The number of mobile health (mHealth) apps has steadily increased in recent years, however little work has been done to define a rigorous and standardized process for the design of this technology. This case study presents our novel user-centered design model for mHealth applications through our experiences developing Battle Buddy, an mHealth app designed to support mental, physical and emotional well-being of US service members and their families. Our approach combines an Information Systems Research (ISR) framework with the qualitative methodology of Rapid Assessment Process (RAP) to 1) guide app development and 2) include end-users into the design process in a meaningful way. The ISR framework is known in the HCI community but is rarely applied to the domain of mHealth applications, while RAP is a fast, cost-effective process for gaining insight into a situation from an insider’s perspective. This case study mainly focuses on our team’s experience with RAP to explore the mHealth needs and design preferences of members of the military community through a series of end-user interviews conducted by a community “insider”. Findings from our work support the use of combining the ISR framework with RAP as a process for designing future mHealth apps and understanding the unique needs and design preferences of groups of specific end-users.

CCS Concepts: • Human-centered computing → Ubiquitous and mobile computing design and evaluation methods; HCI design and evaluation methods: User centered design; • Applied computing → Military; • Computing methodologies → Intelligent agents.

Additional Key Words and Phrases: Wearable Technology, Virtual Human, User Interface, User Testing

ACM Reference Format:

1 INTRODUCTION

US military leadership are currently ranking the well-being of soldiers and their families as the Army’s top priority, above combat readiness and weapons modernization [13]. Vulnerability to mental illness in both veteran and active duty military populations has been well-documented, with research identifying deployments and combat to be predictive of high rates of PTSD, depression, and other mental health problems [3, 5, 6, 8]. In 2020, incidents of violent behavior have spiked as service members struggle with COVID-19, war-zone deployments, national disasters and civil unrest. In particular, military suicides have increased by as much as 20% when compared to the same period in 2019. Though the
causes at the root of these issues are complex, Army and Air Force officials say they believe the pandemic is adding stress to an already strained force [13].

It is estimated that between 40–60% of military personnel who could benefit from professional treatment do not access help or services [15]. Military life is often characterized by experiences that can make accessing adequate health care challenging: mobility, separation, and risk. Military personnel can also face various barriers to care including stigma and working in an environment that rewards displays of physical and mental strength [12]. Moreover, admitting to mental health concerns can place restrictions on a soldier’s determined fitness for duty [15].

Emerging mobile health (mHealth) technologies, specifically mHealth applications (apps) designed to support mental health, are considered promising tools for overcoming stigma and engaging service members in their own care [16]. In fact, the National Center for Telehealth and Technology and the Department of Veterans Affairs are releasing mHealth apps to deliver evidence-based mental health treatments. This rapid rise in interest is in part due to the ability of these apps to transform mobile and wearable devices into monitoring and therapeutic platforms that can capture mental health symptoms in real time and deliver on-the-go mental health support [17]. Mobile apps also offer a viable option for military personnel to access care confidentially, anytime, anywhere – reducing stigma-related barriers that can include career implications and social judgement as well as occupational or social barriers to care, such as being deployed at the time of need. [16].

Despite the widespread consensus in the mHealth research community that identifying the needs and perspectives of targeted users is a vital component in good intervention development, user-centered design has not been widely applied in the domain of mHealth apps [19]. In fact, many current mHealth interventions are designed on the basis of existing healthcare system constructs that may not be as effective when delivered in a novel medium without including end-users in the design process [14]. Development that neglects incorporating the voice of the user can adversely effect adherence, efficacy and even full validation of interventions due to user attrition [18]. This is particularly concerning as interest in mHealth apps grows in both the military and the civilian sector, with current tallies of mental health offerings exceeding 10,000 apps [17].

The purpose of this case study is to report on the user-centered design process employed in the development of the mHealth application, Battle Buddy, intended for use by military personnel and their families. Battle Buddy is a smartphone app that leverages sensors native to popular smartwatches to deliver adaptive multi-media content via a Virtual Human (VH) coach. This VH coach can help users to set and track progress on various health and wellness goals. In addition, the Battle Buddy app delivers 4-5 minute wellness modules daily in the interdependent domains of physical, mental, and emotional health that are specifically tailored to the individual user through novel adaptive logic-based algorithms.

