Promoting Military Family Well-Being with Digitally-Supported Adaptive and Just-In-Time Adaptive Interventions: Opportunities and Challenges

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Introduction

Mobile Health (mHealth) tools show promise for helping people achieve and maintain behavior change (e.g., to manage psychological distress, increase physical activity, quit smoking etc.). Intervention components are described as mHealth when mobile and wireless devices (e.g. smartphones, tablets, wearables) are applied to promote health.[1] Mobile and wireless devices allow for more accessible and cost-effective interventions because their widespread use, acceptability and convenience can help reduce certain societal and structural barriers[2] and because they offer strong capability for scalability across geographic locations,[3] including within resource-limited,[4] hard-to-reach,[5] and deployed settings.[6] Mobile devices are capable of giving round the clock, real time reminders and feedback. Smartphones and tablet computers are also able to host applications (apps) with therapeutic content, and a multitude of capabilities such as social networking and gaming.[7] Using these technologies to support behavioral or mental health care in the wild (i.e., in the person's natural environment) can mitigate logistical burdens (e.g. scheduling conflicts, childcare, travel to treatment facilities) associated with traditional in-person clinical care. The option to receive care outside of standard treatment settings (e.g., in the privacy of one's own home) may be particularly appealing to MSVs who are concerned about stigma associated with seeking behavioral or mental health care.[8] A scoping review of youth mental health interventions via mobile phones provided evidence for the utility of these tools in engaging youth (ages 13-24 years) in therapeutic activities, highlighting the flexibility, interactivity, and

spontaneous nature of mobile communications as key advantages in encouraging sustained access to care outside clinical settings.[9] Given that in the United States young adults age 18-29 represent the age group that is most likely to own a smartphone (94%) or any cellphone (100%),[10] interventions that capitalize on these devices may be particularly promising among enlisted MSVs, most of which are 17-29 years old.[11] Moreover, children and adolescents are avid users of mobile devices;[12,13] these tools can be leveraged to promote the health and well-being of military families, and families with children more broadly. A recent meta-analysis of mHealth intervention studies for improving health outcomes in youth concluded that mHealth is an effective modality for promoting health behavior change in youth 18 years or younger, and that effects can be strengthened by involving caregivers (i.e., by providing a mHealth intervention to a caregiver).[14]

Because mHealth interventions can be disseminated conveniently with potential to promote behavior change at low cost, they may have particular utility in the initial phases of stepped-care policies. Stepped care policies are defined as evidence-based, staged systems comprising a hierarchy of interventions, from the least to the most costly/intensive, matched to the individual's needs.[15] Stepped-care can be a resource-efficient strategy for population level prevention and intervention. As compared to fixed treatment, in a stepped care approach minimal support (i.e., the least expensive and/or burdensome) treatment component is offered initially, and then more costly/burdensome components are offered only to those who need it most (e.g., those showing early signs of non-response); whereas even less costly/burdensome components can be offered to individuals who show adequate response to minimal support. The goal is to step up and down the intensity or cost of treatment based on early signs of progress in order to achieve a more cost-effective intervention. Such a stepped-care strategy is a form of an adaptive intervention (AI). AI is an intervention design in which information about the individual's progress in the course of the intervention (e.g., early signs of non-response or poor adherence) are used

to modify aspects of the type, dosage, intensity, or delivery modality of an intervention. AIs aim to address not only the unique, but also the changing needs of individuals over time. By providing appropriate treatments only to those who need it, when they need it,[16,17] AIs can improve long-term outcomes for greater numbers of individuals, hence increase the reach and impact of treatments.

mHealth tools also offer novel opportunities for delivering just-in-time adaptive interventions (JITAIs). A JITAI is a form of an AI that aims to address in real-time the rapidly changing needs of individuals.[18,19] Consistent with the notion of personalized medicine, JITAIs operationalize the personalization of the real time selection and delivery of intervention strategies based on real time data.[19] JITAIs have been developed and evaluated for a wide range of behavioral health issues, including physical activity,[20,21] alcohol use,[22,23] mental illness,[24] and smoking cessation.[25,26]

The current paper provides a brief introduction to AIs and JITAIs in mHealth. A particular focus is on the utility of digitally-supported AIs and JITAIs for advancing the health and well-being of MSVs and their families. We discuss opportunities and challenges relating to the development of digitally-supported AIs and JITAIs for this population and provide recommendations for future research.

