



Optimizing Internet Use during Adolescence: eHealth Solutions

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Abstract

Internet offers an immense opportunity as a resource for education, training, and health promotion. This narrative review summarizes the opportunities for health promotion among adolescents through use of the Internet and technology (defined as eHealth). The details of technology and use of Internet for adolescent-health related topics such as nutrition, fitness, sexual health, adventure, and violence were searched through PubMed. The review reports few digital solutions to address key challenges during adolescence like promotion of nutrition and sexual reproductive health, prevention of noncommunicable diseases, substance abuse, and mental health issues. eHealth was concluded as a potential solution for preventive and promotional health practices during adolescence. However, concerns of Internet addiction, safety, privacy, mental health disorders, and misinformation need to be addressed and monitored during adolescence.

Keywords

- ▶ adolescent health
- ▶ digital technology
- ▶ mHealth
- ▶ screen time
- ▶ social media

Introduction

In the last decade, there have been advancements in technology and an increase in popularity and frequency of Internet use on a global scale. The term eHealth describes a broad range of digital technologies and interventions, and it is the intersection of medical informatics, public health, and business for healthcare. mHealth is defined as medical or public health practice supported by mobile devices, such as mobile phones, personal digital assistants (PDAs), pagers, and tablets.¹

Preventive mHealth services during adolescence have been used for teleconsultation, health information delivery, involvement in self-care through tracking and reminders, and access to health services. These are found convenient, readily accessible, personalized, with increased family involvement in healthcare and are not limited by geographical boundaries.¹

Coronavirus disease 2019 pandemic has brought unforeseen times for the public where telemedicine emerged as

the most expedient solution. Telemedicine has been explored for providing consultation, managing medications, wellness and fitness, peer-group support, and maintaining communication.² Its use increased exponentially for managing general health issues and developing indigenous solutions for providing mental health, reproductive health, and substance abuse services to adolescents and young adults.³

Through this review, we evaluate an increasing number of Internet-based interventions that can be developed and applied to the needs of adolescents.

Methods

This was a narrative review with preferential inclusion of Systematic Reviews and Meta-Analyses. Studies were selected from the PubMed electronic base. The search terms

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included “internet positive adolescents,” “health-related internet use,” “eHealth adolescents,” “eHealth adolescents positive,” “mHealth adolescents,” and a search string was created. On filtering for the research in the last 5 years, over 1,776 articles were shortlisted. Two authors independently scrutinized the abstracts for suitability. The relevant articles included were based on the age group (adolescents and extending to young people up to 25 years of age) and if relevant to the six key areas under the national program for adolescents that are nutrition, sexual and reproductive health, mental health, noncommunicable diseases, substance abuse, and injuries and violence.⁴ The studies using eHealth and mobile health (mHealth) for monitoring or management of chronic diseases (except mental health problems) were excluded. Similarly, digital interventions with focus on maternal and child health were also excluded.

The review was intentionally adjusted to include a broad range of interventions to acquire a deeper understanding of unique aspects of eHealth related Internet use in adolescents in each intervention.

eHealth Interventions

The key eHealth interventions that may be applicable for adolescents are listed below:

1. **Nutrition interventions:** The rising incidence of obesity in adolescents globally has implications on incidence of other chronic diseases and an overall negative impact on health.⁵ Digitalization has become rampant as the use of mHealth and wearable technology is appealing among adolescents and has also demonstrated efficacy in providing approaches toward weight loss. These apps help to roughly track daily calorie consumption with micronutrient intake. The results of validation studies for such apps and technology, however, show variable results with poor accuracy with traditional diet calculation.⁶ Another approach toward providing this is motivational interviewing in which telecounseling with face-to-face, telephone, group sessions, work books, and activities are used to resolve ambivalence to change unhealthy behaviors. Internet interventions with components such as self-monitoring, reminders, web-based lessons, and discussion groups in addition have also been shown to be very effective. In a systematic review, out of six studies having solely eHealth interventions (particularly, Internet-related), four showed significant improvements in body mass index z-score, or obesity-related behaviors after the intervention.⁵
2. **Noncommunicable diseases:** Physical exercise and fitness are crucial determinants for wellbeing during growing years. The last decade reported a huge increase in use of fitness technology through fitness gadgets and smartphone apps. A meta-analysis on almost 1,740 participants reported modest increase in physical activity with the use of smartphone apps when used for a short term (<3 months period). The effect was less pronounced when these were combined with dietary interventions.⁷ Smartphone apps have also shown good performance in weight control and obesity prevention programs. A meta-analysis of 12 studies on adolescents and adults showed significant reduction in weight (−1.07 kg, 95% confidence interval [CI]: −1.92 to −0.21) and body mass index (−0.45 kg/m², 95% CI: −0.78 to −0.12) with the use of mobile apps; however, with nonsignificant effect on increase in physical exercise. The duration of intervention in these studies ranged from 6 weeks to 9 months thereby indicating the need of evaluating the long-term efficacy of these interventions.⁸
3. **Substance abuse:** Cigarette use and tobacco consumption are exponentially increasing problems recently because of their alluring portrayal in the digital world. Digital health interventions as community outreach apps and personalized teleHealth options have been evaluated for substance abuse. SIHLEplus is an integrated digital intervention that was found efficacious among African American female youth for substance use disorder and human immunodeficiency virus (HIV) prevention.⁹ It employs weekly group sessions and personalized teleHealth counseling with parental involvement conducted as role plays, discussions, interactive games and skill demonstrations. Mobile phone messaging also showed significantly higher chances of smoking cessation at 6 and 12 weeks, with nonsignificant effect at 26 weeks.¹⁰ The Internet based intervention delivered by professionals was efficacious in decreasing drug use (marijuana, cocaine, inhalants and prescription drugs), cigarette and alcohol use. These can be tailored to mimic the individualism of one-to-one counseling and were useful in maintaining anonymity and decreasing stigmatization.¹¹
4. **Sexual and reproductive health (SRH):** SRH has long been a coveted topic with limited access to free, correct, and reliable information for adolescents. Digital technology can play a supportive role with the presentation of sensitive information in a more casual and amicable manner without barriers of stigmatization, discrimination, lack of privacy, and confidentiality or embarrassment.¹² The digital interventions have focused on the ways media influences sexual decision making and sexual health, identifying gender stereotypes and countering them, representing healthy romantic relationships and counter portrayal of unhealthy and abusive relationship behaviors, providing accurate sexual health information and safe sexual health practices, and countering the wrongly glamorized sexual violence and assault. Media literacy provides information for menstrual care, contraception, and sexually transmitted infection protection.¹³ A survey among healthcare providers showed that almost one-third of them had sensitized their clients to the use of SRH mobile apps, though most reported a need for further training in better using the app.¹⁴ Creation of supportive peer-groups or support groups on digital social media can be another positive aspect of technology. A review reported peer support eHealth interventions for HIV prevention to be acceptable and effective in influencing healthy behaviors but raised concerns of privacy.¹⁵

5. **Mental health:** The excessive use of digital media has been linked with increased vulnerability to cyberbullying, anxiety, insomnia, and depression. Many recent mHealth applications have been developed to assist in positive thinking, meditation, relaxation, and maintaining good sleep hygiene, though they vary in the efficacy, privacy, and availability of a safe app.¹⁶ A study showed improved engagement of children and young patients with mental health problems with Internet-based cognitive behavioral interventions (iCBT) as disease specific interventions and person specific interventions. It consisted of communication strategies such as limited text messages, ability to personalize, ability to connect to others, and option to receive text message reminders; virtual experiences like virtual shows; robotic and computer-based intervention involving quizzes, photographs, animations, multimedia, psycho education, skill development, etc.¹⁷ iCBT being self-directed has a major issue of adherence, but still moderate-to-high satisfaction rates have been recorded. Benefits are not just in terms of clinical improvement but also in terms of cost, availability, accessibility, and time.¹⁸ A systematic review of smartphone apps for mental illnesses showed an increased usage of these apps for common mental health illness with decreased need for physical contact with the therapist or psychologist, thereby allowing flexibility and cost-effectiveness in treatment.¹⁹ Field studies of smartphone apps that provided teleconsult followed by promotional messages were found useful for the management of depression and anxiety.²⁰ Another meta-analysis also reported the advantage of mHealth in mental health disorders and substance abuse with interventions like setting reminders, support messages, psychoeducation, and setting interactive voice responses.²¹ Computer games have been developed that subject the candidates to relatable situations similar to the anxiety or low mood provoking situations which they have to solve. During the game, the candidate can talk/ take guidance from the therapist using a virtual interface.²² Furthermore, the Internet-based interventions also allow the family members and friends to become a part of therapy sessions more frequently, thereby reducing the sense of isolation or inferiority in the child. Recent studies on high school students and adolescents have reported positive health outcomes measured for social well-being, positive mental health, and self-rated health with routine use of social media.^{23,24} Peer-lead online workshops for students in late adolescence also improved the help-seeking behavior.²⁵ The same technology can also be used to promote normal healthy mental well-being among adolescents right from dealing with emotions, handling stress and anxiety. The apps can promote relaxation, assist in cognitive behavior therapy, and can suggest nonstigmatizing interaction with a psychologist during teleconsultation.
6. **Violence:** The types of violence to which children and adolescents may get exposed include community and domestic violence, physical and verbal violence at schools,