Our user-centered design model is unique as it incorporates a methodology borrowed from participatory action-research, Rapid Assessment Process (RAP), within the Information System Research (ISR) framework. The ISR framework has been independently applied in technology development, however, it has not been widely applied to the design of mHealth apps nor combined with RAP [14]. The main focus of this case study will be on the use of RAP as part of the design phase of ISR to identify 1) the mHealth needs of the military user; 2) their mobile app design preferences in order to maintain user interest, and 3) the barriers that would prohibit uptake and sustained use of this app for a particular population. Though our findings regarding the Battle Buddy app may be specific to the military community, this novel methodology utilizing RAP can be applied across groups of specific end-users with the aim of increasing adoption, adherence, and efficacy of mHealth applications.
2 METHODS

2.1 Theoretical Framework

The ISR Framework conceptualizes the design process as an embodiment of three closely related cycles of activities (Fig. 1). As applied to the ongoing design of Battle Buddy, the Relevance Cycle helped to bridge the contextual environment of the research project with the design science activities. The Rigor Cycle connected the design science activities with the knowledge base of scientific foundations, experience, and expertise. The central Design Cycle iterates between the core activities of building and evaluating the design artifacts and processes of the research [2].

As part of the Design Cycle, our team engaged in a form of participatory action research, Rapid Assessment Process (RAP), a form of intensive, team-based qualitative inquiry using triangulation, iterative data analysis, and additional data collection to get a preliminary understanding of a situation from the insider’s perspective [1]. The strength of this process is that RAP enables a research team to develop a preliminary understanding of a complicated situation in which issues are not yet well-defined – an aim that maps directly onto discovering the needs of a specific group of end users. RAP shares many characteristics with ethnographic research, however, it is more cost-effective in terms of both time and money, as it utilizes intensive team interaction and rapid cycles of data collection followed by data review and analysis rather than the prolonged fieldwork typically associated with generating this level of understanding.

Rapid assessment is grounded in the qualitative tradition of the early 1970s, specifically taking a systems approach in which all aspects of a local situation are considered. At that time, the acronym for “RAP” also signaled the need to communicate with participants using their own vocabulary. The ability of a RAP team to quickly develop a preliminary understanding of a situation, from the perspective of in-group participants, is facilitated by having an insider on the research team. This insider must be a full team member and must be involved in the planning, data collection, data analysis, and the preparation of the report.

For the purposes of this case study, we will briefly describe team activities in the overarching ISR framework and delve more deeply into our first round of RAP. We will share our findings, lessons learned, the limitations of our current work, and future directions for this project.
2.2 The Relevance Cycle

To understand the desired function and design of the proposed mobile application for the military community our research team conducted a series of interviews with various members of the military and subject matter experts in mental health. At the conclusion of these interviews, three interdependent areas were determined to be of high priority for US service members and their families: physical, mental, and emotional well-being [10]. Health-related content for this application was then sourced from the US Army’s Performance Triad, a guide focused on these three areas, and adapted to be interactive [11].

2.3 The Rigor Cycle

In the rigor cycle, our team performed a literature review to identify previous technology-based mental-health interventions, including mobile apps, designed for both military and civilian users. In our review of the literature, we did not find any mHealth applications that utilized a virtual human (VH) coach who would guide users through the content. However, through our review of the literature exploring engagement and motivation in behavior change we determined cause for the inclusion of a VH coach as well as options for varying the gender and ethnicity of the character [9]. Evaluating this novel design aspect of our application and the ability of a VH coach to increase levels of adoption and adherence was therefore deemed high-priority in Design Cycle activities.

2.4 The Design Cycle

The goal of the design phase is the creation of a highly usable application. To achieve this goal, our team of clinical psychologists, UX designers, technical artists, and software engineers built a functional prototype of content, features and functions based on the Performance Triad Guide and the findings of our literature review (Fig. 2). This prototype contained minimal functionality to facilitate both speed and conversation in anticipation of receiving user feedback and iterating multiple times as part of the RAP process. Here we will explore our first round of RAP interviews.
Table 1. Interview Guidelines for Session 1 Organized by Overarching RAP Aims

<table>
<thead>
<tr>
<th>RAP Aims</th>
<th>Interview Guidelines</th>
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| Identify mHealth Needs | Military affiliation and background  
|                   | Healthcare needs of service members and their families (probe for mental health needs)  
|                   | Telehealth experiences  
|                   | Situations in which Battle Buddy would be useful                                      |
| Mobile App Preferences | Attitudes toward/Experiences with everyday tech use (broadly)  
|                   | Attitudes toward/Experiences with digital assistants (e.g., Siri, Alexa, etc.)  
|                   | Impressions of the Battle Buddy Virtual Human Coaches  
|                   | Impressions of the Battle Buddy UI                                                   |
| Identify Barriers | Access to smartphone/smartwatch  
|                   | ADA considerations                                                                  |
|                   | Stigma to discuss/disclose mental health topics                                     |
|                   | Uncanny Valley/negative attitudes towards Battle Buddy Virtual Human Coaches         |

