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Review article

Digital Health Technology to Enhance Adolescent and Young Adult Clinical Preventive Services: Affordances and Challenges

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A B S T R A C T

The lives of adolescents and young adults (AYAs) have become increasingly intertwined with technology. In this scoping review, studies about digital health tools are summarized in relation to five key affordances—social, cognitive, identity, emotional, and functional. Consideration of how a platform or tool exemplifies these affordances may help clinicians and researchers achieve the goal of using digital health technology to enhance clinical preventive services for AYAs. Across these five affordances, considerable research and development activity exists accompanied by signs of high promise, although the literature primarily reflects demonstration studies of acceptability or small sample experiments to discern impact. Digital health technology may afford an array of functions, yet its potential to enhance AYA clinical preventive services is met with three key challenges. The challenges discussed in this review are the disconnectedness between digital health tools and clinical care, threats to AYA privacy and security, and difficulty identifying high-value digital health products for AYA. The data presented are synthesized in calls to action for the use of digital health technology to enhance clinical preventive services and to ensure that the digital health ecosystem is relevant, effective, safe, and purposed for meeting the health needs of AYA.

IMPLICATIONS AND CONTRIBUTION

Studies about digital health tools to enhance clinical preventive services for adolescents and young adults are summarized in relation to five key affordances—social, cognitive, identity, emotional, and functional. Challenges discussed include integrating digital health into clinical care and safeguarding privacy, safety, and quality for youth.

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The lives of adolescents and young adults (AYAs) have become increasingly intertwined with technology. National surveys show approximately 92% of teens go online daily and 95% of teens report having a smartphone or access to one [1,2]. Many seek and share health advice through Internet social sites and receive daily step counts from wristwatches [3–5]. As technology is increasingly available to manage AYA health and well-being, both AYAs and clinicians see the potential for using these platforms to extend health care delivery and advance patient engagement and education [6–10].

Adolescence and young adulthood are periods that afford opportunities and challenges for maintaining health and preventing disease in the present and across the life course [11]. Health status and behaviors established during the AYA years (ages 12–26 years) are integral to later life patterns of health, family, and community engagement and productivity [11]. Health care during this time helps young people navigate normal physiological changes. Clinical preventive services typically track benchmarks germane to physical maturation (e.g., pubertal changes, growth, nutrition) while simultaneously targeting socioemotional development, including reproductive health and other common concerns (e.g., mental health, substance use, safety, and violence) [12,13].

Newly articulated pillars of AYA-centered health care are meant to help AYAs overcome a range of access barriers and to advance services that are comprehensive, patient centered, and focused on physical, mental, and psychosocial determinants of well-being [14]. Nevertheless, AYAs consistently have low preventive care access and utilization [15–19]. AYAs are expected to begin independently navigating the health care system during these formative years and, in so doing, assume greater responsibility for their health-promoting self-care and disease management [20]. Greater autonomy may contribute to, although not fully explain, low utilization. As we grapple with the challenges and opportunities for strengthening the health care system to better engage and care for AYAs, digital health technologies offer unique potential for enhancing the reach of this system. However, AYA health care providers may be unfamiliar with the digital health ecosystem and how it might be leveraged to extend their reach while also acknowledging that challenges exist specific to AYA preventive service needs. In this scoping review, we characterize today's digital health technologies and their associated opportunities and challenges to enhance AYA clinical preventive services. We describe and evaluate this ecosystem guided by the following affordances framework.

An affordances framework for digital health use for AYA preventive care

Digital health refers to the use of information and communication technologies to help address health problems and challenges [21]. The technology domains of digital health discussed in this scoping review include social media, mobile health (mHealth), wearable and digital devices, and games for health. Social media enable interaction with virtual communities built through the creation and consumption of shared information, ideas, and networks. mHealth encompasses applications on mobile devices designed to promote health. Wearable devices provide real-time, personal health information—from sensors, trackers, or other inputs—to motivate behavior change. Games for health are serious video and computer games focused on health education or behavior change.

