professional role		
Psychologist trainee	9 (100%)	0 (0.0%)
Psychologist	0 (0.0%)	8 (50.0%)
Social worker	0 (0.0%)	4 (25.0%)
Licensed counselor	0 (0.0%)	2 (12.5%)
Nurse case manager	0 (0.0%)	1 (6.3%)
Social services sssistant (SSA)	0 (0.0%)	1 (6.3%)

studies, the mean SUS score was 70, and the median SUS score is 70.5; all scoring, adjective ratings, and letter grades are determined based on these benchmarks (Bangor et al. 2009).

Self-Report Questionnaires and Focus Groups In addition to the SUS, participants responded to additional questions about personal opinions using 5-point Likert-type scales (i.e., 1 = "Very Unlikely," 1 = "Very Difficult," or 1 = "Not at all Useful/Beneficial"; 5 = "Very Likely," "Very Easy," or "Very Useful/Beneficial"). Proxy patients rated utility and benefit of mood tracking, likelihood of using the mobile app in the future (either for personal reasons or to share data with a provider), likelihood of recommending the app to others, and interest in using other mobile apps geared toward service members. Additional items were designed to test if proxy patients had any difficulties using various aspects of the mobile app and, if so, space to enter details about the types of difficulties they experienced. Proxy patients were informally debriefed based on their retrospective experience after at least 1 week of use, allowing them to comment on additional aspects of the app while navigating through it or by looking at screenshots of the mobile app as they responded to questionnaire items (Krug 2010).

Providers rated applicability of the mCare Provider Portal to their clinical practice, likelihood of using the portal with patients, likelihood of recommending the portal to a colleague, and utility and benefit of the portal. We conducted structured focus group interviews with provider participants that prompted them to make observations about the mCare Provider Portal. All patient responses were analyzed to determine satisfaction levels and to obtain user suggestions for improving the mCare platform. Whenever possible, we gathered verbatim statements from proxy patient and provider participants. These statements were provided back to the project team to guide iterative development of future product versions.

Results

Proxy Patient mCare Plus Mood Tracker Smartphone App

All nine patient participants reported that they were "some - what" to "very experienced" users of personal technologies and that they were regular internet and smartphone users. Three participants downloaded mCare Plus Mood Tracker to their personal Android phones (33.3%) and five to iPhones (55.6%).

Proxy Patient Usage Results Technical difficulties resulted in data loss from one proxy patient. Most used the application over a period of 7–12 days, with two proxy patients using it over a 22- and 37-day period, respectively. Proxy patients opened and used the mCare Plus Mood Tracker app an average of seven different days over the test period (range 4–14, SD = 3.87). Follow-up self-report questionnaires revealed that three participants reported having used the app once daily and the remaining six for two to four times a week over the test period.

Proxy Patient Self-Report Measures Proxy patients gave the mCare Plus Mood Tracker mobile application positive feedback based on total SUS score ($M = 74.7$, SD = 11.5, median = 73.0, $n = 8$), for an adjective rating of "Good" and a corresponding letter grade of "C," which falls in the acceptable range. Similarly, usability was also "Good" ($M = 71.1$, SD = 11.8, median = 71.5, $n = 8$), for a rating of "C," and learnability was considered "Excellent" ($M = 89.1$, SD = 12.4, media$n = 91$, $n = 8$), for a rating of "B." Results are displayed in Fig. 3. Most proxy patient participants indicated that the mood-rating scales were easy to use, though six of eight indicated they would be "Unlikely" to use the app in the future (see Table 2). Despite low likelihood of personal use, a majority ($n = 5$) said they would be likely to both recommend the mCare Plus Mood Tracker to other service members and to use the app to share their mood information with a provider. Figure 4 depicts proxy patient participant responses to selected follow-up self-report measures.

Proxy Patient Qualitative Feedback Qualitative responses gathered in debriefing sessions were mostly positive about the utility of the mCare Plus Mood Tracker app. Several proxy patient participants commented that the app would be useful within the behavioral health system, particularly in the context of managing new medication effectiveness. Proxy patients also gave suggestions for improvements to the mCare Plus Mood Tracker app, which included very specific app modifications to address technical difficulties (e.g., "The 'save' function disappeared when I scrolled down…should remain at top of screen or just be at the bottom," "Sometimes I submitted the data, but because of poor cell phone connection it didn't save"). Others commented on scale redundancy, in which multiple scales had similar names for mood symptoms. Finally, overall functionality of the app also generated feedback (e.g., "With all the functions (icons) at the bottom appearing 'grayed out' it makes me think you can't use them," "The load screen is enough to block Millennials. More prompting even within the app [is needed]"). Proxy patients also reported that the automated reminders from the mCare Provider Portal were not consistent and did not arrive at the same time every day, despite having a designated time in the Provider Portal. Overall, proxy patients indicated the app could be useful if functionality issues were addressed (e.g., "I think the app has potential, but it currently crashes too much and takes up too much space on my phone to justify keeping it").

