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Review article

Leveraging Technology to Improve Health in Adolescence: A Developmental Science Perspective

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A B S T R A C T

As technologies continue to evolve at exponential rates, online platforms are becoming an increasingly salient social context for adolescents. Adolescents are often early adopters, savvy users, and innovators of technology use. This not only creates new vulnerabilities but also presents new opportunities for positive impact—particularly, the use of technology to promote healthy learning and adaptation during developmental windows of opportunity. For example, early adolescence appears to represent a developmental inflection point in health trajectories *and* in technology use in ways that may be strategically targeted for prevention and intervention. The field of adolescent health can capitalize on technology use during developmental windows of opportunity to promote well-being and behavior change in the following ways: (1) through a deeper understanding of the specific ways that developmental changes create new opportunities for motivation and engagement with technologies; (2) by leveraging these insights for more effective use of technology in intervention and prevention efforts; and (3) by combining developmental science-informed targeting with broader-reach technologic approaches to health behavior change at the population level (e.g., leveraging and changing social norms). Collaboration across disciplines—including developmental science, medicine, psychology, public health, and computer science—can create compelling innovations to use digital technology to promote health in adolescents.

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IMPLICATIONS AND CONTRIBUTION

This article describes how developmental science provides insights into how plasticity in social and identity learning can interact with technology use to enhance opportunities for intervention and prevention. The field of adolescent health can capitalize on these opportunities, using technology to deploy tailored and compelling initiatives during key developmental periods.

Designing Developmentally Informed Interventions: the Case for Technology

From a developmental science perspective, it is important to recognize that the moment-to-moment daily experiences in

which learning and brain development are occurring are increasingly happening in the context of digital platforms. Recognition of these transformative changes in learning environments is raising compelling questions about both vulnerabilities and opportunities. Consider the foundational social and

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emotional learning that shapes identity development in adolescence. Universal developmental changes beginning with the onset of puberty influence motivational tendencies (e.g., increases in exploration, sensation seeking, social motivations to engage peers, and greater sensitivity to negative and positive social feedback) that can make specific types of technology particularly captivating. Indeed, adolescents interact with technology more than any other age group [1]. The first two decades of the 21st century have seen youth technology use become nearly ubiquitous in the U.S., with around 90% of U.S. teens reporting accessing the Internet and technologies enabled by the Internet (e.g., multiplayer video games, text messaging, Snapchat, and Instagram) at least once per day [2]. This ongoing digital technology revolution naturally amplifies and expands the natural adolescent proclivities to explore, seek, and learn from socially and affectively salient experiences.

The field of adolescent health can strategically leverage insights into this period of dynamic changes and the interactions between this digital technology revolution and adolescent developmental plasticity by approaching adolescent-facing services from a developmental science perspective—one that recognizes adolescence as a uniquely influential period of foundational social and identity learning. This perspective emphasizes an integrative understanding of developmental processes, including a broad range of biological, cognitive, behavioral, social, and contextual factors interacting on multiple levels of the youth's system (school, family, broader cultural, and societal forces) [3]. To effectively leverage technology in interventions and prevention efforts, we must strive to understand what is most reinforcing at different developmental time points within these contexts, and why.

Although the onset of adolescence is generally marked by the onset of puberty, the “end” of adolescence does not have such clear-cut physiological markers. In many technologically advanced societies, the transition from adolescence to young adulthood is marked by the attainment of adult social roles in the early 20s [4,5]. However, this overarching term belies the diversity and nuance of changes in structure and function across nearly all developmental domains within the years between puberty and adulthood. Adolescent health experts working in the clinical, research, and policy realms must recognize the windows of opportunity inherent within adolescence, as certain types or foci of interventions may be more impactful at different cognitive, physical, and psychosocial stages [6–8] and by gender, risk status, and racial/ethnic group within these developmental stages [9]. For example, there are gender and racial differences in the timing of the pubertal maturational changes, in motivational tendencies, and in social opportunities for positive risk taking. Moreover, any discussion of youth technology use warrants mention of the growing evidence of technology amplifying social inequities (often called the “digital divide”) [5,9,10]. Although an in-depth discussion of these issues is beyond the scope of this article, a comprehensive developmental science perspective certainly calls for thoughtful consideration of these factors when tailoring initiatives.