Adaptive Interventions (AI) in mHealth

What is an Adaptive Intervention?

An AI is a sequence of individualized treatments that use ongoing information about the individual's progress (e.g., early signs of non-response or non-adherence) to decide whether and how the intervention should be modified. As an example, consider the following AI for promoting weight loss among overweight/obese adults (motivated by R01 DK108678; PIs: Spring & Nahum-Shani). At program entry, a weight loss mobile app is offered to all individuals; this app is designed to support self-monitoring of dietary intake and physical activity. The individual's response status is determined at weeks 2, 4, and 8 based on the amount of weight loss. If the individual does not lose at least 0.5 lb. on

average per week, s/he is classified as a non-responder; otherwise the individual is classified as a responder. As soon as the individual is classified as a non-responder, s/he transitions to the second stage of this AI, wherein additional support is offered in the form of weekly coaching sessions. As long as the individual is responsive, s/he continues with mobile app alone. This intervention is adaptive because it uses ongoing information about the individual's progress over time (i.e., weight loss) to decide whether or not coaching should be added to the mobile weight loss app.

AIs can be protocolized with decision rules. For example, the following decision rule protocolizes the weight loss AI described above:

At program entry,

First-stage intervention option = mobile app

Then, at weeks 2, 4, and 8

If response status = non-responder

Then, second-stage intervention option = add coaching (and stop assessing response status)

Else, continue with app alone (and continue assessing response status until week 8).

Decision rules are a useful approach to protocolizing an AI so that the intervention can be replicated (e.g., in other locations and times). As we explain below, this approach can also aid in clarifying the various components that comprise an AI.

What are the Components of an Adaptive Intervention?

An AI includes 4 key components (1) decision points, namely points in time in which treatment decisions should be made. In the weight loss example above, decisions are made at program entry, and then every several weeks (i.e., weeks 2, 4, and 8); (2) tailoring variables, namely information about the individual used to decide whether and how to modify the intervention. In the example AI above, the tailoring variable is the participant's response status. The participant's response status is determined

based on the amount of weight lost by the participant; (3) Intervention options, namely different types of treatment, different tactics, intensities, dosages or modalities used to deliver the treatment. In the example AI above, there are two intervention options, which represent two alternative tactics: either add coaching (and stop assessing response status) or continue with app alone; (4) decision rules, which link information about the individual (i.e., the tailoring variable) to intervention options; the decision rules specify for each decision point what intervention option should be offered under various conditions. In the weight loss example above, the decision rule specifies the conditions (i.e., insufficient weight loss) in which more support in the form of coaching should be added to a weight loss mobile app; as well as the conditions (i.e., when sufficient weight loss is achieved) in which such additional support is not required.

What is the Motivation for Adaptive Interventions?

AIs are often motivated by evidence of high heterogeneity in response to treatment, as well as by considerations pertaining to cost and burden. To clarify this, consider the weight loss AI described above. Coaching is an effective, yet relatively costly and burdensome weight loss treatment component.[27] The mobile app is less costly and less burdensome. However, empirical evidence suggests that there is high heterogeneity in response to mHealth weight loss interventions. Not all individuals benefit sufficiently from using a mobile app to lose weight; about 50% are unlikely to achieve ultimate treatment goals. Importantly, empirical evidence suggests that these individuals can be identified early, based on insufficient weight loss during the first few weeks of a mHealth intervention.[28] Hence, instead of offering coaching to all individuals, this AI starts with the less costly/burdensome mHealth treatment component (mobile app) and then adds coaching only to those participants who need it most, namely those who show early signs of non-response. As long as the individual is responsive, s/he continues with

the less costly/burdensome mHealth treatment component. This AI represents a more cost-effective approach than offering coaching sessions to all individuals throughout the intervention program.