2.4.1 RAP Session 1.

Recruitment and participants. The target population was US Department of Defense (DoD) personnel, or those who live with military personnel over the age of 18. We specified our target to those in the Los Angeles area, in order to conduct in-person interviews. Eligible participants were required to be familiar with smartphone technology and have a family tie or direct affiliation with members of the DoD. The team used USC’s communication network to send out an e-mail and virtual flyer to gather interested personnel. All participants completed a screening questionnaire via Qualtrics to determine their eligibility to participate. If approved, participants were asked to set up a video chat with research personnel to prepare them for the in-person interview and give an overall brief of the study objectives. All participants were required to sign a written informed consent document and provide verbal consent to be video recorded. Following RAP protocol we aimed to recruit 10 participants as previous research has shown themes begin to repeat after 8-10 interviews [1]. Ten participants (n=5 women; n=5 men) enrolled in and completed the study. Participants were 30±10 years in age (range, 18-50 years) and were classified as either DoD personnel (n=4) or military family (n=6).

Procedures. The primary aim of the first RAP session was to determine alignment between our initial prototype and user-identified 1) mHealth needs, 2) mobile app design preferences (including VH elements), and 3) barriers to adoption and adherence. Successful RAP sessions depend on teamwork. Multidisciplinary research teams, comprised of both insiders and outsiders, have been shown to increase sensitivity to insider categories and definitions [1]. Our multidisciplinary team consisted of both insiders (N=2; US military cadets), and outsiders (N=2; Psychologists), (N=2; Research Assistants), (N=2; Software Developers) who contributed to study design, data collection, data analysis, and prototype refinement.

Interview Protocol. Interviews were led by a US Military Cadet who was not only a full member of our research team but was also considered to be an insider to the military community by our study participants. The interviews were one-on-one, approximately 60 minutes in length, and video-taped for future data analysis by additional team members. RAP protocol stresses that the most important way of learning about a specific group of people is to get those people to tell you about their life and community. The goal is not to simply get people to answer a series of scripted questions, but to get them to tell you personal stories. This process is often identified as a semi-structured interview but is perhaps better characterized as a directed conversation. Therefore, our interviewer did not engage in sequential questioning or
solely traditional UX “think aloud” exercises, but instead engaged the participants in conversations that gave them adequate time to think about and share their stories.

Interview guidelines drafted by the research team (see Table 1), were provided to our interviewers in advance of the conversation with participants. These guidelines serve as reminders of the issues that should be covered, rather than a sequential list of questions for the interviewer to walk-through. RAP protocol has also demonstrated the value of opening sessions by posing a general “grand tour question”. Our interviewer opened each session with a question focused on personal military experience or the participant’s relationship to the military. The interview then moved to attitudes about artificial intelligence (e.g., digital assistants), healthcare needs of the military community, and impressions of the Battle Buddy app. Throughout the conversation, our interviewer engaged in back-channeling (e.g., mm, uh-huh) to signal active listening and kept the discussion moving forward and on-task with non-directive probes being mindful not to inject the vision of our research team into the conversation.

Analysis. RAP is an iterative process that explicitly divides research time between blocks used for collecting information and blocks when the RAP team conducts data analysis and considers changes for successive rounds of data collection. Following Miles’ and Huberman’s data analysis model our team 1) coded the data, 2) visualized the data, and 3) drew conclusion on the data [7]. Team members read the interview transcripts several times and watched the interview videos. The transcripts were then divided into thematic units and a coding system was developed based on recurrent themes. The transcripts were double-coded by two Research Assistants using NVivo 12 software. Data displays of the resulting analysis were presented to the RAP team, highlighting code counts and representative sections of text. The RAP team then worked together to consolidate relevant findings from the codes through the synthesizing of identified patterns. The preliminary findings of this first session of RAP were utilized by the team to inform future rounds of RAP and refine app design (Fig. 3).

2.5 Preliminary Findings
The data we collected via the RAP method was rich and multifaceted. For the purposes of this case study we will briefly review seven major findings derived from the interviews we conducted with participants recruited from the military community.

