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Iterative Development of a Tailored mHealth Intervention for Adolescent and Young Adult Survivors of Childhood Cancer

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Abstract

Objectives.—Methods for developing mobile health (mHealth) interventions are not well described. To guide the development of future mHealth interventions, we describe the application of the agile science framework to iteratively develop a mHealth intervention for adolescent and young adult (AYA) survivors of childhood cancer.

Methods.—We created the AYA STEPS mobile app (AYA Self-management via Texting, Education, and Plans for Survivorship) by modifying and integrating two existing programs: an online survivorship care plan (SCP) generator and a text messaging self-management intervention for AYA off treatment. The iterative development process involved three stages of agile science: 1) Formative work, 2) Obtaining feedback about the first AYA STEPS prototype, and 3) Pilot testing and finalization of a prototype. We determined preferences of AYA stakeholders as well as discovered and addressed technology problems prior to beginning a subsequent randomized controlled trial.

Results.—AYA survivors reported that the app and the embedded tailored messages related to their health and SCP, were easy to use and generally satisfying and beneficial. Usage data

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supported that AYA were engaged in the app. Technology glitches were discovered in the pilot and addressed.

Conclusions.—The iterative development of AYA STEPS was essential for creating a consistent and acceptable end user experience. This study serves as one example of how behavioral scientists may apply agile science to their own mHealth research.

Keywords

mHealth; adolescents/young adults; cancer; chronic illness; self-management; agile

The burgeoning field of mobile health (mHealth) has led to a rapid proliferation of mobile applications (apps) and text message interventions intended to influence health, many of which have demonstrated initial efficacy and acceptability (Fidel et al., 2017; Militello, Kelly, and Melnyk, 2012). However, the process of developing mHealth interventions remains opaque and rarely described in detail (Wu, Steele, Connelly, Palermo, & Ritterband, 2014). Understanding the development process is important given the lack of standard evidenced-based guidelines for how to develop mHealth interventions (Davis & Oakley-Girvan, 2017). Further, there are clear differences in developing mHealth interventions compared to traditional interventions such as the need to partner with a technology vendor, consider the tension between rapidly changing technology and standardization, manage technology, employ user-centered design to maximize engagement, and consider competing demands for attention with an intervention intended for real-world use (McCurdie et al., 2012; Michie, Yardley, West, Patrick, & Greaves, 2017; Wu et al., 2014). As such, sharing the process of mHealth intervention development can elucidate effective methods and inform best practices across researchers engaged in the development of mHealth interventions. In the current paper, we describe the iterative development of a new mHealth intervention for adolescent and young adult (AYA) survivors of childhood cancer called AYA STEPS (AYA Self-management via Texting, Education, and Plans for Survivorship).

AYA survivors of childhood cancer are a vulnerable group at risk for relapse and late effects of treatment. The carcinogenic nature of cancer treatments increases their risk for secondary cancers and treatment-related late effects, such as cardiovascular, pulmonary and renal dysfunction, endocrinopathies, and cognitive difficulties (Armstrong et al., 2014; Zeltzer et al., 2009). After treatment, AYA initially require frequent follow-up appointments. After a few years, they require, at a minimum, annual appointments for risk-based survivorship care (Children’s Oncology Group, 2008). These patients, who report many unmet needs, also need age-appropriate transition support (Freyer, 2010) and individually-tailored education about their physical and psychological health vulnerabilities, need for follow-up care, and health behaviors to mitigate their unique risks (Hudson & Findlay, 2006). They often live great distances from their treating hospital, and/or are relatively transient in young adulthood, leaving them vulnerable to difficulty accessing appropriate follow-up care. Despite the potential of tailored mHealth interventions for AYA survivors, very few have been developed and tested with this population (Fedele, Cushing, Fritz, Amaro, & Ortega, 2017; Casillas et al., 2017; Wesley & Fizur, 2015).

To address the needs of AYA survivors, we combined two programs of digital/mHealth intervention research to develop AYA STEPS—an app that facilitates the delivery and storage of tailored text messages within the app, and includes other features related to self-management as a survivor, with the goal to enhance health and well-being. The first initial research program that informed AYA STEPS involved internet-based digital survivorship care plans (SCPs) for AYA survivors. The second was a mHealth texting intervention for AYA survivors intended to support adjustment and health after treatment. Digital/mHealth interventions are optimal for AYA survivors given the ubiquitous use of smart phones and text messaging as the primary mode of communication, the ability to reach AYA who may have limited contact with medical providers after treatment ends, and the growing evidence of the ability of mHealth interventions to influence positive health behaviors.