When considering intervention and prevention efforts aimed at adolescent behavior change, conversations of ecological validity and meeting teens where they are must take technology into account. A developmental science framework suggests that technology may be most effective in prevention of common adolescent challenges such as poor sleep hygiene and interpersonal conflict by considering not only *when* to intervene, and

with what platform, but also *how* to encourage penetration of novel efforts by accounting for contextual variables in the youth's broader system (e.g., using developmentally informed strategies such as recruitment of influential peers to shift norms).

Given the complexity of cross-domain developmental processes over the course of adolescence, transdisciplinary collaborations across the fields of adolescent health, developmental science, and computer science create unique opportunities for contributions to research and practice, particularly given the rapidly evolving digital and social landscapes. A number of systematic reviews, large-scale investigations, and meta-analyses have been published investigating various aspects of adolescent technology use [11–13]. To an extent, such endeavors are crucial to understanding modern adolescence. Near ubiquitous use of technology is projected to remain stable [14]. This reality, along with the evidence that typical adolescent development naturally poises youth to be motivated by and engaged with technology, renders the digital world an important context for intervention delivery, as well as a necessary area for promotion of adaptive behaviors. However, because of the speed at which both technology use and our understanding of adolescence as a period of plasticity and opportunity is developing, reviews are often becoming outdated by the time of publication, and investigations into adolescent use of specific platforms may rapidly become obsolete. Thus, an effective integration of adolescent technology use into research and practice necessitates both a developmental science framework and a look to the future of technology (e.g., artificial intelligence and machine learning; refer to the study by Rowe et al., in the current issue). This framework can allow us to take a nuanced yet generalizable approach to understanding the ways technology facilitates exploratory and learning experiences for youth (i.e., affordances [15]), such that the field can promote adaptive use of technology we may not fully understand or that may not even exist yet. This article presents the case for leveraging technology to enhance adolescent well-being through this integrative, forward-thinking lens. Optimizing the timing and targets for intervention and preventive measures is key; and moreover, clinicians, researchers, and policy groups working in adolescent health can make innovative contributions by leveraging technology as an increasingly salient adolescent social context. Approaching adolescent-facing services in the digital space through this integrative developmental framework can both enhance healthy technology use specifically and maximize the effectiveness of adolescent health promotion more broadly.

Priming for Technology Use: Transdisciplinary Evidence and Theory

In order to use technology to enhance adolescent behavior change efforts, the field must also clarify the factors that drive youth engagement in the digital space. Developmental and behavioral theory, as well as empirical evidence from neuroscience, behaviorism, and developmental psychology, broadly suggest two primary motivational mechanisms: (1) certain factors that make technology use compellingly attractive *are amplified* in adolescence (e.g., entertainment, information-seeking, passing time, reinforcement, mastery, and self-efficacy) [16–21] and (2) certain aspects of the environment that are especially stimulating and engaging in adolescence (and which may be different at different psychosocial and cognitive

stages within adolescence) are rendered more accessible and compelling by technology.

Adolescents find experiences that facilitate social connection, allow for exploration and engagement, and enhance affective learning and higher cognitive processes particularly reinforcing [5–7]. From a developmental perspective, several developmental tasks, defined as “the benchmarks of adaptation that are specific to a developmental period and are contextualized by prevailing sociocultural and historically embedded expectations” [22], underlie these adolescent proclivities. The reinforcing nature of these experiences for adolescents is functional, as they contribute to the development of skills and aptitudes that are crucial for the transition to adulthood, and technology broadens the scope of opportunities for social interaction and exploration of identity.

Evidence from developmental neuroscience underscores the pragmatic relevance of recognizing the positive social learning opportunities and motivation to master related developmental tasks during adolescence—as a maturational period of rapid growth, learning, and development, with heightened receptivity to specific social contexts. The implications for practice, policy, and youth-serving organizations have been recently reviewed in a report by the National Academies of Science, Engineering, and Medicine “The Promise of Adolescence: Realizing Opportunity for All Youth,” [10] (May 2019). This report, inspired by the revolutionary *Neurons to Neighborhoods* [23], which made a powerful social, political, and scientific impact by greatly increasing recognition of the importance of early childhood development, brings a similar lens to the developmental science of adolescence. Importantly, it synthesizes and underscores the converging evidence for adolescence as a period of opportunity, characterized by developmental shifts and neural plasticity supporting dynamic learning and growth, and describes corresponding implications for practice and policy.