mCare Provider Portal

Provider Self-Report Measures Provider participants had less favorable views of the mCare Provider Portal based on total SUS score ($M = 61.9$, SD = 12.0, median = 66.5, $n = 16$), for an adjective rating of "OK" and a corresponding letter grade of "D," which falls in the marginal range of acceptability. The usability sub-score ($M = 60.7$, SD = 13.2, median = 62.5, $n = 16$) received an adjective rating of "OK," as did the learnability sub-score ($M = 66.4$, SD = 19.7, median = 66.5, $n = 16$), for a grade of "D." Results are displayed in Fig. 3. Twelve of the 16 providers indicated that content of the portal applied to them "Somewhat" to "A lot," while three reported that the content had no applicability to them. Eleven providers thought the mCare Provider Portal would be "Somewhat" to "Very Useful and Beneficial" to their clinical practice. Of the remaining providers, two thought it would be "Only a little Useful/Beneficial" and three thought it would be of no benefit. Despite mostly favorable views, only seven providers said they would use the mCare Provider Portal personally with their patients. The remaining were either undecided ($n = 7$) or indicated that they definitely would not use the system ($n = 2$). Eleven providers were undecided about whether or not they would recommend the mCare Provider Portal to another provider, whereas five indicated they would be likely to recommend it, and two reported that they definitely would not recommend it. Figure 4 depicts provider participant responses to these rated items.

Provider Qualitative Feedback EBH clinic staff was somewhat enthusiastic about the potential of the mCare Provider Portal and the mCare Plus Mood Tracker app in enhancing patient-driven intervention (e.g., "[increases] patient engagement, doing something active," "reinforcing skills, techniques discussed during session versus traditional paper homework"). Providers generally viewed the combination of the mCare Portal and mobile app as an intervention, rather than an assessment tool because it lacked empirical support (e.g., "Not empirical but valuable," "Not aligned to commonly-used clinical scales"). Participants recommended a modification to the mCare Provider Portal platform to make the clinical scales more relevant to treating providers (e.g., "The scales don't make sense to me as a clinician. Higher = bad/worse to me, but on the Portal, it seems higher scores = better/improved").

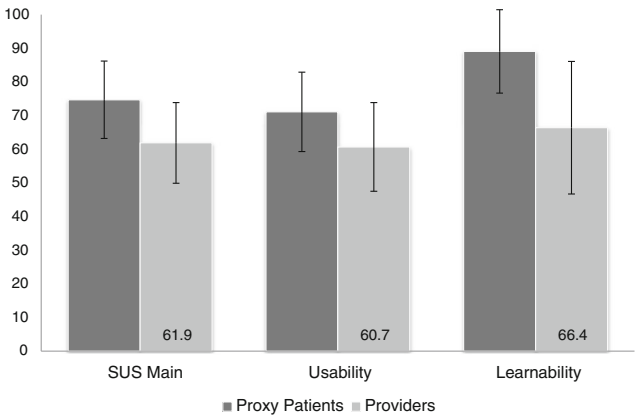

Fig. 3 Proxy patient ($n = 8$) and provider participant ($n = 16$) System Usability Scale (SUS) Scores. Proxy patient participants ($n = 8$) completed the SUS after using the mCare Plus Mood Tracker mobile application for at least 1 week. Provider participants ($n = 16$) completed the SUS after a group demonstration of the mCare Provider Portal. Mean scores for the SUS Main, Usability sub-factor, and Learnability sub-factor are displayed. Error bars depict standard deviations for each

Providers expressed concerns about liability of using the mCare Portal when monitoring patient inputs of mood symptoms, (e.g., "Potential risks associated with suicidal patients now putting their information out there [when] you're responsible for it"). Provider-suggested strategies to mitigate risk included embedding an artificial intelligence interface to prompt a user to dial 911 or an emergency contact if they indicated suicidal statements in the notes section of the app, and having a pop-up intervention or coping strategy if users entered low scores.

Providers also desired more control over which scales their patient received, suggested transmitting prompts to patients, and asked for greater visibility over user-provided data (e.g., "should be able to go back and see what the patient entered on each of the scales," "Sending patients reminder feature was not user-friendly at all – you cannot cancel reminder texts"). Other perceived difficulties with implementation of the mCare Plus Mood Tracker app included limitations of internet capability in the clinics, and being unable to work with the patient in-session to download and set up the app or to facilitate general use (e.g., "The fact that the activation code expires in one hour is frustrating because patients often don't have service in the clinic"). Providers saw potential benefits of the system, but functionality concerns and liability risks appeared to limit their willingness to implement such a system in their clinical practice.