The aim of this paper is to describe the development of AYA STEPS, with attention to selected beginning stages of the agile science framework. This is a framework more often applied in other fields for rapid technology development, yet its use has been called for by other pediatric psychologists (Aylward et al., 2017). We specifically describe formative work of the initial prototype, acquisition of feedback and modifications, and prototype testing with a pilot sample. By detailing these methods, we address calls for more transparency and rigor in mHealth as we provide an example for behavioral scientists aiming to develop acceptable, feasible, and efficacious mHealth interventions (Wu et al., 2014).

Methods/Results

Development of the AYA STEPS app involved three main stages of agile development: 1) Formative work to develop an app for AYA survivors, 2) Obtain feedback about the first AYA STEPS prototype, and 3) Pilot the second prototype with study team members and AYA survivors and finalize the app (see Figure 1). We describe the agile framework and each of these steps and outcomes separately (combining methods and results) below in detail. However, we first describe our two prior programs of research on SCPs and text messaging that served as the basis for AYA STEPS.

Preceding Formative Research: Smart-ALACC and THRIVE

SCPs have only recently been used for childhood cancer survivors and have been studied by our team. SCPs are a tool to improve health-related knowledge, engagement, and patient-provider communication (Shalom, Hahn, Casillas, & Ganz, 2011). They contain information about cancer treatment history, risks for late effects, and resources and strategies for health promotion. Only 38% of adult oncology patients reported receiving treatment summaries, a key component of SCPs (Sabatino et al., 2013), and about half of survivors of childhood cancer report receiving a survivorship care plan (Casillas et al., 2011). The University of Pennsylvania developed OncoLife, a publicly available SCP generating tool for adult cancer survivors that has generated over 60,000 SCPs to date (Hill-Kayser, Vachani, Hampshire, Jacobs, & Metz, 2009). Smart-ALACC (Adult Living After Childhood Cancer) was adapted from OncoLife to serve as a digital health tool for generation of SCPs for AYA survivors of childhood cancer (Szalda et al., 2016). Smart-ALACC content was written by a team of oncology physicians, nurses, psychosocial team members and a young adult to incorporate

recommendations from the Children's Oncology Group guidelines and other AYA resources. In pilot testing, Smart-ALACC demonstrated high feasibility (easy to use, taking less than 10 minutes to complete) and acceptability (Szalda et al., 2016). The incorporation of Smart-ALACC into an app intended to enhance uptake of the SCP is one aspect of AYA STEPS.

Our prior texting intervention, which also informed AYA STEPS, is called THRIVE (Texting Health Resources to Inform, motiVate, and Engage; (Schwartz et al., Submitted). THRIVE was tested through a pilot randomized controlled trial (RCT) for AYA survivors within one year after completing treatment. It was informed by our SMART framework of transition readiness (Schwartz et al., 2013), as well as the Health Belief Model and Social Cognitive Theory (Glanz & Rimer, 2005). Daily text messages were intended to enhance awareness of health vulnerability and the importance of continued engagement in care, while providing support and encouraging positive health. Text messages were tailored to patient age, a selected health goal (e.g., increase physical activity), medication adherence (yes/no), medical appointment reminders, and included general content on health-promoting behaviors, academic and social adjustment, and engagement in follow-up medical care. THRIVE demonstrated high acceptability and feasibility and preliminary efficacy related to improvements in health knowledge, health behaviors, and perceptions of health vulnerability.

Agile Science Framework

For the current study, we combined Smart-ALACC and THRIVE into a mobile app called AYA STEPS. It contains individualized SCPs generated via Smart-ALACC and delivers daily tailored messages within the app to improve knowledge of personal health history and risk as well as support adherence to recommendations within the SCPs. To integrate and optimize these interventions, we adopted an agile science framework (Hekler et al., 2016). Agile science is an iterative process of intervention development, which involves ongoing optimization based on the fit between the individuals, contexts, and intervention in order to produce interventions intended for real-world use (Hekler et al., 2016). This framework borrows from agile software development, user-centered design (McCurdie et al., 2012), and implementation science methods such as pragmatic trials (Glasgow, Phillips, & Sanchez, 2014). Compared to traditional phase-based models of intervention development, agile science adopts small but rapid steps to specify, iteratively improve, and optimize intervention ideas (Patrick et al., 2016). Thus, agile science is especially well-suited for mHealth intervention development, as technology often changes at a faster rate than the scientific process. The ultimate goal is transparency of the process to determine components and when, where, for whom, and in what state to use a given tool (Murray et al., 2016). Behavioral scientists and clinical researchers have increasingly incorporated aspects of the agile process into their development of mHealth interventions, but none have clearly articulated the steps of the agile process (Casillas et al., 2017; Jibb et al., 2017). The complete steps to development of AYA STEPS, informed by the agile science framework, are described below.