For this review, we use the affordances framework, which places emphasis on design attributes and capabilities of digital media as they may match envisioned uses. We recognize that there is a diversity of digital platforms and "brand name" technologies that may be familiar to AYAs and providers, which could comprise a platform-specific framework for describing the use of digital media for preventive care. However, this landscape changes rapidly, hampering professionals' abilities to keep up with apps, devices, and profiles. The platform-specific approach may also hinder researchers who design interventions for a specific platform and face challenges in its translation to other media.

The affordances framework draws on insights from the design field, centering on the concept that "design aspects of objects […] suggest to the user how the object should be used" [22]. For example, the design elements of a chair suggest to a person the object could be used for sitting. Hence, the affordances framework may assist clinicians and researchers in determining the best type of platform for an intervention or service from the perspective of matching AYA's needs to digital technology-enabled capabilities for meeting those needs.

We consider five affordances as they apply to digital health technologies: social [23], cognitive [24], identity [25], emotional [26], and functional [24]. These affordances were selected based on their prominence in the affordances literature and their relevance to the topics of digital health technology for AYAs [22–26]. We present the results of our scoping review of digital health technologies relevant to AYA health and clinical preventive services through the lens of these affordances, recognizing that any given technology or application may reflect myriad affordances.

Methods

We undertook a scoping review on the use of technology to enhance AYA clinical preventive services. Scoping reviews, in contrast to systematic reviews, provide a mechanism for assembling and reviewing a broad body of multidimensional work in which methods and standards of evidence may vary. Within the rapidly changing field of digital technologies for AYA preventive care, a scoping review is a more appropriate and feasible approach to summarize data for practicing AYA providers, researchers, and advocates.

We examined the peer-reviewed literature on PubMed from May 2017 to March 2018 as a first-tier search strategy. We then reviewed relevant articles (peer-reviewed or not) from the bibliographies of the first-tier review articles. Keywords were searched using a three-tiered search strategy (Table 1). First-tier keywords included terms that defined the digital health technology domains, the population, and the preventive health care domains. Second-tier included keywords were search terms for the five affordances, followed by third-tier search terms for the three challenges of using digital health technology.

We synthesized the main findings and themes from the identified sources by team-based consensual research processes. Specific examples of digital health interventions or research studies are presented for illustrative purposes when discussing the affordances and challenges.

Results

The scoping review results are summarized across five affordances—social, cognitive, identity, emotional, and functional (Table 2).

Table 1
Search term strategy for scoping review of digital health technologies to enhance adolescent and young adult clinical preventive services

Technology domains	Social media; mobile health, also mHealth, health and wellness apps; wearable/digital devices, also self-tracking device; games for health, also gamification; digital health and eHealth, as broader terms because the taxonomy of the health-related technology ecosystem is not standardized [27]
Population descriptors	Adolescents, teenagers, young adults, youth, young people
Preventive health domains	Physical activity, nutrition, and growth; reproductive and sexual health; mental health and substance use; violence and safety
Affordances	
Social	Social support, relationships, networks, communities, peer support
Cognitive	Knowledge, information seeking, cognitive development, education, health information, information sharing, skills, self-efficacy
Identity	Identity development, identity portrayal, self-perception, identification with illness, self-tracking, self-monitoring, personalization
Emotional	Emotional response/connection, inspiration, affective response, affective socialization, cyberbullying, emotional support
Functional	Dissemination, scalability, permanence, searchable, accessibility, feasibility
Challenges	
Connectedness to care	Clinician use, leverage technology, functionality, and interoperability
Privacy and security	Privacy, security, personally identifying data, protected health information, patient safety, identity, password sharing, anonymity
High-value products	Reliability, accuracy, misinformation, high value, interpretability, validation, regulation

Social affordance

The social affordance refers to how engagement with digital technology can enhance social interaction in peer networks and broader communities. Youth may be motivated to adopt digital health technology that includes a social component because it enables a sense of belonging and social support [23,39], which, in turn, may reduce stress or physical illness and improve psychological and physical well-being [40,41]. Such technology can also provide opportunities for online conversations and knowledge sharing, which may protect against health risk behaviors [42,43], promote positive health behaviors [42], and increase AYAs' health-related self-efficacy [44].