In brief, developmental neuroscience suggests that the adolescent brain is particularly receptive to specific types of social learning [6,24,25]. This receptivity interacts over time with shifts in learning, exploration, motivation, and mastery, and partly explains the aforementioned gravitation toward experiences relevant to gaining competence in the social world. Social media and other types of content-generation platforms (e.g., YouTube, TikTok), video games, and smartphone applications reinforce these exploratory inclinations. Importantly, survey data on adolescent technology use suggests that contrary to findings in the early days of the Internet linking youth interactions with technology with reduced social connectedness [26–28], current adolescent technology use is inherently social, is often used to strengthen offline relationships [29–31], and can be beneficial across domains [32]. By and large, adolescents use technology to maintain existing relationships and social connections [29,30,33–35], and surveys suggest that teens view technology as having a positive or neutral effect on their social and emotional well-being [14]. Adolescents do not view technology use and social interaction as mutually exclusive; instead, they appear to integrate technology and their social lives both cognitively and affectively, seeing technology as a tool to enhance connections with, and expand modes of connecting to, people they know in their daily lives [16,36,37]. Given this use of technology as an extension of the social world, research and intervention with adolescents is now firmly situated in this setting of steady and increasing integration of technology into daily life, and these platforms must be leveraged to enhance adolescent development.

Technology use can have negative impacts, particularly in the context of existing psychosocial vulnerabilities [38,39] and with excessive use [31,32]. The authors of a recent large-scale study of the impacts of technology on adolescent well-being reported that “there is a small significant negative association between technology use and well-being.” However, they also noted that these findings should be placed in context as these effects, “when compared with other activities in an adolescent’s life—[are] minuscule” [13]. It is also important to reiterate that technology use can differ greatly based on risk status, gender, and race/ethnicity. More broadly, concerns about privacy and safety remain at the fore of conversations about the rapid digitization of nearly all aspects of life in Western culture [40]. This reality renders the need to take proactive, preventive measures such as teaching healthy engagement, self-regulation, and technological literacy during adolescent windows of opportunity all the more urgent, and these concerns should be thoughtfully integrated into conversations around innovative approaches to prevention and intervention. These concerns have also served as a call to the adolescent health community (as well as entities such as social media and other technology corporations) to balance issues of access with very real concerns about regulation, privacy, and protection and to place children and adolescents at the forefront of emerging policies [41] (refer to the Wong et al. [15] article and the commentary by Thadane et al. in the current issue for a more in-depth discussion of these important topics).

Adolescent inclinations to explore and seek novelty, particularly in the social realm, contribute to behavior viewed by adults as risky and dangerous; however, these behavioral tendencies also underpin a good deal of the normative and adaptive social exploration, learning, and creativity that characterizes this period. The adolescent tendency to be among the first to adopt and popularize technological trends (often relating to and borne of social media and streaming platforms [42]) aligns with evidence suggesting enhanced social and affective flexibility and creativity in adolescence [25].

Importantly, research indicates that early adolescence (9–14 years of age) is a particularly important period for prevention and intervention [3]. This period of dynamic growth and developmental and social change provides a rich example of actionable insights at the interface of developmental science and technology. The onset of puberty appears to be a pivotal time in developmental trajectories, as it is an inflection point in several aspects of adolescent health (i.e., youth in this age range are often exposed to health habits or behaviors that may later become entrenched and are seeking greater autonomy from parental control) and in technology use (most American youth obtain their first smartphone in early adolescence [43]). This stage is a window of opportunity because youth have begun to be more motivated by the social and affective learning and begin to experience the concomitant neural plasticity but generally remain more receptive to adult counsel than in later adolescence. As such, it is a crucial period for instillation of healthy habits, strengthening of self-regulation, and maximization of the positive ramifications of technological literacy and early exposure to technology over the lifetime.

In light of the confluence of evidence pointing to adolescence as a period of malleability and opportunity, near-ubiquitous adolescent technology use, and the ongoing digital technology revolution, investment in this area of inquiry could harness a largely untapped potential in the form of innovative technology-based efforts for habits and behavior change. However, rigorous

longitudinal research at the intersection of developmental science and technology is needed to optimize such efforts.