Stage 1 Methods: Multidisciplinary Formative Development of AYA STEPS

Building on Smart-ALACC and THRIVE, we began with 1) developing a multifunctional mHealth app that could display the SCP document and allow two-way tailored messaging for AYA survivors, and 2) modifying and expanding the THRIVE text bank to reinforce, and enhance the uptake of, individual SCP recommendations. This involved the creation of new treatment-specific text messages and algorithms, by which the cancer treatment history would inform both the content of their SCP as well as the text messages they received within the app (see Figure 2). We convened a multidisciplinary working group of cancer survivorship researchers and providers [1 adult MD, 4 pediatric MD specialists (one of which is trained in medicine-pediatrics), 3 psychologists, 2 advanced practice nurses), technology specialists (LST team, 4 team members with mHealth expertise), and AYA volunteers (2 paid and 3 unpaid research assistants)] to determine tailoring algorithms and create or modify text messages from THRIVE. Each individual text message was developed with consideration of guiding theoretical models and prior acceptability data.

We identified a vendor (LifeScience Technologies; LST) who had an existing, yet modifiable, HIPAA-compliant disease self-management app (LSTCare). LST was selected due to optimal features of their automated app that included: 1) an integrated messenger applet that allows for two-way text messaging tailored to specific patient attributes, 2) capability of interfacing with the electronic health record (EHR) to upload information about appointments, medications, and so forth, 3) it has a configurable set of 50 health-related applets designed to facilitate self-management, including various applets for tracking health behaviors (e.g., step counts), medication reminders, capacity to upload and display documents (e.g., SCP) and videos, and 4) the ability to include gamification via a point system to reinforce engagement. Our multidisciplinary team selected applets hypothesized to facilitate survivorship self-management and support the aims of the study, while graphic designers at our institution were called on to make design modifications to customize the “look and feel” of the app for AYA survivors.

Stage 1 Results

As depicted in Figure 2, the multidisciplinary team identified four major message tailoring components important for survivorship self-management and SCP uptake: time since completion of therapy (completed therapy in the last two years vs. long-term cancer survivor), age (15–17 years old vs. 18 years or older), personal health goal (e.g., getting more sleep), and treatment history (e.g., types of chemotherapy and location of radiation). After identifying these tailoring components, we modified existing THRIVE messages or created new messages to fulfill each of these components. Treatment history messages were developed to directly match with SCP content. For example, an AYA who received cisplatin, a type of chemotherapy drug that poses risks for hearing deficits, would receive a message related to getting hearing checked.

The development of text messages was done through group consensus during weekly meetings for three months, with team members suggesting and revising content to be theoretically grounded, developmentally appropriate, specific to intervention goals, and at a 6th grade reading level. The final text bank included 227 messages, about half of which

were tailored to individual characteristics, with two-way functionality. Specifically, some messages invited a response (e.g., a trivia question or “text back for more information”), but also allowed free text to engage the team with questions or comments.

During this stage, weekly teleconferences with our technology vendor (LST) took place to review app navigation and applet functionality, user tracking and incentivization options tied to engagement in the app (gamification), and tracking of usage data. We then finalized the first prototype, which included the tailored text message bank, embedded SCP, selected applets for facilitating survivorship self-management (i.e., nutrition and activity tracking, goal tracking, points accrual, SCP content, messaging, appointment reminders and list of medications and allergies based on syncing with EHR), and branding/design elements (i.e., new color scheme and AYA STEPS logo).