Discussion

Usability testing is a valuable tool for assessing the feasibility of a new system and for gathering feedback to improve end-user satisfaction and ultimately improve access to care. This usability test assessed the feasibility of combining two existing systems: mCare, a secure mobile messaging platform, and T2 Mood Tracker, a mobile application, into a single system. This system, integrated patient-entered emotion self-monitoring and provider access to view results and provide feedback. Both proxy patients and providers expressed enthusiasm about the potential of the system, but with specific concerns about its current state. Most proxy patient participants found the app easy to use, though they stated they would be

Table 2 Proxy patient ratings ($n = 8$)

Item	*M*	SD
How easy or difficult was it to open and view your results for different mood categories? ($n = 5$)	3.6	1.36
How easy or difficult was it to add a note about any of your mood ratings? ($n = 5$)	4.8	0.40
How easy or difficult was it to make and use a custom category? ($n = 3$)	2.3	1.25
How easy or difficult was it to make and save reports? ($n = 3$)	4.0	1.41
How likely is it that you would consider using the Mood Tracker app in the future to collect mood information for your own use?	2.1	0.93
How likely is it that you would consider using the Mood Tracker app to collect mood information to share with a health care provider?	3.5	1.12
How interested are you in using other health apps designed for Service members?	4.0	0.71

Participants who responded with N/A—Never Used were removed from the calculation of mean scores and standard deviations. The number of proxy patients responding to each item is listed as applicable. Higher numbers reflect ease of use or more positive ratings, whereas lower numbers reflect difficulty of use or more negative ratings

unlikely to use the app personally (as non-patients). They were more likely to recommend the app to a service member and to use the app to share mood information with a health care provider.

On the whole, providers evaluating the mCare Provider Portal saw the potential utility of the system. However, they were undecided about using it in their clinical practice or recommending it to patients and other providers. This hesitation seemed to stem from concerns about liability, clinical effectiveness, and practicality of the system (e.g., identifying patient-endorsed suicide risk, scales not empirically validated or relevant to a behavioral health provider, and difficulty downloading the application). Usability ratings from providers indicated the Provider Portal was not within the acceptable range for use. Providers considering use of this system may benefit from an instruction sheet and after-hours contact for customer support to their participating patients. Concerns about provider liability can be addressed through education about ethical use of technology in behavioral health care (Giota and Kleftaras 2014). Furthermore, although the military health care system typically focuses on enhancing access to care in remote combat environments, the lessons learned from this and similar studies could have applicability in civilian settings as well. For example, the same kind of mobile and distributed platforms utilized in the current study could help to overcome barriers to care in rural areas and among other geographically dispersed populations (e.g., Hoeft et al. 2018). A number of limitations were identified in this study that suggest directions for future research. First, usability testing is typically conducted with the intended users of a product to obtain

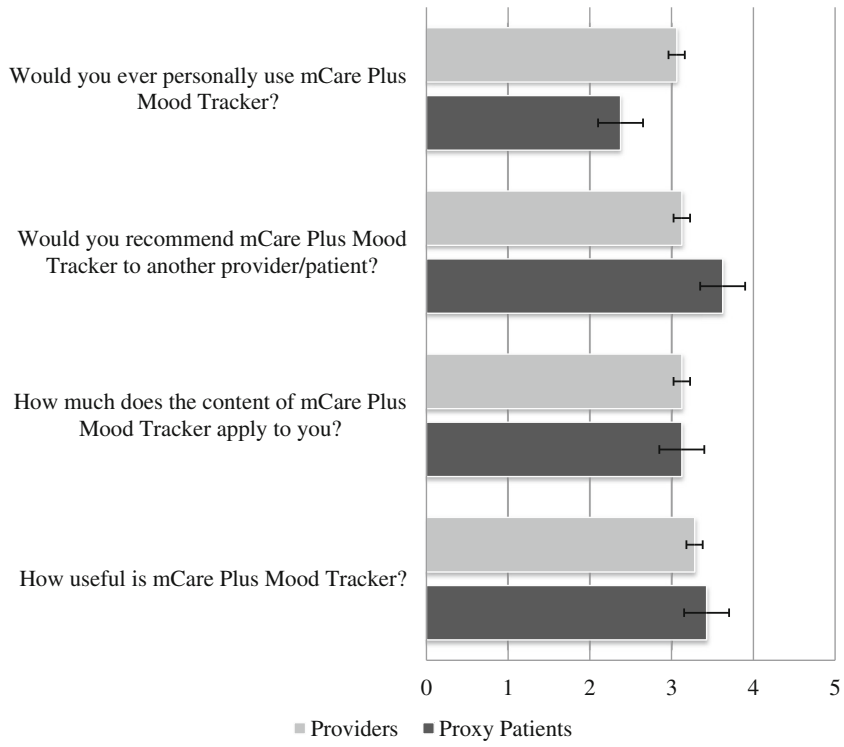

Fig. 4 Selected mCare Plus Mood Tracker proxy patient and provider ratings. To better consolidate multiple questions into one figure, 5-point (1–5) and one 4 point (1–4) scores were averaged over all participants. Verbiage was slightly different on these items based on whether the participant was a proxy patient or provider