Social media platforms exemplify digital tools designed around humans' values and preferences for social connection and support. When using social media platforms engineered around social affordances, AYAs report high satisfaction and engagement with interventions that target various clinical preventive service domains, such as physical activity, weight loss, smoking cessation, and reproductive and mental health [28,29,45,46]. Metrics of social engagement used in such studies include sharing peer support messages, goal achievements, and updates on progress and setback via text, picture, and video posts.

Social groups and support for health are also available with mHealth. Users can be linked via live social groups and buddies to share activities and goals. Adolescents using an mHealth intervention with a motivational texting component for Type I diabetes reported improved self-efficacy and adherence [47]. Apps created to curb overeating in overweight adolescents paired users with a buddy and online support community for coping and positive feedback, although evidence of impact is very limited [48].

Social support–infused digital health interventions pairing multiple technology domains or coupling with traditional

Table 2
Illustrative examples of how digital health technology affordances may align with goals for AYA clinical preventive services

Digital health affordances	Affordance description	Illustrative examples (*study design, sample size, primary outcome*)
Social	Enhances interpersonal interaction in relationships, networks, and communities; enables sense of belonging and support	• Facebook plus text messaging weight loss trial in college students [28] (*randomized trial, n = 52, weight loss*) • Social media intervention for AYA smoking cessation [29] (*quasi-experiment, n = 238, smoking cessation*)
Cognitive	Facilitates acquisition and sharing of general and personal health information in the domains of knowledge, skills building, and self-efficacy	• Interactive game to reduce risky sexual behavior in young men who have sex with men [30] (*randomized trial, n = 921, risky sexual behavior*) • AYAs log and review caloric intake on Twitter in healthy lifestyles intervention [31] (*observational pilot, n = 12, steps, healthy eating*)
Identity	Impacts how users create digital health identities and how they identify with their own health or how others perceive their overall health and well-being	• Half of AYAs say they feel like they always have to show the best version of themselves online [5] (*online survey, n = 1,337, multiple use and mental health outcomes*)
Emotional	Generation of positive or negative emotional responses from digital health platform, directly or indirectly influencing health and well-being	• Praise and feedback on weight management from avatars [32] (*qualitative study, n = 77, interest and preferences*) • Easier for LBGT youth to discuss or reveal difficult topics online related to sexual health (*mixed methods study, n = 32, multiple use and preference outcomes*)
Functional	Allows for the scalability, dissemination, and adoption of health messages and interventions through leveraging the technical capability of electronic communication to efficiently reach populations	• Digital technology may be able to reach minority and vulnerable adolescent populations [29,33–38], [167] (*survey, n = 94, technology use*)

AYA = adolescents and young adults; LBGT = lesbian, bisexual, gay, transgender.

interventions (e.g., telephone quitlines or in-person support) have also demonstrated efficacy for some AYA clinical preventive services. In an AYA weight-loss trial, participants assigned to a Facebook Plus group, which included daily, personalized text messages and a nonstudy buddy for in-person support, lost significantly more weight than participants in a Facebook-only group [28]. Similarly, in a smoking cessation study among AYA, participants who engaged in a social media intervention integrated with traditional quitline cessation services reported higher 7-day and 30-day quit rates compared with participants accessing the quitline alone [29].

Digital health interventions intentionally designed for group activities and group achievement have also demonstrated success. Games for health, for example, can be designed for groups to enable social support. However, results are mixed on whether group-based games more effectively promote behavior change than individual games [49,50].

In sum, social features of digital health tools show promise for advancing AYA engagement, health behavior adoption, and change. These successes extend to activities and concerns central to optimizing delivery and support of clinical preventive services. Formal integration of these approaches into care and evaluation are important frontier areas.