Stage 2 Methods: Obtain End User Feedback about the first AYA STEPS Prototype

Our next step was to solicit feedback about the first prototype from purposefully sampled AYA survivors (a.k.a., end users for this intervention) (see Figure 1). After obtaining IRB approval, we invited former THRIVE participants (n = 38, ages 15–25), who had experience with an AYA mHealth intervention within one year of completing treatment, to participate in a focus group or individual interview. Ten THRIVE participants participated in a focus group or individual interview. Consistent with an agile approach, flexibility and efficiency were optimized in the form of providing AYA the option of focus group or interview (Patel & Arya, 2017). The principal investigator (L.S.) led the focus group ($n = 5$); one of two trained study team members (A.P. and E.V.) conducted individual interviews ($n = 5$). A research assistant took notes during the group and interviews. A semi-structured interview guide included questions about experience with THRIVE, feedback about AYA STEPS and a sample SCP, and feedback about text message content (e.g., topic, wording). Participants downloaded AYA STEPS to their phone in order to provide real-time feedback on design, navigation ease, and content. A web-based program (Socrative; https://www.socrative.com) was employed to solicit feedback about message content, such as acceptability of certain text messages, recommended links, and other media. Through Socrative, participants could respond anonymously about what they liked or disliked (e.g., text messages, or graphics). We specifically had them review 34 messages representative of various types of messages on which the team decided further AYA input on acceptability/interest would be beneficial (e.g., messages representing quiz questions, stories, relaxation topics such as yoga, different types of media such as video or memes). Queries included, “Would you like text messages to be personalized with your name?”; “Would you be interested in cancer survivors’ stories?”

The group and interviews were audio-recorded and transcribed for review. Following an agile approach, the transcripts were not coded or analyzed using traditional qualitative methods. Rather, notes and transcripts were reviewed for feedback to improve the end user experience with the app and to assess if additional feedback was needed (e.g., if the feedback was too variable to draw conclusions on how to improve the app). Feedback informed refinements to the messages, while our technology vendor made recommended changes to the app design and functionality. These changes resulted in a second prototype of the AYA STEPS app.

Stage 2 Results

Mean age of the 10 AYA providing feedback was 19 (Range = 15–21), 60% were female, 50% identified as non-Hispanic White (30% identified as non-Hispanic African American and 20% identified as Hispanic White), 80% had a prior leukemia/lymphoma diagnosis, and the average time since completing cancer therapy was 1.6 years (range 1–2 years). The feedback was constructive and actionable, and somewhat consistent across the 10 AYA, with interview responses overlapping with focus group feedback. Table 1 described feedback and subsequent modifications to the AYA STEPS prototype, including changes to text messages, functionality, and usability/design. For example, since AYA desired text messages to be tailored to their name, we added the participant's own name to approximately one third of messages. We also modified several messages to be more salient to AYA values, such as independence and maturity. For example, a text message on sticking to a bedtime routine was edited to appeal to independence (i.e., …*it not only takes discipline but shows that you are capable of taking care of your health)* and preference for personalization with their name embedded.

Results of Stage 2 also informed further modifications to app functionality (e.g., adding a weekly survey assessing and graphing health goal progress; adding ability to sync fitness tracker data with app) and design (e.g., ability for users to display a photo). We also created an introductory video that showed two of the study doctors (LS and DS) welcoming participants to the study and orienting them to the app. While we were able to accommodate many suggestions for improvement, working with a shelf-ready app limited us in accommodating all areas of feedback (e.g., app functionality did not allow AYA to select their own color scheme).

Stage 3 Methods: Pilot Test the Second AYA STEPS Prototype

During Stage 3, members of the study team ($n = 6$) tested the app on their phones, receiving messages for one month based on randomly chosen characteristics to create a "sample" patient. Once these initial issues were resolved (within the month), a pilot study was implemented with 14 AYA who were consecutively recruited in the Cancer Survivorship Program (all at least 2 years off treatment) as a convenience sample. The full procedures of the larger ongoing RCT were enacted (e.g., randomization, follow-up assessment) to test the feasibility of study procedures in their entirety; we only report here on 8 AYA who were randomized to the app. (The outcomes of the ongoing RCT will be reported when the trial is complete). AYA survivors, aged 15–29, who were treated for pediatric cancer, off treatment at the time of study participation, and able to read and speak English, were eligible for the AYA STEPS study. For those randomized to the intervention group, the app was manually downloaded on their phone by a team member, and was then relatively automated and did not require any further manipulation by the participant. The messages were delivered daily within the app and AYA received push notifications when new messages arrived in the app.

We assessed any problems with functionality and usability (e.g., ease of use, technology glitches) of the app and elements within it (e.g., text messages, SCP display, applets such as nutrition and step tracking, connection with electronic health record). Acceptability, including perceptions of the value, appropriateness, convenience, and helpfulness of AYA

STEPS, as well as feedback on usability, was assessed with a 59-item survey created for the study containing both close-ended and open-ended questions. We report on 12 of those items related to specific experiences with the mobile app and/or text messages (other items pertained to general experiences or feedback on the SCP). We also assessed the end user usage data via the LST dashboard, which included frequency of views of the SCP and messages.