Wellness Content is On-Target. Our first RAP session elicited personal stories within the health and wellness domains the Battle Buddy app specifically targets. Participants shared stories that communicated a need for an effective and engaging app, designed specifically for the military community, that is focused on mental, physical, and emotional health. Frequently, these stories included a desire for a safe place for military personnel and their families to disclose mental health concerns and connect to additional resources. Furthermore, participants considered the Battle Buddy app to be a good fit growing telehealth needs.

Request for greater customizability for disabilities. Critical feedback was given by participants regarding physical and mental disabilities that are known to occur within the military community. During the interviews participants pointed out that the application should capture information in these domains during the on-boarding process (e.g., amputation, TBI, wheelchair use) in order to accommodate all potential users. In particular, they noted that VH word choice (e.g., try to increase your movement today by taking the stairs instead of the elevator) and available multi-media content (e.g., home workout videos) did not apply to all potential military members who might use the app and care should be taken to deliver customized content that would be useful to each of these users based on their needs.

Power of Uniforms. All participants commented on the virtual humans’ appearance and clothing. However, the participants fell into two distinct buckets regarding their feelings toward the virtual human coach appearing in uniform.
Some of the participants (n=6) felt they would prefer to speak to a virtual human in uniform, while others (n=4) felt that the uniform would make them feel uncomfortable and unwilling to disclose any difficulties or struggles they were experiencing. All participants commented that if the character were to appear in uniform, users should be able to select their unit patch in order to engender camaraderie.

**Preference for Positive Reinforcement.** All participants reacted favorably to instances of positive reinforcement and about half the participants reacted negatively to the absence of positive reinforcement, even when daily goals were not met. In these instances the participants suggested that it would add to their enjoyment of the app if the virtual character was supportive and provided some positive reinforcement for effort, even if the user fell short of their goals.

**Preference for “Real” Voice.** Participants were exposed to virtual human content that was delivered in two ways 1) a Text-to-Speech (TTS) voice and 2) a pre-recorded voice performed by a voice actor. It was not surprising that the participants overwhelmingly preferred the “real” voice actor voice to the more “robotic” TTS voice. However, it was surprising that participants revealed that this robotic voice would be a deal-breaker and they would not want to engage with the character or use this app if the final version utilized a TTS voice.

**Preference for shorter VH utterances.** The virtual human coach was designed to deliver health and wellness information. Our original app modules aimed to keep the virtual human dialogue concise and engaging. Despite this, a clear theme emerged that although our users enjoyed the presence of the character, the longer utterances (e.g., several sentences in a row) triggered feelings of being lectured to, even when the lines were delivered with the voice-acted “real” voice. The virtual human seemed to be most effective when providing brief instructions, positive feedback, or acting as a concierge for multimedia content.

**Request for updated aesthetic and functionality.** The daily Battle Buddy modules are concise by design, all less than 5 minutes in length. For this reason, our team did not think to include pause functionality assuming this content
would be consumed in one sitting. Despite this, the most common UI request from our participants that emerged from the interviews was a desire to have a built-in pause button on the screen. The reasons ranged from lifestyle (e.g., becoming unexpectedly busy after the lesson began) to concerns for privacy (e.g., not wanting to disclose personal information with others around). Additionally, participants unanimously expressed a desire for a sleeker UI design and updated aesthetic in order to increase the appeal of the app.

3 DISCUSSION

A major reason for failure in mHealth interventions is poor design that does not meet the standards nor requirements of the end users [4]. The purpose of this case study was to report on our proposed user-centered design model for the development of mHealth applications. The ISR framework plus RAP method proposed here, is an iterative process that includes needs assessment, content and functional requirement identification, UI/UX design and rapid prototyping.

This case study serves as a proof of concept regarding the utility of this novel approach and supports the use of this design model to quickly and efficiently understand a specific user group. Utilizing ISR as an overarching framework helped our team distill the needs of our intended end users and create an application they identified as filling a gap in care for their community. Our first session of RAP provided quick and actionable information in the three areas we set out to explore with our user testing, including 1) the mHealth needs of the military community, 2) their mobile app design preferences, and 3) any barriers that would prohibit uptake and sustained use of this app.