Adaptive Interventions and the Well-Being of MSVs and their Families

AIs hold great potential for advancing the well-being of MSVs and their families. First, the needs of MSVs and their families vary over time (i.e., within-person or within-family heterogeneity). During times of peace and war, military lifestyle demands such as relocation, deployment and separation, reunion and re-integration into family routines require adjustment and re-adjustment to different circumstances and stressors.[29–32] This implies that even if a given treatment or an intervention program appears to be working well now for a particular MSV and his/her family, the same approach might not be effective in the future as circumstances and conditions change. AIs can be used to address such within-person or within-family heterogeneity by modifying the type and/or intensity of the intervention over time to effectively address the changing needs of MSVs and their families. mHealth tools may have an important role to play in these AIs. Modifying the treatment to address the changing needs of individuals requires continuous monitoring the individual's response to treatment. Given the pervasiveness and convenience of mobile devices, they offer opportunities for unobtrusively collecting ongoing data about the individual's changing needs and hence inform treatment adaptation. Moreover, the demands of military life (e.g. frequent moves) can impact continuity of care and treatment response for MSVs and their families.[33,34] During times of transition when traditional forms of treatment are not feasible (e.g. in-person clinical visits), mHealth interventions that can be utilized anytime and anywhere have the potential to facilitate continued access to some form of treatment.

Second, there is high heterogeneity in response to interventions aiming to improve the health and well-being of MSVs and their families. As an example, consider therapies for posttraumatic stress disorder (PTSD). Although treatments such as prolonged exposure (PE) and cognitive processing

therapy (CPT) were found effective in reducing military-related PTSD symptoms, across studies, at least half of, but typically most, veterans still meet diagnostic criteria for PTSD following treatment.[35] This has led Steenkamp and Litz[35] to conclude that "overall, dissemination models must move beyond simple one-size-fits-all conceptualizations of treatment if they are to adequately reflect the evidence base and the complexity of PTSD in veteran populations". AIs can be used to address such between-person heterogeneity by identifying early those individuals who show early signs of non-response and modifying their treatment (e.g., providing additional support) in order to prevent ultimate non-responders.

Third, barriers to mental health care in military families include availability (e.g., shortage of qualified mental health care professionals, high-cost, long wait-time), accessibility (e.g., absence of reliable transport to an off-base clinic, limited availability of childcare) and acceptability (i.e., stigma and negative attitudes to mental health care).[36,37] Developing stepped-care AIs that capitalize on mHealth tools as minimal support (i.e., relatively low-cost, low-intensity level of care) has the potential to address these barriers. The term "stepped care" describes an AI in which individuals not responding to the initial (minimal) level of care are then provided more intensive and/or costly treatments. When properly implemented, stepped care can reduce the negative effects of inappropriately assigned treatment and conserve resources by assigning individuals only the amount of care they need. Moreover, individualized treatments may attract and retain MSVs and their families who are in need but unlikely to seek out traditional therapeutic intervention (e.g., due to burden and/or stigma),[38,39] especially when low-intensity tools are integrated in care.[40] Given the widespread use, convenience, and acceptability of mHealth tools, utilizing them to deliver initial (minimal) support can further increase access to care. This is particularly critical in the context of military families given that over 50% of Active Duty military families live off-installation[41,42] Living off-installation decreases access to care (due to lack of

services for military families far away from military installations) and hinders integration into a military support network.[41] Low-cost, low-burden, and accessible mHealth tools can be used to deliver universal (designed to reach and target an entire population) interventions and screening to MSVs and their families. Individuals or families identified as needing more than minimal support can then be linked to more costly/intense indicated care (i.e., designed only for individuals showing warning signs of problem) to address their specific needs. Moreover, once the desired outcome is obtained, it may not be clinically appropriate to stop treatment completely or resume an intense treatment schedule.[38] mHealth tools can be used to "step-down" treatment to maintain gains (e.g., via extended monitoring[43]).