Cognitive affordance

Many digital tools enable health-related behavior change through the cognitive affordance, which encompasses domains, such as knowledge acquisition, skill building, and self-efficacy [24,51,52]. Health information seeking and sharing is common for AYAs on digital health platforms. Social media and mHealth have been widely used by AYAs for anonymously seeking and sharing knowledge on stigmatized and sensitive topics, such as sexual health [46,53–57], mental health [5,46,58–62], substance abuse [63,64], and violence and safety [63]. Serious games have also demonstrated short-term increases in knowledge on sensitive topics, although their long-term effects are less clear [65–70]. Although digital health technology facilitates information seeking, challenges exist for finding accurate and reliable content (See "Identification of High-Value Digital Health Products for AYAs").

Wearables and mHealth platforms enhance self-knowledge and skill development by allowing AYAs to track and improve behaviors, such as physical activity [71–73] and nutrition intake [31]. In a study among overweight young adults who used an mHealth app, Twitter, and fitness trackers, intervention participants liked being able to review their daily dietary logs in the app and to use social messaging via Twitter; the pilot study demonstrated increased fruit/vegetable and decreased sugary beverage intake [31]. In another example, an interactive digital role-play intervention for adolescents combining motivational interviewing with skills training to reduce alcohol misuse and violence resulted in reduced negative alcohol consequences at 6 months [63].

Digital health technology has also been linked with increased AYA self-efficacy. For example, college-aged youth have found games for health to be more engaging than traditional didactic lessons because they feel the locus of control lies with them [68,74]. In a randomized evaluation of a digital game with interactive narratives and virtual avatars about risky sexual behavior for young men who have sex with men, initial results were promising for increased self-efficacy and prediction of reduced future risky sexual behavior [30].

Cognitive affordances across the landscape of digital health tools may play a vital role in advancing AYA's understanding of and commitment to health behaviors that are germane to effective delivery of clinical preventive services. Targeted demonstrations across the AYA age spectrum are needed to ascertain whether and for whom these approaches are helpful.

Identity affordance

Digital health technology can impact AYA identity development, providing a means for AYAs to create identities—accurate and inaccurate—that reflect their values and views about their own health and well-being. These depictions can influence how others perceive, respond, and reinforce health and well-being-related features of a young person's identity. Conversely, aspects of others' identities that are shared via digital technology can influence AYAs' sense of identity as it relates to health, in a dynamic cycle of influence.

The online profiles AYAs create and follow may influence how they think about their health, especially in relation to peers, celebrities, or gendered body image ideals (e.g., thin or athletic females and muscular males) [75]. AYAs report creating multiple online identities through multiple accounts, even on a single platform, to represent different aspects of their identity [76]. In one study of more than 1,200 AYAs, aged 14–22 years, approximately half reported that they felt like they always had to show the best version of themselves online and that they felt like other people were doing better than themselves [5]. On social media, users tend to avoid presenting themselves as "patients" to their friends and often use separate, secret accounts for expressing health concerns or other sensitive matters [77]. Although some AYAs report feeling motivated by the health content on others' accounts (e.g., videos of people's workouts [78]), research suggests that sharing and viewing "fitspiration" (fitness plus inspiration) and "thinspiration" accounts may adversely affect AYAs' body image and self-esteem [79–81]. One study found time spent on social media, such as Facebook, was significantly related to body surveillance and body image concerns, especially among girls [82].

Games for health also allow AYAs to create identities, such as avatars and virtual selves, for more personalized health-related gaming experiences [83–85]. For example, an online virtual world targeting AYA customers facilitated experimentation with self-representation, establishment of relationships and socialization with peers, and other developmental processes toward adulthood [86]. Another body perception intervention that included avatars representing AYAs' perceived, actual, and goal body images was well-liked by AYAs, who appreciated viewing the avatars to track their body changes, weight progress, and goals [32].

A better understanding is needed regarding how the identity affordance of digital health technologies may influence AYA identity development, related to health and clinical preventive services in positive or negative ways.