accurate feedback about how a product would be used in context (Dumas and Redish 1999). It is important to note that the service members who agreed to participate using the mCare Plus Mood Tracker app were psychology interns and residents. As such, their comments may have been more critical than what the typical soldier (with no behavioral health training) would provide. Furthermore, these psychology interns and residents may significantly differ from the general population of service members due to advanced graduate education, possibly biasing results and limiting the generalizability of findings. Nonetheless, these active duty interns and residents also are consumers of military health care, and have a good foundation in the standard of care against which to compare the new app capabilities. A similar limitation was that participation by providers in the testing was limited to a structured walkthrough exercise (Krug 2010). Although valuable for eliciting feedback in a focus group setting, this exercise may have limited overall usability findings because the providers were not able to interact individually with the portal. Future iterations of provider portal testing may benefit from over-the-shoulder guided experiences to assess usability.

Another limitation is that, despite a long-held standard of five users to detect 85% of the problems in technology development, the industry has since suggested small-sample usability testing is insufficient to identify as many problems as originally thought (Virzi 1992; Faulkner 2003). We were able to identify several problems that placed the integrated mCare Plus Mood Tracker system in the marginal range for acceptability even without a large number of participants, saving overall costs of implementing a large-scale usability test. Finally, the mobile app users were exclusively "digital natives," whereas several providers testing the mCare Provider Portal were "digital immigrants" as described by Prensky (2001). This generational divide may explain the disparity in ratings and the hesitation by providers to engage in use of technology for patient care. The concerns raised by providers were largely that patients may be unable to download or access the system; however, the vast majority of current military personnel were born in the digital age and are likely adept at using technology (Zur and Zur 2016). The civilian providers who participated in this usability test overlapped the generational divide between digital immigrant and native groups. For digital immigrants needing to adopt new technology in order to interact with patients, supportive training by digital natives who are skilled with navigating new systems intuitively may be of great benefit (Zur and Zur 2016).

Technical problems resulted in data loss for one proxy patient. Despite immediate reach back support to the development team, we were unable to resolve the technical problem that prevented the participant from using the mobile app. The technical problem resulted from the exact concern voiced by providers, which is that the access code times out within the span of 1 h. New codes could not be sent to the proxy patient participant, and even when the account was reset at the TATRC development site, we were unsuccessful in gaining access to the mobile app for the proxy patient. The purpose of a short access window is to improve security, but it was apparent from this usability test that additional considerations address security and accessibility.

Developers received feedback on technical problems and the collected responses from participants to initiate improvements in the mCare Provider-patient app system. Participants suggested that we address some of the technical concerns, including the look and feel of the mobile app, and technical slow-downs and glitches in both the provider portal and mobile app. Other recommended improvements included making the reminder system more user-friendly and consistent in delivery, and making the scales more clinically relevant for providers. Additionally, findings suggest that a combination of mCare and T2 Mood Tracker will be feasible after additional usability considerations have been addressed.

The study of this combined system is an example of how usability research can reduce expenditures within the MHS and promote safe use of connected health technology. Although both proxy patient and provider participants indicated a desire for the fully operational system, their feedback demonstrates that the current state would not be feasible for broad implementation. Although the system is secure in its current iteration, if beneficiaries and providers find it too cumbersome for routine use, they may forgo the system entirely and use less-secure workarounds. These results help teams such as ours recognize the need for further development using iterative usability testing prior to deployment.

This outcome is important for the MHS and DHA. Our findings can encourage retrofitting and modification of other existing systems rather than initiation of new development to meet clinical needs. When possible, teams should consider whether the capabilities of systems can be combined to fill gaps and thus save on development expense. If feasible, the approach could be applied to other complimentary applications, potentially putting accessible military health care into the hands of service members and their beneficiaries and meet the goals of the National Defense Authorization Act for Fiscal Year 2017 (2016). Indeed, as a result of the current study and other pilot projects, the mCare platform has been expanded to be a complete mobile health care environment, with direct linkage to wearable frontline sensors that can be reviewed by providers. The T2 Mood Tracker similarly has added wearable interface technology to compare self-rated mood with physiological data. These examples show the potential utility of reaching the deployed environment with innovations in mobile technology.

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Compliance with Ethical Standards

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

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