Challenges and Directions for Future Research

Although multiple evidence-based AIs exist, very limited attention has been given to the systematic development and implementation of AIs for military families. First, stepped care is loosely implemented in the treatment of service members and their families, and the decision rules regarding when to step treatment up or down are not well defined.[38] Moreover, current stepped-care approaches for MSVs do not explicitly specify how, when, and for whom mHealth should be used in the process of care. Second, while mHealth tools are natural candidates to be integrated in a stepped-care approach for MSVs, these tools have limited evidence of efficacy in this population.[44–46] In fact, acceptability of mHealth tools varies among MSVs. For example, MSVs' attitudes towards mHealth for mental health treatment were found to vary, with strong opinions expressed either for or against smartphone apps.[47] Third, more evidence is needed to evaluate and optimize existing stepped-care models for MSVs. Recently, the first large, randomized effectiveness trial on collaborative care for PTSD and depression in the Military Health System (MHS) was conducted.[48] Both treatment arms received collaborative care interventions in primary care settings, but one of the arms incorporated a central assistance team and placed greater emphasis on bolstering the stepped components of the model. The enhanced care model

resulted in improved PTSD and depression outcomes above the traditional collaborative care model.[48] Although this study clearly demonstrates the advantages stepped-care approaches might have over standard of care, limited research attention has been given to optimizing and evaluating stepped-care interventions for other domains of mental health issues confronted by MSVs. Finally, existing stepped-care approaches focus primarily on service members, with less attention given to including family members in treatment or to improving the well-being of family members.[49] Existing phase-based intervention approaches for military families focus on addressing the emotional cycle of deployment (i.e., pre-deployment, deployment, sustainment, re-deployment, post deployment[50]) by offering adaptive support to military couples, yet critical and largely ignored are the parenting processes associated with the deployment cycle.[51,52]

Just-In-Time Adaptive Interventions (JITAI) in mHealth

What is a JITAI?

A JITAIs is a form of an AI that seeks to address the rapidly changing needs of individual. As an example, consider this simplified description of Sense2Stop,[53] a smoking cessation JITAI. This JITAI is based on evidence suggesting that if smokers attempting to quit experience stress (a state characterized by high arousal and displeasure[54,55]), these experiences likely lead to a lapse (an isolated smoking episode), which in turn likely leads to a full relapse.[56] To prevent stress episodes from leading to full relapse, in Sense2Stop smokers attempting to quit wear a collection of sensors (see AutoSense[57]) that monitor their physiology continuously. An algorithm on the mobile device[58] uses this data to determine, for every given minute, whether or not there is sufficient evidence that the person is experiencing stress. If there is sufficient evidence that the person is experiencing stress, and the person is receptive (i.e., s/he is not driving a car and did not receive an intervention in the past 60 minutes), the mobile devise prompts the individual to engage in a stress regulation exercise. Similar to AIs, JITAIs can be

protocolized with decision rules. For example, the following decision rule (simplified for illustrative purposes) protocolizes Sense2Stop:

Every minute

If Stress and Receptivity =Yes

Then, intervention option = [Prompt]

Otherwise, intervention option = [Nothing]

What are the Components of a JITAI?

JITAIs include the same 4 key components that AIs include, namely decision points, tailoring variables, intervention options and decision rules. Different than traditional AIs, where decision points are set in relatively long intervals (e.g. every several weeks, or months), JITAIs rely on rapid decision points. For example, in Sense2Stop decisions are made every minute. The tailoring variables in Sense2Stop are the participant's stress status (determined based on passive sensing of the participant's physiology), and receptivity (determined based on whether or not the participant is driving a car and the number of minutes since previous intervention prompt). Sense2Stop includes two intervention options: either deliver a prompt to engage the participant in a self-regulation exercise, or do nothing. Finally, the decision rule in this JITAI specifies the conditions (i.e., when the person experiences stress and is receptive) in which more support in the form of a prompt should be delivered; and the conditions (i.e., when the person does not experience stress, or when s/he is not receptive) in which a prompt should not be delivered.

What is the Motivation for JITAIs?