Harnessing Technology to Promote Adaptive Behaviors and Behavior Change

Harnessing technology to promote positive behavior change has become a subject of intense interest, and innovation to engage and strategically nudge adolescents toward behavior change via online platforms is underway [12,44–47] (refer to the study by Wong et al. in this issue for a more targeted discussion of the use of technology to extend the reach of the clinician in primary care). Re-examining efforts to target adaptive behavior change in adolescence is particularly crucial, given evidence suggesting that some interventions, such as those targeting bullying and social competencies (i.e., socioemotional interventions), decrease in efficacy over the course of adolescence [48]. This is due, in part, to a paucity of developmentally informed and ecologically valid designs. A dual approach, using technology and the familiar and appealing environment of the online space as a “hook” to increase engagement and adolescent agency, while designing interventions specific to psychosocial and cognitive characteristics at different stages of adolescence, could transform adolescent behavior change intervention.

Although intervention in early adolescence appears to be ideal, it is not always feasible, and technology can help to address the problem of reduced effectiveness of the didactic, adult-mediated approaches to behavior change that work quite well in other populations but that are less effective as youth age [49]. As teens are primed to seek social approval and gain autonomy, they are especially motivated by status and respect [48] and generally become less attentive and receptive to adult counsel. A developmental science lens suggests that leveraging this desire for independent thinking and social success by having interventions and information mediated through a relevant, inherently engaging, exploratory context that youth are intrinsically motivated to use can motivate and empower, ultimately facilitating youth-driven changes. As such, later adolescence and the transition to young adulthood also create opportunities for targeted strategic technology use. For example, a recent neuroimaging study of information processing provides promising actionable insights about the effects of population-level health messaging (in this case to reduce smoking) for older and younger adolescents alike [50]. An example targeting older adolescents and transition-aged youth can be illustrated by the use of technology to scaffold independent life skills, which may be particularly useful for youth with conditions that impact social and cognitive development such as attention deficit hyperactivity disorder or intellectual disabilities [51,52]. Research indicates that adolescents with such conditions may be particularly drawn to technology [53], which can additionally enhance engagement and underscores the potential for developmentally informed tailoring of interventions.

Given the increasing complexity of technology and the challenge of maintaining engagement as technology evolves, user-centered design and co-design of technology bear mentioning as [54] important tools in tailoring interventions and prevention efforts to developmental stage and other contextual variables (refer to the study by Ozer et al. in the current issue for an example of the use of iterative co-production methodologies with adolescents as well as review the study by Gibbs et al. for

review of using technology to scale up Youth-Led Participatory Action Research).

Approaches to adolescent behavior change

The underlying interventions used in technology-based behavior change efforts can reflect the increasing needs for autonomy and self-determination that characterize adolescence by allowing for increased agency and input. Interventions focused on sustained behavior change are often based on skills and strategies drawn from cognitive behavioral therapy (CBT), as well as concepts from motivational interviewing and social cognitive theory. In CBT-based interventions, youth are taught principles and strategies that can be used to affect change on thoughts, emotions, and behaviors. This information is commonly delivered by a clinician in a decontextualized intervention setting, and youth are then tasked with recalling and effectively deploying these skills on their own. CBT interventions have been found to be moderately effective for behavior change across development, and at the same time, engagement and compliance can become barriers to progress in adolescence [55]. As technological interventions are often user driven, an opportunity exists to draw on the evidence-based principles and strategies from CBT while also more fully tapping into the adolescent desire for autonomy, agency, and self-determination. Social cognitive theory's emphasis on the impact of social norms on behavior also lends itself well to technology as a medium for intervention [56]. Ultimately, through technological interventions, the adolescent may feel more ownership over goals and priorities, which are often influenced by the broader sociocultural context.

Although social norms are influential across the lifespan, a developmentally informed approach recognizes that these norms are particularly strong determinants of adolescent behavior, and as such, designing compelling and interesting technologically based interventions is only half the battle. Aiming to have preventive efforts, and subsequent habits and changes in behavior, adopted by influential individuals in the social milieu is likely one of the most effective ways for these measures to have an impact for youth. For example, taking a two-pronged approach designing an engaging and compelling app to enhance sleep hygiene while also focusing on recruiting influential students and tailoring messaging to highlight outcomes that are important to adolescents (e.g., appearance and mood) could enhance positive impact.