Stage 3 Results

Prior to pilot participant enrollment, the 6 study team members discovered many technology and text message issues, such as typos in text messages and weekly goal and medical adherence surveys triggered at inconsistent or wrong times. We also tested with different types of devices (Android vs. iPhone) and remedied as needed. These issues were resolved within one month and we subsequently began recruiting pilot participants.

Data from 8 AYA survivors who were randomized to the intervention group and piloted the second AYA STEPS prototype (*M* age = 18, 88% female, 75% White/Non-Hispanic, *M* number of years since completing treatment = 8.5 with a range of 6–14, 88% history of leukemia/lymphoma) are reported here. Seven had iPhones and 1 had an Android. Responses on the acceptability survey revealed all AYA reported that the app was easy to use and it was easy to access the messages. All but one reported that messages were useful, they looked forward to receiving daily messages, and links and resources embedded in the app were helpful or interesting; that the app improved health knowledge and emotional and physical well-being, had positive impact on quality of life, related to own experiences, and provided new information not discussed with health providers; and that the applets were generally useful or interesting. In open ended comments, one participant reported losing the app. Some participants suggested syncing AYA STEPS with existing health apps rather than providing applets.

In terms of usage data, all eight AYA participants opened the app and engaged with it. Engagement with the app ranged from 19.3% to 98.2% of app intervention days, with a median of 63.9% of days actively using the app. All AYA viewed their SCP within the app (range = 2 to 9 times; M views per participant = 5.4). All participants read text messages in the app and 3 read all of them (range of % viewed = 24–100, median = 98.4). All AYA provided text responses (response to question in message or free text), ranging from 1 response to 46 responses.

From the pilot, we also discovered several functionality difficulties that were resolved before launching our ongoing RCT. For example, ensuring similar end user experiences across iPhone and Android devices was a significant challenge. For instance, iPhones needed app updates pushed, requiring an active update by the participant, while Android users' apps could automatically update depending on their phone's settings. Further, viewing the SCP on an Android was hindered by the lack of a native PDF reader, which complicated the enrollment process, since it required an additional app installation. A second functionality issue was variability in linking the AYA STEPS to outside applications. For example, a fitness device such as a FitBit needed to be registered, while iHealth (iPhone's native fitness tracker) automatically synced with AYA STEPS. Third, several glitches occurred

with specific app components, including functionality of graphics, repeated or missing text messages, and duplicate points for responding to text messages. We also found a variety of glitches in the usability/design of AYA STEPS, including individual user's settings needed to be adjusted to ensure that push notifications, data sharing with iHealth, font sizes, default colors, and so forth worked as expected. Individual Wi-Fi connectivity issues caused delays in loading features (e.g., missing graphics). There were also issues with the EHR integration, such as problems with automating the integration process.

Discussion

Informed by the agile science framework, we described the iterative development of a tailored mHealth intervention for AYA cancer survivors. AYA STEPS resulted in the merging of two digital/mHealth intervention programs of research—Smart-ALACC SCPs (Szalda et al., 2016) and THRIVE (text messaging intervention for AYAs recently off treatment; (Schwartz et al., Submitted), as well as the modification of an existing disease management app (LSTcare) to serve as the platform. Following general guidelines for formative work and prototype testing, the agile science framework emphasizes the need to adapt to changing technology and user preference, even in the context of a RCT (Hekler et al., 2016). Although this paper discussed the stages of development up until the launch of the RCT, the need to adapt to changing technology remains (e.g., upgrades of the app, addressing glitches; Michie et al., 2017). As such, it is critical for mHealth intervention apps to be functioning properly and acceptable to users before launching efficacy trials, and there remains the need to be agile during the course of trials (Murray et al., 2016).

The agile process facilitated our ability to integrate stakeholder preferences and identify technology problems needing correction before beginning our current ongoing RCT (goal is 200+ AYA). Testing the features of the study, and the app itself, was essential to creating a consistent and acceptable end user experience. The glitches fell into many categories such as developing an accurate SCP, syncing with other technologies, and perfecting the components in the app. This process of testing and fixing is not unlike any essential pilot phase of a trial. However, the pilot of mHealth requires a significant amount of attention, expertise, and resources. Any problems that arose had to be communicated to the vendor to make changes. Subsequently, further attention was paid to the functionality of the app across pilot participants, and anew or remaining issues required continued attention and staff support from our team and that of LST. Having research staff who are comfortable with technology, track functionality on a daily basis, and understand how to identify and communicate any deviation is critical (Wu et al., 2014).