JITAIs are motivated by the need to address conditions that change rapidly, unexpectedly and in the person's natural environment.[18,59] These conditions can represent vulnerability (high risk) or opportunity for positive changes. For example, Sense2Stop is motivated to address stress episodes. The

key assumption is that stress represents a state of vulnerability (high risk) for relapse. Hence, Sense2Stop is designed to provide support (in the form of a prompt recommending a stress-regulation exercise) when stress is detected in order to break the link between the vulnerable state and the adverse outcome (relapse). However, JITAIs can also be motivated to capitalize on states of opportunity for positive changes. For example, a JITAI for promoting physical activity can use information about the person's location to identify when s/he are close to a park or a recreational facility to trigger a recommendation for the person to engage in physical activity. Here, proximity to a park or a recreational facility represents a state of opportunity for engaging the individual in physical activity, rather than a state of vulnerability to adverse outcomes. Stress episodes are expected to occur rapidly (e.g., every minute a person can transition from experiencing no-stress to experiencing stress), unexpectedly (it is not possible to predict exactly when a person will experience stress during the day), and in the person's natural environment (e.g., stress can happen at work due to job demands, or at home as a result of family-related demands). Addressing such conditions require the capabilities to continuously monitor the person's state and context (e.g., in order to identify when stress occurs, as soon as it occurs), as well as to deliver interventions in the wild, outside of standard treatment setting. Advances in mobile and wireless devices provide these capabilities. Sense2Stop capitalizes on sensors to monitor the person's physiology continuously in order to identify episodes of stress, and on smartphones to host a collection a stress-regulation exercises and to deliver a prompt as soon as stress is detected. Finally, because the conditions JITAIs attempt to address are expected to emerge in the person's natural environment, where multiple demands compete for the person's time, effort and attention, these interventions are also motivated to explicitly minimize disruptions to the daily lives and routines of individuals. This is done by providing an intervention only when the person is receptive, namely able and willing to capitalize on a given intervention. In Sense2Stop an intervention (prompt) is delivered only when the person is

vulnerable (i.e., experiencing stress) and receptive (i.e., not driving a car and did not receive an intervention in the past 60 minutes). The assumption is that the person should not act on the prompt when s/he is driving a car (due to ethical/practical considerations) and will not be able to capitalize on the prompt if s/he has already received an intervention prompt in the past 60 minutes (due to burden and/or habituation).

JITAIs and the Well-Being of MSVs and their Families

Although the daily experiences of all families involve states of vulnerability (e.g., worry, conflict, stress[60]) as well as states of opportunities for behavior change and growth (e.g., meals, active leisure, religious activities, and housework[61]) the day-to-day experiences of military family members might be unique in relation to marital and parent-child relationships.[62–65] Specifically, family life consists of daily/weekly routines and rituals (i.e., specific, repeated practices involving two or more family members[66]) that evolve over time and represent important aspects of family health and child development.[66,67] Routines (e.g. family mealtime,[66,68] adequate sleep[68,69]) can be protective by providing both a predictable structure and emotional climate that guide behavior and support healthy development.[66] Stressors specifically associated with military duties (e.g. separation, reintegration) can be highly disruptive to the daily routines of military families, influencing both marital and parent-child interactions.[64,65,70]

Research on the mental health implications of military deployment highlights the dynamic relationship between the MSV and his/her partner as a source of both vulnerability and opportunity for personal growth.[70] For example, increased demands at home in the absence of the service member can hinder the ability of his/her spouse to provide support that alleviates the service member's stress, and vice versa. Dyadic coping is the interplay between the stress of one partner and coping reactions of the other.[65] Empirical evidence indicates that in instances of chronic illness (e.g. cancer), positive or

common dyadic coping (i.e., when both partners work symmetrically) is associated with improved relationship quality, self-care, and psychological functioning in both patients and their partners.[66–70] JITAIs have the potential to promote positive dyadic coping by providing real-time feedback and suggestions to address conditions specific to each person in the relationship (e.g., stress experienced by the MSV due to family separation,[64] parenting stress experienced by the non-deployed spouse[71]), as well as dyadic conditions that arise between the MSV and his/her partner (e.g., asymmetry in relational maintenance associated with communication restrictions[72,73]).