Technology can increase rates of sustained engagement in developmentally informed interventions by increasing information processing via interaction and active participation; mediating the delivery of messages and education through an intrinsically motivating technological platform; repeating information in a memorable and interesting way; providing in-the-moment feedback; utilizing personalization; and facilitating the practice of skills in ecologically valid situations, ideally increasing generalization to daily life [16,45,57]. Interventions mediated by technology can further enhance the existing autonomy-facilitating aspects of this modality, allowing for more independent personalization and exploration of the adolescent's own agenda, and removing the element of adult facilitation of change that can persist in face-to-face therapy while accounting for social, developmental, and other environmental factors in the design of the intervention. Designing interventions that are inherently engaging, fun, and socially motivating also increases the likelihood of consistent practice. Furthermore, a more

fundamental issue regarding the effectiveness of behavior change interventions and one that technology is poised to address is that of barriers to care. For practitioners in primary care settings, the identification of the need for behavior change intervention beyond in-office counseling is by no means a guarantee that the patient will access and benefit from such an intervention [58]. For example, a study of adolescents aged 14–17 years found that although 67% of adolescents referred by a primary care provider for mental health care “accepted” the referral [59], just 18% of youth actually followed up with a face-to-face visit within 6 months. This low rate of access underscores the need to develop innovative initiatives that expand intervention platforms and settings, and technology-based interventions can reduce motivational and structural barriers to care that may be unique to adolescents.

Passive collection of select smartphone data can be one way to enhance both the effectiveness and reach of behavior change interventions. Data can be used to “nudge” individuals to use skills in real-time as situations arise in daily life, just as myriad recreational smartphone applications sustain attention with notifications. These types of tools, often referred to as “Just In Time Adaptive Interventions” [60], may be particularly effective when deployed clinically with adolescents, for whom much of life is mediated via smartphones. The strategic deployment of such interventions at opportune windows in adolescence is one developing pathway to creating effective behavior change frameworks around issues that are important and relevant to adolescent well-being, such as sleep, depression, anxiety, interpersonal conflict, high-risk sexual behaviors, substance use, eating disorders, treatment adherence for chronic illness, and physical activity.

Despite the possibilities for behavior change presented by infusion of developmental science into technological interventions, few studies have developed and tested theoretically sound, developmentally informed technological interventions accounting for the unique adolescent stages and motivations (e.g., using principles discussed previously to target sensitivity to peer norms and desires for autonomy, respect, social prestige). This represents a missed opportunity and may help to explain the relatively small effect sizes found across adolescent-facing interventions. It also bears mentioning that although technologically based interventions are theoretically more engaging and effective at changing behaviors [44,45], the active ingredients and enhancement of impact over conventional approaches remain an open question. To pinpoint and replicate the mechanisms of effects in such programs, both theory-driven design and empirical study of technology-based interventions are warranted. Below, we highlight just two of many domains that are ripe for application and investigation of a developmental perspective to innovative technological interventions.

Sleep. Adolescent sleep is an arena where developmental windows of opportunity, enhancement of CBT interventions, and technology-enabled “Just In Time Adaptive Interventions” can converge. Developmentally, sleep hygiene is particularly important in early adolescence at the onset of puberty [61], as hormonally initiated changes in sleep patterns occur around this time. In a vacuum, the associations between these changes and alterations in circadian rhythm are minimal, but evidence suggests that the reciprocal interaction between these changes and social, cultural, and behavioral factors [8] leads to a shift to later bedtimes and a preference for later wake times. The evidence

that smartphones are so compelling to adolescents that they have contributed to sleep changes detectable on a population level has led some to conclude that limiting smartphone use is the solution to poor teen sleep hygiene [62]. Establishing parameters around nighttime smartphone use is an undeniably important aspect of any sleep intervention, but the high motivational salience of electronics also presents an opportunity such that some researchers have begun leveraging the technology implicated in sleep disruption in sleep interventions themselves [63].

Adolescent Cognitive Behavioral Therapy for Insomnia [64] has been shown to be moderately effective, with medium to large effect sizes depending on the outcome measured. However, CBT-I for adolescents is generally sought after sleep concerns have reached clinically significant levels despite the fact that many of the components (e.g., stimulus control, sleep hygiene, relaxation, and cognitive strategies) could be beneficial as a low-cost, universal preventive initiative before adolescent sleep problems emerge or while they are at subclinical levels. As such, technology could allow for accessible, engaging, and cost-effective delivery of this type of intervention as a prophylactic measure.