Using an existing disease management app, which was modified for our study, has many advantages such as saving time and money, partnering with vendors already committed to improving health outcomes, and the avoidance of major technological glitches that are inherent to a brand new app. However, modifying an existing app also proved challenging at times. There were limits to how much we could adapt the app to meet the desires of the population and study goals. For example, the initial version of the app did not allow for customization of colors or for the appointment reminders to exist as a pop-up notification in the app. There is a need to balance the financial and time cost of such upgrades with

continuing with the study as planned and budgeted. There can also be tension between the study team and the vendor when there is disagreement about the best features and how to modify them.

With rapidly changing technology, challenges related to adapting mHealth interventions to the real world pace of app development will continue. This is especially true when involving multiple operating systems undergoing constant updates, in addition to planned improvements and expansion of apps. While the agile science framework provides important guidance for relatively rapid and fluid development of mHealth interventions, there is little direction on maintaining internal validity and standardization of trials in the context of ongoing changes, upgrades, and modifications (Eysenbach, 2011). This remains a challenge in the field, especially as behavioral scientists adapt evidence-based interventions for digital health/mHealth platforms (Michie et al., 2017; Murray et al., 2016) and seek to maintain interest and engagement of users.

One noteworthy limitation was our small sample of stakeholders for the pilot that was mostly female and survivors of leukemia or lymphoma, thus calling into question the generalizability of the feedback. Further, the sample that intitially provided feedback (Stage 2) consisted of more recent survivors while the pilot (Stage 3) included only long-term survivors, thus limiting input from survivors across the broad spectrum of early and later survivorship at each stage. However, despite these sample limitations and more general limitations related the to this nascent field of rigorous mHealth behavioral interventions, the current study's methods of adopting an agile science framework for merging two interventions into an existing app platform is intended to be generalizable. The process of evaluating and modifying an mHealth intervention in a relatively rapid timeframe can be applied to other mHealth interventions. However, the specific features and preferences of AYA STEPS may not be generalizable to other ages and populations. Thus, it is important to ascertain and incorporate stakeholder feedback as part of any mHealth intervention development.

The next step in this current program of research is to complete the ongoing RCT of over 200 AYA and to disseminate results of the trial. Consistent with the need for more transparency and guidance in mhealth interventions, we also plan to analyze passive end user data. This will provide an objective measure of what sections of the SCP, app features, and text messages were most attended to, as well as serve as a proxy for level of engagement—a potential moderator of outcomes and acceptability data. Given the detailed input on the intervention development from multiple stakeholders described here, we will be able to gauge whether or not some of the preferences during the development stage were corroborated by reports of follow-up self-report acceptability data and end user data. Thus, the detailed description of the agile development not only provides an example of methods for mhealth intervention development, but also may yield important information for interpreting data from the intervention.

In the future, it is important for those developing similar interventions to disseminate details about the development process, and be transparent about challenges and glitches along the way, so that researchers can better traverse this process and identify shared difficulties

and common solutions. Dissemination of such details could lead to additional guidance and standardization for the development and implementation of such behavioral mHealth interventions. It also would generally enhance the rigor of mHealth research, and thus facilitate well-designed, meaningful interventions for end users.

The use of apps or other mHealth technologies by pediatric psychologists in clinical practice can also benefit from modification or evaluation incorporating an agile science framework. An iterative process can be applied that includes expert review and testing, end user feedback and testing, and subsequent informed decisions (either identifying "best fitting" app or platform, or making modifications to an existing one, if possible). When making decisions about mHealth in clinic practice, it is also important to review the development process of mHealth tools under consideration (Davis & Oakley-Girvan, 2017). Greater transparency and stakeholder involvement in tool development should lead to better informed consumers and clinicians when choosing the most effective tools to support goals for patient health and well-being.

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Implications for Impact Statement:

This study describes the development of a new mHealth intervention for a vulnerable population with unmet needs—AYA childhood cancer survivors--in three iterative stages informed by an agile science framework. The methods are generalizable to future mHealth intervention development in pediatric psychology.