Military service can also impact child well-being and family functioning.[31,74–76] Potential sources of stress for military family children include frequent moves (i.e., every 2-3 years), parental deployment(s), and/or parental injury.[77–79] According to Rosenblum and colleagues (2014),[80] although these 'large-scale' disruptions pose challenges for parent-child relationship, meeting children's needs and addressing 'smaller-scale' disruptions during everyday experiences are important processes by which relationships can be restored and strengthened. Additionally, resilience is the dynamic process of positive adaptation within the context of significant adversity.[74,78] Critical to resilience is self-regulation,[76,81] namely the flexible modulation of cognition, behavior, and emotion.[82] Empirical evidence suggests that engaging in evidence-based self-regulatory activities, such as behavioral substitution, mindful attention, relaxation techniques, and searching for strengths within common everyday experiences, can promote self-regulatory skills.[83–86] JITAIs can be used to address in real-time parents' and children's needs for hands-on strategies for managing everyday small-scale difficulties, and building self-regulatory skills. Current family-based models encourage training parents and children to identify personal- and family-level triggers and developing collaborative strategies for modulating their impact.[76] Such models can be used to guide the development of JITAIs that address family needs more holistically, by detecting personal- and family-level triggers in real-time and delivering

recommendations to engage in collaborative self-regulatory activities and supportive familial transactions.

Challenges and Directions for Future Research

As with adaptive interventions, very limited attention has been given to the systematic development of JITAIs for military families. Below, we review several challenges that hinder the development of these interventions and highlight directions for future research.

First, existing empirical evidence and theories lack the temporal specificity needed to guide the development of efficacious JITAIs.[1,2] Little is known about how rapidly risk and protective factors change over time in the context of military families. Even when the dynamic nature of mechanisms such as stress, coping and conflict is acknowledged,[63] it remains unclear how and to what extent these mechanisms might change over time and what kind of support should be offered to address them. Moreover, critical to the development of efficacious JITAIs is evidence concerning what constitutes receptivity to specific just-in-time interventions, and how fast receptivity is expected to change over time. However, limited attention has been given to investigating receptivity to just-in-time interventions and even less is known about receptivity as it pertains to MSVs and their families. Much work is needed to fully understand the mechanisms through which digitally supported interventions can improve the well-being of military families in everyday, real world settings.

Second, given the demonstrated interrelated health of family and empirical support in favor of scientific models that address the family as a system,[31,79,87,88] greater emphasis should be given to developing family-centered interventions for military families, namely interventions that address the family as an interconnected unit within the context of military life. The development of family centered JITAIs requires integrating behavioral theories geared towards an individual and behavioral theories

geared towards family-systems, and further advancing these theories from relatively static, to more dynamic portrayals of behavior and processes.

Third, JITAIs require continuous monitoring of the individual's state and context to inform the triggering of an intervention in real-time. This can be done via active assessments (e.g., Ecological Momentary Assessments: EMAs), which are self-reported and hence induce data-entry burden on the participant. Passive assessments via contemporary smartphones (i.e. mobile phones with computational capacities) represent a less burdensome alternative. Sensors embedded in contemporary smartphones (e.g., light sensor, Global Positioning System [GPS], accelerometers, microphone) can be leveraged to passively track behavior with minimal data entry-burden on the individual. Thus, as smartphone owners carry the device for personal use, the embedded sensors could potentially collect information that may inform the triggering of an intervention in real-time.[89] However, research using smartphone sensors in health and well-being research is in its infancy, and it is unclear whether the types of behavioral data collected with these sensors could serve as meaningful indicators of vulnerability/opportunity and receptivity to just-in-time interventions.

Fourth, more work is needed to develop robust and clinically tested algorithms to identify states of vulnerability/opportunity and receptivity based on data from wearable physiological sensors. Consider stress as a hypothesized state of vulnerability for adverse events (as discussed earlier in the motivation for Sense2Stop). Multiple approaches have been developed for using wearable physiological sensors to detect stress. These approaches use a wide array of features calculated from sensor data measuring physiological responses to increased sympathetic nervous system activity associated with stress,[90] such as heartbeat,[91–93] skin conductance,[94–96] and respiration. Challenges to this approach involve high individual subject variability in physiological responses to stress, self-reported perceived stress not correlating well and consistently with physiological stress response, and physical activity