Emotional affordance

Intertwined with the social affordance, the emotional affordance describes the properties of a digital health platform

Table 3
Challenges to leveraging digital health technology for adolescent and young adult (AYA) clinical preventive services

Challenge	Key points
Ensuring connectedness of digital health to clinical care for AYA	• Tiers of complexity for connecting digital health technology to clinical care exist, from using digital platforms while in the clinic to bidirectional digital communication between AYAs and clinicians • Digesting large volumes of digital health data from AYAs is a new frontier for data scientists and clinicians • Setting expectations among AYAs for timeliness of digital response on technology platforms is important
Advancing AYA privacy and security on digital health	• AYAs may be particularly vulnerable to privacy and security breaches on digital health platforms because of their access via mobile devices • Digital privacy settings and policies are lacking or difficult to navigate for AYAs • AYAs may be unaware of third-party sharing of digital health data
Identifying high-quality digital health products for AYA	• AYAs are prone to trust inaccurate information or inadequately assess creditability of digital health sources • Content of digital health platforms can normalize or reinforce self-harming or high-risk behaviors in AYAs (e.g., disordered eating and substance use) • Digital health platform algorithms are opaque and typically not tailored to AYA health needs (e.g., goals on physical activity trackers)

that can generate positive or negative emotional responses in AYAs [26], directly or incidentally influencing AYA health and well-being. Through their capacity to convey emotionally rich content (stories or images) or enable feedback and support, emotional affordances may contribute to the salience and attraction of digital health platforms for AYAs and the persuasive potential of interventions and messages.

Some digital health platforms may directly address mood and emotional health [87]. Applications that support meditation or emotional short-form journaling are examples [88,89]. Avatar counselors have also been leveraged to provide virtual counseling to young people with chronic disease, including substance use [90,91]. Online chatting and support during times of distress have been associated with increased self-esteem [39], although evidence is mixed on whether online support decreases stress and increases well-being and life satisfaction [40,92]. In contrast, cyberbullying has an array of negative affective outcomes, including lower self-esteem, depression, and suicidal ideation [93–95].

Digital health technology interventions that provide emotional feedback and support may, in turn, change behavior. For example, overweight teens expressed interest in receiving weight management assistance from avatars that act as coaches or as buddies for empathic support and guidance [96]. In another study highlighting how the emotional effect of an intervention can be a key mediator, researchers found adolescents who received varied feedback from a virtual pet based on photos reflecting the content of their breakfast (i.e., how healthy their breakfast was) were twice as likely to eat breakfast than participants who received only positive feedback or those without a pet [97].

Digital health technologies can also serve as an outlet to explore emotionally loaded or stigmatized topics related to AYA clinical preventive services. Reproductive health services can trigger emotional reactions that may not be adequately addressed during busy preventive visits. In a mixed methods study of 16- to 24-year-old lesbian, gay, bisexual, transgender youth, participants perceived online platforms as a place to anonymously say or reveal difficult thoughts and to efficiently identify offline lesbian, gay, bisexual, transgender events and services relevant to sexual health [98]. Gun violence is another preventive health topic for which digital technology facilitated a social movement and fervent national discussion on gun violence prevention among AYAs following school shootings [33].

Digital health platforms can induce and support emotional responses from AYAs and serve as venues to share feelings with others. As AYAs gain emotional maturity while interacting with technology, the direct and indirect emotional affordance of digital health technology should be acknowledged, and opportunities considered to leverage this affordance to advance the reach and acceptability of clinical preventive services.

Functional affordance

Digital health technology allows for the scalability, dissemination, and adoption of health messages and interventions among AYAs through the technical capability of electronically reaching populations efficiently. In short, the functional affordance enables scale for all other affordances. The high level of acceptance and use of digital technology by AYAs, particularly on their mobile devices, facilitates the broad reach of digital platforms for preventive health at relatively low cost [5,34–37,99–102]. Clinicians, for example, can reach large groups of AYAs by fielding anonymous health-related questions on digital platforms [46,103]. A clinician-run platform, Go Ask Alice!, has been recognized as a reputable and accurate Web site for AYA health and receives hundreds of questions and millions of site visits monthly [103].

Digital health technology also appears promising for reaching diverse AYA populations. Several studies have shown minority, and vulnerable adolescent populations frequently seek online health information [36,38]. For example, in a study of youth aged 14–22 years, African American youth were more likely to say they connected with a health care provider online or shared their own health stories online than white or Latino youth [5]. Automated digital language translators have enabled youth more comfortable in non-English communication to access content on mHealth apps and social media platforms [99]. A study of 531 urban middle-school students found students used digital technology for diverse purposes regardless of their first language [37].