One aspect of a multipronged developmental science approach could entail educating teens via media such as personalized smartphone applications in early adolescence, before changes in sleep patterns become entrenched. Such applications could also be used in conjunction with school-based sleep education programs, which, while requiring relatively few monetary and professional resources, have been shown to be generally ineffective on their own [65–67]. This type of intervention can take an intervention with demonstrated effectiveness such as Adolescent Cognitive Behavioral Therapy for Insomnia and increase personalization and “tailoring [of] the interventions based on biopsychosocial symptom profiles” [64] through technology while reducing the overt presence of adult figures directing adolescent behavior. In effect, they can extract the elements of technology that appeal to teens and contribute to sleeplessness and instead use them to motivate engagement in the intervention at the juncture when sleep disruption is likely to begin [68], ultimately positively impacting the adolescent sleep trajectory.

It bears reiterating that an engaging platform will only go so far; for such preventive efforts to be effective on a population level, they must also be widely adopted such that norms within the social milieu shift. A second prong to the implementation of such interventions may involve gaining buy-in from high status or influential adolescents. Social motivators can serve as both barriers to good sleep hygiene and as incentives to improve sleep hygiene. For example, studies have found that “difficulty unplugging” from electronic media, fear of missing out, and intense emotions (which can often be triggered by interactions on online platforms) are often implicated in difficulty falling or staying asleep [69,70]. Shifts in social norms such that peers are not engaging with technology late at night (or highlighting evaluative motivators such as fatigued appearance or irritability resulting from poor sleep) could meliorate some of these factors.

Interpersonal conflict. A similar opportunity for optimization exists in the realm of interpersonal conflict and aggression (e.g., bullying), where designing technologically based interventions through a developmental lens becomes increasingly complex. Technologically based interventions targeting social competence tend to focus specifically on cyberbullying and/or approach the

problem from the skills-deficit (e.g., knowledge, empathy, and moral disengagement) lens [71]. However, the nature of interpersonal conflict changes over the course of adolescence. Bullying in younger children is indeed often driven by deficits in social competence and self-regulatory skills, but as youth age into adolescence, bullying is often better explained by a desire for status, social approval, and respect [72–75]. Antibullying and violence prevention programs, which are often predicated on this social skills deficit model across development, show small but significant effects into early adolescence but are essentially ineffective starting around middle adolescence (eighth grade). As such, a social competence enhancing intervention developed for youth in mid-adolescence would have to look significantly different from one developed for younger youth, addressing the root motivations for bullying at this stage rather than focusing on acquisition of skills and knowledge they likely already possess and may actually be using for ill. Adolescent motivation for status and respect is strong, and designing interventions that foster buy-in to adopt more prosocial behaviors is difficult. As much of adolescent social life is mediated through social media and technology, design of social media interventions based on social-cognitive theory and principles of change based on peer norms and contagion can be re-purposed to educate and provide adolescents with opportunities to gain the influence that developmental science tells us motivates teen bullying, both on and offline, in prosocial ways.

Conclusion and Future Directions

Although our increasingly connected world poses novel challenges and threats to healthy adolescent development, technology also presents rich opportunities for prevention and intervention in adolescent health, and a developmental science framework can help the field to maximize the impact of these opportunities. Evidence from developmental neuroscience suggests that the heightened risk taking, impulsivity, and sensitivity to social stimuli that often characterize and shape views of adolescence as a problematic period stem from neural changes that are also associated with heightened flexibility and plasticity in contexts that facilitate the enhancement of key social and identity-related developmental tasks and skills [6,20,42]. The increased salience of social stimuli, social norms, and desire for exploration increase adolescent motivation to pursue mastery of these tasks, and given that these tasks are being navigated via technology with increasing frequency, the digital world can be viewed as both a necessary domain for proactive education and skill-building analogous to high-quality, comprehensive sexual education, and as a natural extension of the intervention context.

Transdisciplinary collaboration between physicians, psychologists, developmental researchers, health services researchers, the technology sector (e.g., artificial intelligence and machine learning) and others is imperative to maximize effective design with strong theoretical bases and behavior change strategies. Rigorous implementation research is also necessary to determine mechanisms, optimal delivery platforms, and differences based on ages and stages. We must determine the key aspects of technology that are compelling and strive to make technology-based interventions more relevant to adolescent interests and motivations at varying points in development while also gathering additional information regarding ways that teen cognition and psychosocial

functioning are similar or different online versus in face-to-face interactions.

We are poised to capitalize on adolescent engagement with technology, and the challenge lies in determining exactly how the field can use developmental science when designing and utilizing novel efforts in the online space. Effective integration of these lines of inquiry could lead to the development and evaluation of innovative tools and strategies based on conceptually valid, tailored frameworks to enhance engagement and promote adaptive behaviors.

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