leading to masking and confounds of stress detection (as it triggers physiological signals similar to stress) (see Winslow et al.[97]). Currently, there are no robust and clinically tested algorithms to identify stress episodes in the wild, in real time.[97] However, major progress is being made in this realm for adult populations. For example, Hovesepian et al.,[58] Plarre et al.,[92] and others[98–100] have provided a strong foundation for stress detection based on wearable physiological sensors. Specific to MSVs, Winslow et al.[97] developed a classifier of real-time physiological stress based on wearable sensor data and demonstrated the feasibility of using this classifier to inform the just-in-time triggering of stress management techniques in a small clinical sample (n=10) of armed forces veterans undergoing CBT for stress and anger management.

Finally, methods for continuous monitoring of state and context in children are extremely limited. EMA methods are increasingly used in behavioral science, but best practices with youth are unclear.[101] From the limited available data, EMAs can be successfully implemented with youth ≥7 years from diverse backgrounds.[101] Data collection using wireless and wearable sensors is more challenging in children and teens (compared to adults). Young children's voices are largely absent in the design of existing health tracking devices.[102] For children <13 years, kid-friendly wearables and apps are limited due to privacy laws and regulations such as Children's Online Privacy Protection Rule "COPPA."[103] Moreover, unique to family media use, children are subject to parental monitoring of digital and other technologies, which could hinder use in real-time.[104–106]

Challenges Specific to the Use of mHealth in Supporting Military Family Well-being

As noted earlier, mHealth tools can be leveraged to deliver AIs and JITAIs that promote the health and well-being of military families. However, various challenges are associated with the integration of mHealth tools into family systems.

First, evidence is needed to understand how military families use mHealth tools in their daily lives. Similar to civilian families, military families live in a media-rich world competing for their attention.[107,108] Empirical evidence not specific to military families indicates that mobile and online media consume a significant portion of leisure time for individuals, couples, and families.[107] Families are increasingly connecting "on the go,"[109] with nearly all children <8 years living in a home with some type of mobile device and spending on average ~48 minutes/day using mobile devices.[110] Yet, differently resourced families (e.g. in terms of education and income) vary in how they incorporate digital and other media into their daily routines. For example, a gap in high-speed internet still exists between higher-income and lower-income families.[109,110] Such gaps in connectivity can influence data collection and intervention delivery capabilities. Similarly and unique to family media use, a child's usability may be influenced by parental monitoring and logistical considerations (e.g. young children are less likely to own a phone or are not allowed to download apps).[105,106,111,112] As such, family-centered interventions that capitalize on mHealth tools should be designed with careful consideration to how various family members use these tools in varying contexts. To effectively inform how to integrate mHealth in the care of MSVs and their families, it is critical to gain better understanding of how MSVs and their families make decisions about connectivity and incorporate different technologies into their daily routines, particularly when deployment may restrict/hinder connectivity and communication.[6]

Second, research is urgently needed to promote engagement and address the law of attrition, a phenomenon in digital health where the user abandons a technology shortly after use.[113] Engagement is conceptualized as a dynamic state of involvement, with behavioral, affective, and cognitive elements that contribute to intervention effects.[114,115] Intervention attendance/participation, retention, and app usage are commonly used measures of engagement in mHealth.[114,116–118] Engagement with a mHealth intervention may be influenced by the intervention itself (content and delivery), the context

(the setting in which the intervention is used), the population using it, and the behavior the intervention is designed to target.[119] For example, literature on cognitive behavior therapy mHealth interventions indicate that in addition to content, a positive user-experience is critically important to engagement and adoption.[120–122] User-centered design principles focus on understanding and addressing the routines and workflows of the individuals the mHealth tools are intended to support. This is done via an iterative process that assesses needs, develops the intervention, and tests usability (to refine the intervention).[123,124] Highly relevant to engaging military families with mHealth are design principles that promote joint media engagement (JME), wherein individuals may use media together through a variety of spontaneous and designed experiences.[108] A working assumption of JME is that what goes on between people and around media can be as important as the content included in the media.[108] Principles of JME include mutual engagement (partners equally motivated to participate in the activity), co creation (use media to build shared understanding), dialogic inquiry (collaborate to make meaning of situations), intention to develop (at least one partner grows through the activity), and focus on content not control (technical interface does not hinder partner interaction).[108]