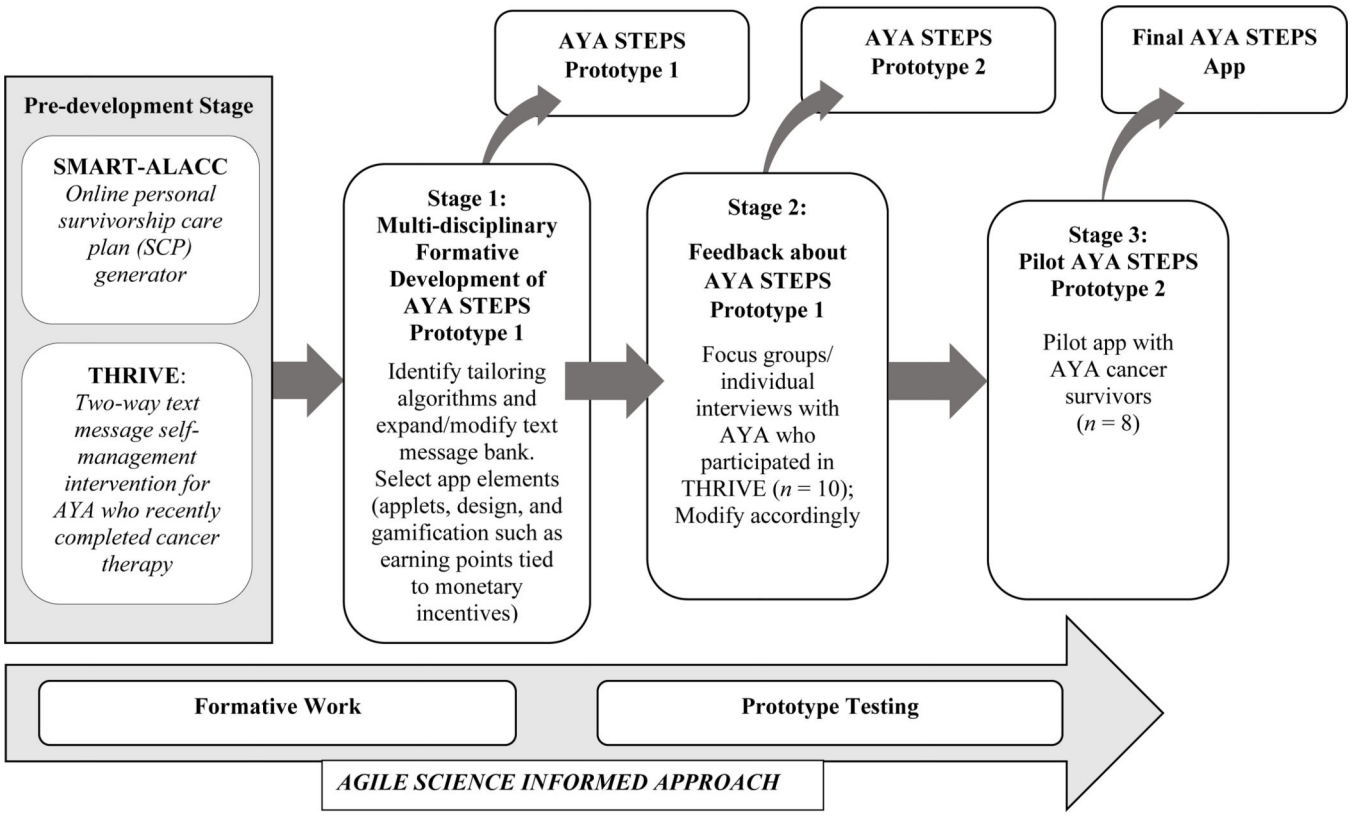

Figure 1.
AYA STEPS Development Stages: An Agile Approach

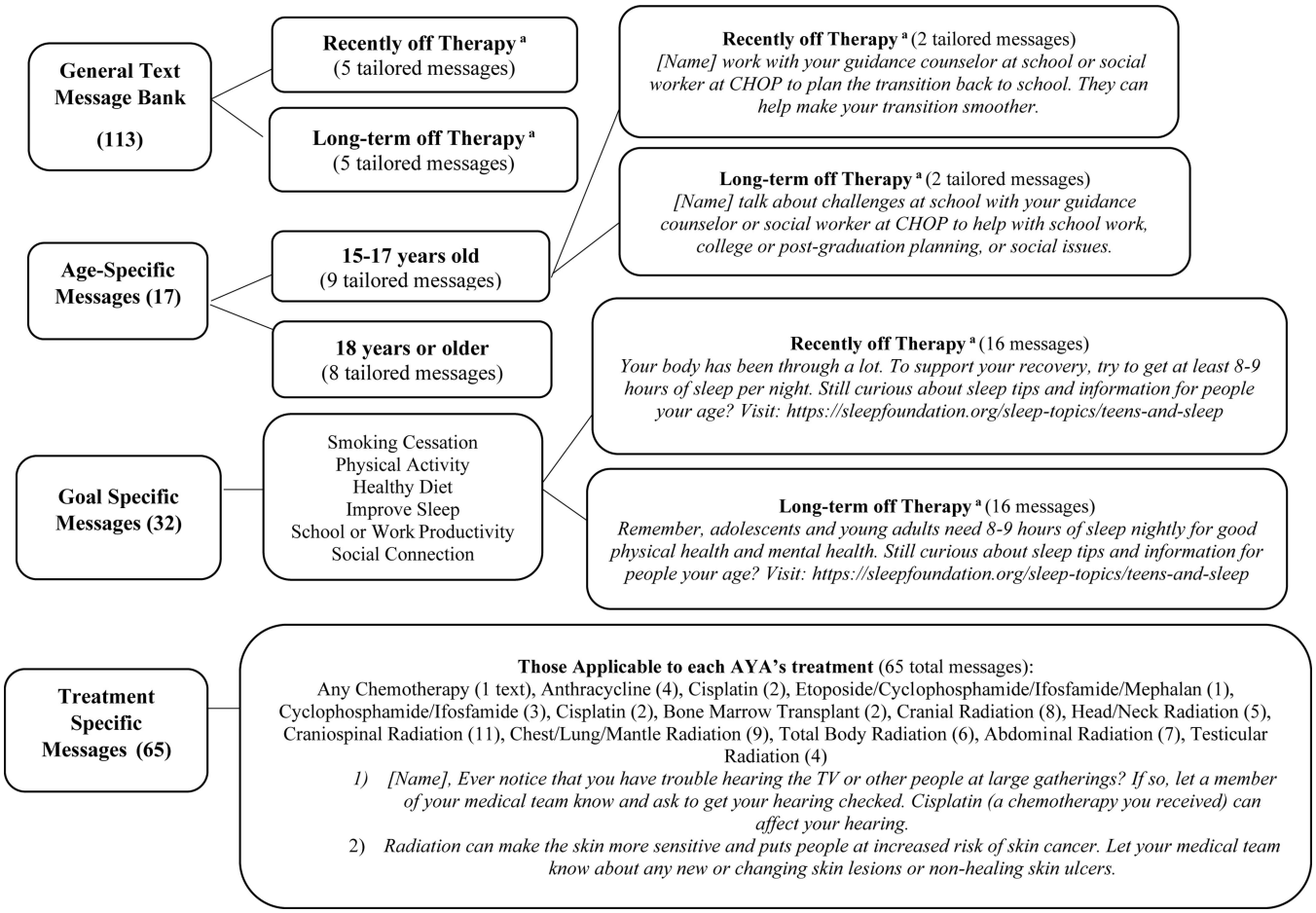

Figure 2.
Text Message Tailoring Algorithm and Examples (227 total messages in text bank)

Table 1.

Key changes to AYA STEPS app thoughout development process

***AYA STEPS Features*:**	**Protoype 1**	**Feedback from Stage 2:**	**Prototype 2**	**Feedback/Modifcations from Stage 3:**
Text Messages	• 227 total text messages • 55% tailored to patient characteristics	• Tailor text messages as much as possible (name, values) • Like psychosocial text messages • More multi-media (e.g., links to information, podcasts, stories)	• Add participant's own name to text messages • Tailor 14 messages to important AYA values (e.g., independence, maturity) • Recommend podcasts within texts • Add resource link for post-traumatic growth	• General satisfaction with the content of text messages
Functionality	• Store SCP as a document within the app • Step counter • Calorie counter • Weekly surveys to assess medication adherence • Use incentives (earning points for responding to text messages) • Weekly updates of medication list, allergy list, and upcoming appointments from electronic health record	• Desired more help with tracking health goal progress • Interest in fitness trackers • Tangible prizes helpful for sustaining engagement	• Add weekly survey and graph to chart goal progress • Add monetary incentive for responding to text messages • Sync with fitness tracking devices (Fitbit/iHealth)	• Moderate use of applets (step count, exercise tracking) • Issues with Android vs. iPhone user experiences • Problems with linking AYA STEPS to outside applications (FitBit, iHealth) • Glitches with graphics, text messages, and incentives • Challenges with integration with electronic health record • Missing diagnoses/ treatments in SCP generator
Usability/Design	• Pop up notification when received new text message • Select color scheme • Create AYA STEPS logo	• App was easy to download and manipulate • Liked the design of app and applets • Want the app to be personalizable (select own colors, select a user photo)	• Add video tutorial of AYA STEPS • Add ability to select user photo	• Easy to access and use but slow (lagging) • Need to adjust individual user settings • Lengthy/cumbersome enrollement process