Although digital health shows promise for reaching wide AYA populations, maintaining youth engagement has been challenging. The use of mHealth apps and wearable devices generally decreases over time [4,73,101,102,104]. One study of youth aged 11–12 years found only 8% of participants were still using their

wearable devices after 5 months [4]. Additional studies have reported difficulty maintaining adolescents' interest in games for health long term [105,106]. Strategies to increase long-term engagement may include pairing technology with other interventions, leveraging existing social connections, introducing new features, and creating story narratives [105,106].

The promise of digital health technologies for AYA clinical preventive services rests in part on the functional affordance. Technical capabilities offer the potential for scale within and outside of clinical settings.

Challenges

Digital health technology may afford an array of functions, yet its potential to enhance AYA clinical preventive services is met with three key challenges: disconnectedness between digital health tools and clinical care, threats to privacy and security, and difficulty identifying high-value digital health products (Table 3).

Ensuring connectedness of digital health to clinical care for AYA. Connecting patient digital health data with clinical care is required if preventive services are to be enhanced using digital health tools. Connecting digital data with clinical care in many cases could augment the affordances of digital health technology by allowing health care systems to leverage these affordances [107,108]. Although other reviews have covered the technical (e.g., interoperability) and regulatory (e.g., approaches to patient data storage) challenges of connecting digital health to clinical care [109–114], we focus on tiers of complexity for connecting digital health technology to clinical care for AYAs.

The simplest tier of digital health connectedness to clinical care is AYA's use of digital health tools while in the clinic. For example, mHealth screening tools completed in the waiting room have effectively identified important risk factors for adolescent preventive services before the clinician encounter [114]. Intervention games used in the clinic have been shown to be as effective as didactic lessons [115]. Challenges to leveraging technologies in this capacity include a lack of AYA confidentiality if parents are able to see their digital responses. Other barriers include prohibitive costs for some digital health platforms and often a disconnect of these patient-generated data in the clinic and the visit's clinical record [116].

The second tier of digital–clinical connectedness is AYAs sharing digital health data generated remotely with their clinician. Some health systems have facilitated digital data transmission through an app that integrates data from fitness trackers, pulse oximeters, blood pressure cuffs, and health diary apps into the electronic health record (EHR) [117]. More sensitive data, such as mood diaries, can also be electronically transmitted to the clinic for provider review [118]. When AYAs send digital health data to clinicians, challenges include how to synthesize and translate the sometimes large data files (e.g., daily physical activity tracking data) into a format useful to inform clinical care [119] and to better understand how AYAs would like clinicians to use their data.

The top tier of digital health connection is bidirectional digital communication between AYAs and clinicians. AYA acceptance of such communication strategies has been demonstrated through platforms addressing reproductive health and other AYA-specific issues [69]. Digital technology can be an alternative to or enhance communication via patient portals in the EHR. Adolescents can face unique challenges with privacy and access to EHR patient portals, depending on privacy and confidentiality rules or technical configurations for minors [120,121]. However, clinicians will need to be clear with AYAs about response time expectations before bidirectional communication is offered. Setting expectations or developing platforms that do not allow real-time posting by AYAs (i.e., posts are displayed on a time delay) may be particularly important for AYAs who are accustomed to rapid and immediate responses on digital platforms, such as Snapchat and text messaging [122].

Connecting digital health technologies to clinical care is crucial for increasing the impact of these technologies on AYA clinical preventive services. A tiered approach to clinical care connection needs to be explored across various digital health platforms and in diverse settings. Policies that encourage interoperable and connected digital health systems can accelerate progress.

Advancing AYA privacy and security on digital health. As AYAs make social connections, develop their identities, and share or store personal health information on digital health platforms, protecting their privacy and security is crucial but challenging [123–125]. Millions of digital health users have experienced unpermissioned/inappropriate access to their health data [11,76,126,127]. AYAs are particularly vulnerable as they connect most often to these platforms on mobile devices [128]. Wireless signals and sensors rely on broadcasting, which is vulnerable to eavesdropping, extraction, and tampering, including inserting new messages and replaying old ones [128].