Third, limited resources (e.g. time, budget) may hinder the development of highly engaging, aesthetically pleasing mHealth tools for military families.[125] When resources are limited, there is empirical support for public-private partnerships[126] and repurposing "popular" apps.[125,127–133] For example, *Family Time with Apps* is a resource to help parents understand a variety of ways that apps can support children's development, family learning, and communication.[134] *Headspace* is a commercially available app (requiring subscription for premium content) with developmentally designed "kid packs" to promote mindfulness/meditation; the app has supporting evidence of efficacy in diverse adult populations.[130,133,135,136] *Breathe* is a free app developed for children ages 2-5 years as part of Sesame Street's Little Children, Big Challenges initiative.[137] The app uses vignettes to teach young children how

to calm down, become aware of thoughts and feelings, and problem solve. However, it is important to note that the design of many mHealth tools focus on individual health and do not address family health in a unified manner.[138] Moreover, empirical support for the efficacy of these apps with young children is insufficient.

Fourth, interventions that employ a stealth health approach, where the targeted outcome is a side effect, but not the primary motivator of participation (also a common gamification technique), may be useful in engaging both parents and children.[139,140] This approach may be particularly beneficial when the targeted outcome (e.g., mental health, obesity) is associated with stigma or burden.[139] For example, although Pokémon GO was not promoted as a health app, across demographics, it was found to improve physical activity (PA), as well as psychological health and cognitive performance.[105,141–146] Note that despite its global popularity, engagement with Pokémon GO trended downward within four months after initial release. Attention to developing empirically-based approaches to promote engagement with mHealth interventions sufficient to achieve the desired behaviors and/or prevent relapse is critical.

Lastly, due to the rapidly changing mHealth landscape, challenges exist to integrating mHealth into clinical care. Providers do not have adequate training on where to find empirically supported and aesthetically pleasing apps necessary to meet the multifaceted needs of children and families. Moreover, parents and pediatric providers are often at odds with regards to technology. For example, contrary to expert recommendations (e.g. <2 hours/day; not before bedtime), families report leaving televisions on in the background most of the time and similarly many children use media shortly before bedtime.[109,110] Provider recommendations to limit technology use in children are counter to parents who use technology for periods of respite. In response to this identified practice gap, app repositories/clearinghouses such as PsyberGuide (mental health app clearinghouse; https://psyberguide.org) are emerging to help providers readily search for, identify, and assess app quality to support children and families beyond the clinic

visit. However, research in this area is extremely limited. As digital health continues to evolve, a military-specific repository would be a beneficial resource to both clinicians and families.

Conclusion

Adaptive stepped-care interventions that integrate mHealth as minimal support have an important role to play in increasing the scalability of and receptivity to traditional treatment approaches for MSVs and their families.[40] Effort should be dedicated to developing stepped-care interventions that (a) integrate mHealth as low level of support; (b) are designed not only for MSVs but also for their family members, and that (c) are empirically-based, namely optimized and evaluated systematically based on rigorous research. Similarly, JITAIs hold great potential for improving the health and well-being MSVs and their families, as they can be used to address rapidly changing conditions (e.g., stress, conflict, and other day-to-day difficulties), in real-time and in the wild. Effort should be dedicated to (a) building family-centered JITAIs that seek to address the inter-related needs of MSVs and their family members (partners and children) in a holistic manner; (b) build the empirical evidence necessary for the construction of these interventions (including evidence concerning how fast the mechanisms underlying vulnerability/opportunity change over time, and what constitutes receptivity to specific just-in-time interventions); and (c) develop robust and clinically tested approaches for using data from wireless and wearable sensors to identify states of vulnerability/opportunity and receptivity to just-in-time interventions. To integrate mHealth in the care of MSVs and their families more broadly, it is important to (a) gain better understanding of how MSVs and their families make decisions about using mobile devices and different media; (b) develop empirically-based mHealth tools for military families, specifically for children; and (c) develop and implement effective strategies for promoting sufficient engagement in mHealth.

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