After receiving feedback that the goals of the Battle Buddy are on-target with the mHealth needs of this community, we are currently engaged in refining the app design to incorporate user input from this first round of RAP. Regarding mobile app design preferences, future iterations of this app (see Fig 3) include a sleeker and more modern UI design, play/pause functionality to increase ease of use and to be mindful of privacy concerns, shorter VH utterances and multimedia additions such as pop-ups to break up longer segments of spoken text. To address barriers that would interfere with uptake and sustained use of the application, future iterations also include more detailed customization to accommodate the specific needs of military members with disabilities, VH characters that can appear in uniform or civilian clothes, updated uniform options to include unit patches, "real" voice (i.e., prerecorded voice actor) rather than TTS and increased instances of positive reinforcement from the VH.

The ISR framework is trusted by the human-computer interaction community, but it has rarely been used in the development of mHealth applications and it has not been specifically paired with RAP as part of the design cycle [14]. The advantages of RAP as part of a user-centered design model were immediately apparent to our research and development team. RAP enabled us to quickly identify the flaws in the first version of the software. We were also able to rapidly ascertain the needs of the population we are aiming to serve while drilling down on specific modifications that would add value to our application without the cost and time typically needed to acquire this information. Insider-led user interviews also gave us access to information that may not have been shared if the interviews were led by a designer or researcher who was not a member of the military (particularly around design elements such as uniforms and their impact on a willingness to disclose). Additionally, the repetition of themes and uniformity across the ten interviews also led our team to believe that the findings of our data collection would also be salient to new members of the military community who interacted with Battle Buddy.

Our team learned several lessons by engaging in this first session of RAP that include:

1. RAP provides quick and cost-effective feedback from end-users early in the design process.
2. Common themes rapidly emerge across end-user interviews.
(3) Utilizing a community insider to conduct interviews puts participants quickly at ease and led to the disclosure of relevant personal stories.

(4) The personal stories shared lacked time-consuming and often unnecessary exposition or explanatory details often provided to “outsider” interviewers.

(5) The personal stories shared can lend insight not only into the general needs of the community but even into particular UI elements that are most useful to these end-users.

(6) Interview guidelines determined a priori provide an invaluable resource to help avoid lulls in the conversation and ensure uniform topic coverage across interviews.

(7) End-users are savvy and able to articulate their design preferences even if their primary profession is not in software design.

(8) The conversational elements of RAP lend themselves to traditional “think aloud” exercises commonly employed in UX studies allowing for additional methodologies to be included in RAP sessions (if desired).

There are several limitations to this case study. Our pool of participants was small and not demographically diverse. Therefore, the information we gathered may be true for the subsection of the military community they represent but not the military community at-large. For example, though our participants were eager to speak on behalf of service members with disabilities, features designed for these individuals should not be developed or tested without their input. Our findings are also limited as we have only engaged in one session of RAP with one interviewer on an early prototype of this mobile app. Therefore, the value and quality of the information gathered could be a function of the particular skill level of our “insider”. Similarly, the reactions to the application could be the result of the novelty of the application and VH experience. Future research, including randomized controlled trials, that look at repeated daily use of this app are needed to evaluate its efficacy. Additionally, future research would be needed to evaluate the efficacy of the proposed model including the evaluation of other mHealth apps designed with the ISR plus RAP model and a cost/benefit analysis of the proposed model in comparison with extant design models.

4 CONCLUSIONS AND FUTURE RESEARCH

In this case study, we presented a novel user-centered design model that leverages the methodology of both the ISR framework and Rapid Assessment Protocol to design an mHealth app for the military community. Service members and their families face unique life experiences that can make accessing healthcare challenging. Recent interest in mHealth apps to provide services to this community have resulted in applications that are often tested for efficacy, but rarely include end-users in the design process [16]. It is critical to include end-users at early stages of mHealth design.

As ICT is an US Army University Affiliated Research Center (UARC), we realize we are uniquely positioned to have access to members of the military community we are hoping to serve. This may not be true for all development teams, however the allocation of development funds to enable user-centered design that includes “insider” members on your team is money well spent. Ultimately, if mHealth apps are perceived as difficult or cumbersome to use, or worse, do not meet end-user’s needs, then they will likely be underutilized, if even used at all [14]. As such, the methodology proposed in this case study as well as the lessons learned are applicable cross-domain to mHealth application design and development. This model is particularly relevant for design that needs to quickly and efficiently ascertain the needs and preferences of specific end-users.

Future research for the Battle Buddy app includes “member checking” our findings from the first round of RAP by again meeting with the end-users we interviewed to check that the design refinements we executed represent their
feedback accurately. Furthermore, we have planned additional RAP sessions to continue refinement. Finally, we aim to conduct randomized controlled trials to investigate repeated daily use of the app in order to evaluate the efficacy and appeal of the Battle Buddy application.

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