Digital privacy settings and policies can be difficult for AYAs to navigate. Many digital health platforms lack publicly available privacy statements; for example, only 19% of mHealth apps for diabetes examined in 2014 had a privacy statement [129]. Even when a privacy policy is present, AYAs report difficulty interpreting them [130]. A review of privacy policies from the 99 highest-ranked apps geared toward youth identified an average reading grade level over 12, which far exceeds the average adult eighth-grade reading level among U.S. adults [131].

A lack of awareness or indifference about privacy settings among AYAs is another challenge. Adolescents often do not change their privacy settings from the default [132]. Even if adolescents use privacy settings, they tend to doubt their effectiveness and believe "urban myths" about privacy, such as schools' ability to hack into data regardless of privacy settings [133]. Data also indicate that adolescents tend to consider privacy for social reasons (e.g., maintaining an image) instead of for security reasons [133]. In a study of 1,040 adults, 56% of young adults, aged 18–29 years, reported sharing an online password with others [134]. In another evaluation of authentication options (e.g., personal identification number, graphical password, and touch identification) for mHealth applications, young adults, aged 18–30 years, had different preferences (e.g., preferred fingerprint) than older adults [135].

AYAs may also not understand that health data can be sold to third parties, including advertisers, private companies, or other commercial entities such as health insurers. Digital health platforms can be linked (e.g., Facebook links to MyFitnessPal), but security agreements between the linked platforms are often lacking, which can inadvertently leave health data publicly accessible [136]. One study of mHealth applications found 50% of paid apps and 60% of free apps sent data to third-party analysts, and one third of these third-party companies were not covered in the apps' privacy policies [128].

The development and application of effective and transparent privacy protections that can govern health-related interactions for AYAs remain challenging, as it is with other populations. Still, developing protections attuned to AYAs' concerns and perspectives is vital to advance the safe use of digital health technologies [137].

Identifying high-quality digital health products for AYAs. As AYAs are increasingly empowered to seek and share health information on digital health platforms, they will create and encounter information with varying degrees of accuracy and reliability [138]. Studies have demonstrated that AYAs place high levels of trust in health information found online and are less likely to assess the credibility of digital health sources than older adults [139,140]. Some research has shown AYAs with low health literacy tend to evaluate sites based on search position, celebrity endorsement, and picture quality [141]. Furthermore, misleading and misinformed health posts on social media tend to attain higher levels of popularity (e.g., more likes and shares) than posts disseminating accurate information on the same topic [142–144]. Fortunately, some studies suggest skepticism among AYAs about digital health information; one study found fewer than 25% of AYAs aged >12 years believed that social media provided them with helpful health information [145].

AYAs may also encounter information on digital health technology that is not health promoting. Some platforms may contain content that can normalize and reinforce self-harming and high-risk behaviors [146,147]. Adolescents who viewed Facebook profiles portraying alcohol use among high school students reported greater normative perceptions of high school drinking and greater interest in initiating alcohol use [148]. Other platforms designed to help patients seek information on symptoms or conditions may encourage care seeking or create undue stress when medical attention is unnecessary. In a study of 23 symptom checkers (e.g., WebMD and Mayo Clinic), platforms regularly yielded incorrect diagnoses and inappropriate triage advice [149]. Importantly, the algorithms used in these tools may not be tailored for AYA populations.

Akin to symptom checkers, wearable and digital health devices rely on proprietary algorithms to provide health information to individuals outside of the clinical setting. Studies have shown commercially available wristband trackers fall short in accuracy and validity when compared with research-grade accelerometers, particularly among people with darker skin tone, larger wrist circumference, and higher body mass index [150–155]. Additional accuracy, usability, and interpretability challenges in wearables arise for AYAs, who are physiologically distinct from older adults [156,157]. For example, the daily 10,000 steps goal, standard among many physical activity trackers, is based on recommended levels of physical activity for adults, whereas adolescent goals may be higher [158,159].

Finally, clinicians also find it challenging to identify high-quality products to incorporate into their AYA preventive services [160,161]. Few of the thousands of health apps have been rigorously evaluated, and fewer have been associated with clinically significant improvement, particularly among AYA populations [162]. Recommendations for clinicians include investigating both scientific literature and consumer reviews and pilot-testing apps among themselves, colleagues, and consenting patients [163]. Although several nonprofit organizations have created digital health trust codes to ensure safe online health information sharing, many of these accreditations are underdeveloped, inconsistent, and expensive, and, most importantly, do not typically consider the unique health needs of AYAs [164,165]. One well-vetted option is federal validation; the Food and Drug Administration recently approved a prescription-only app to treat substance use disorders after reviewing data from a multisite, 12-week clinical trial [166]. A proposed alternative approach is a multistakeholder system of surveillance labeled "trust but verify" [27], which includes the following approaches to improve the quality of medical apps: enhance consumer app literacy, create an app safety consortium to identify harms, enable external validation of apps by third parties, and subject every app to medical review before public release, by both app stores and government regulators.

AYAs may be particularly vulnerable to digital health technologies that are of low quality for clinical preventive services, including those with inaccurate, unreliable, nonyouth-specific, or health-harming information. Calls for increased vetting and regulation of digital health platforms are warranted overall, but particularly for AYA digital health consumers.

Discussion

In this scoping review, studies about digital health tools are summarized in relation to five key affordances—social, cognitive, identity, emotional, and functional. Consideration of how a platform or tool exemplifies these affordances may help

Table 4
Calls to action for the use of digital health technology to enhance clinical preventive services for adolescents and young adults (AYAs)

Awareness and education	• Increase fluency among clinicians and researchers about digital health technology affordances and challenges. Partner with AYA health advocacy organizations (e.g., Society for Adolescent health and Medicine, American Academy of pediatrics) to increase awareness. Platforms may include online courses, CME courses, special issues. • Raise awareness among AYAs and families on the challenges posed by AYA use of digital health technologies, particularly related to privacy, security, accuracy, and reliability. Schools, clinicians, and advocacy organizations are key stakeholders to promote such messages for the health and well-being of AYA
Evaluation	• Conduct more rigorous evaluation on the impacts of digital health technologies specifically among AYA populations • Incorporate the AYA perspective in evaluations of digital health technologies
Policy	• Leverage existing American Academy of Pediatrics guidelines for improved privacy and security measures for AYAs using digital health technology [168] • Advocate for policies directly protecting the identities and digital data of minors • Advocate for policies to accelerate interoperability and connectedness of digital health products with clinical preventive services
Development	• Partner with digital health technology developers to increase high-quality AYA health content available on technology platforms

clinicians and researchers achieve the goal of using digital health to enhance clinical preventive services for AYAs. Across these five affordances, considerable research and development activity exists accompanied by signs of high promise, although the literature primarily reflects demonstration studies of acceptability or small sample experiments to discern impact. Concerns are also evident for thoughtful integration of digital health into clinical care and for the development of policies and practices to safeguard privacy, safety, and quality.

To move the field forward and optimize the potential for using digital health to enhance AYA clinical preventive services among AYA, action in several areas is needed (Table 4). These include enhanced awareness and education about affordances and challenges of digital technology, more rigorous evaluation on the impact of digital technology, advocacy for policies to protect AYA on digital platforms, and strategies that allow the AYA clinical, health research, and advocacy communities to find strategies to work with the private sector where the most widely used digital health tools are developed. Because the business model of health technology developers can conflict with that of the service model of care or the evidence-based model of research, leadership and partnership from AYA health experts are needed. These partnerships can inform the development, diffusion, and integration of high-quality tools into the digital health ecosystem for youth. As a collective, AYA stakeholders can ensure that the digital health ecosystem is relevant, effective, safe, and purposed for meeting the health needs of AYA from early adolescence, when youth are often exploring digital health technology, to young adulthood, when needs for autonomy, agency, and mastery of personal health behaviors and health care interactions are high.

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