sexual violence, cyberbullying, and emotional or psychosocial violence by neglect, discrimination and threat. Adolescents exposed to violence are often in the precontemplation phase and may be hesitant to share it to seek help. mHealth apps against cyberbullying or bullying at school and positive parenting digital intervention can play a positive role against violence during childhood and adolescence.²⁶ In 2011, "Feel the ViBe" (feel the violence beaten, FtV) was developed to support adolescents and young adults who faced family violence by providing information, offering peer support, lowering the threshold to regular healthcare services, and helping find appropriate need-based healthcare. Like other eHealth interventions, attrition was a drawback and an increase in the depressive thoughts in those undergoing intervention as a consequence of seeking help and becoming more aware of the situation. However, FtV was found to be effective with most participants feeling helped and 2/3rd starting other healthcare options.²⁷ Similarly, Circle of 6 app, which enables alert and support when they face violence, was used as an integrated approach with other formal measures to reduce dating and relationship violence among 13 to 15-year-old students in southern England. The study reported a decrease in dating and relationship violence from 50 to 35% at follow-up with good acceptability among students.²⁸

7. **Injuries:** During adolescence, mild traumatic brain injuries (mTBIs) or concussions have a high incidence and pose problems such as associated loss of productivity and longer term morbidity (somatic, cognitive and/or behavioral symptoms beyond 1 month in up to 30%). Web-based self-management programs were found to be an innovative way to provide resources to address consequences of mTBI. A program entitled Self-Management Activity Restriction and Relaxation Training included daily symptom and activity monitoring along with personalized feedback and educational modules incorporating principles of anticipatory guidance, problem-solving, and stress management/relaxation training. The results of the program demonstrated declining symptoms following mTBI usage and an improvement in functional disability and executive functioning of the adolescents as reported by parents. An additional advantage was improved well-being and reduced worries about recovery.²⁹ Several assistive technologies, which can be assistive, adaptive, and rehabilitative to compensate for loss of function and disabilities, leads to a support in cognition in individuals with acquired brain injury. These are becoming more prevalent with the advent of mHealth and examples include Neuropage (a paging device that schedules reminders for individuals with cognitive problems), electronic calendars, PDAs, and apps (Evernote, Google Calendar, Family tracker, etc.).

Advantages of eHealth Interventions

A review on use of mHealth interventions in low- and middle-income countries showed that the data on efficacy of mHealth interventions was limited as mHealth was

usually designed as one-way communication as a message or a reminder for follow-up schedule or health behavior.³⁰ However, the adoption of the concept of mHealth and digitalization of health informatics was appreciated even in the rural area. Overall, another systematic review reported good feasibility and acceptability of text messages and smartphone apps for improving clinic attendance, contraceptive use, oral health, physical activity, adolescent vaccination practices, smoking cessation, and sexual health among adolescents.³¹ The different health-related Internet interventions have been classified as shown in **Table 1**.³²

The Internet and smartphone can also be used in pediatric health promotion by helping with self monitoring, goal setting, immediate feedback, and contingency management.³³ Few school mandated eHealth programs promoted both harmonious and obsessive Internet use, while self-initiated programs (goal and education directed) promoted relative harmonious use without obsessive use.³⁴ A new mHealth app called “Brain in Hand” is being implemented for autism and mental health. It synchronizes with a smartphone app and helps users create a structured daily routine for difficult to remember tasks or problem situations and gives patients instant solutions, to assess in real time, improving their independence.³⁵ The Indian Academy of Pediatrics has released the following guidelines on appropriate use of digital devices among the adolescents as shown in **Table 2**.³⁶

Disadvantages of eHealth Interventions

The ease and availability of Internet and technology have led to an increasing number of reports highlighting its potential negative consequences to an extent that the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) has included it as a distinct disorder.³⁷ The DSM-5 states Internet addiction disorder as the “inability of individuals to control their

Internet use, resulting in marked distress and/or functional impairment in daily life” (**Table 3**).³⁷

The prevalence of Internet addiction has been on a rise, being higher in boys than girls with similar addiction rates between urban and rural areas.^{38–40} The reported prevalence in few countries like India was higher (31–40%),^{38–40} than in China (11.3%) and European nations (4.6% to 6%).^{41,42} The various risk factors for Internet addiction are underlying comorbid psychological illness, Asian race and few genetic polymorphisms in dopamine receptor, and serotonin transporter.⁴³

Various mechanisms have been proposed for the development of pathological addiction and high-risk behaviors in adolescents. It has been observed that the development of the prefrontal cortex takes longer time compared with the limbic system that causes decreased inhibition of subcortical structures by the cortex and results in more impulsivity and high-risk behavior during this time. Among neurotransmitters, oxytocin plays an essential role and regulates mesolimbic dopamine reward system. Other neurotransmitters like melanocortin, neurotensin, orexin, and substance-P also affect the high-risk behavior, though the exact mechanism is unclear.⁴³

The major problems related to Internet addiction in adolescents include less human and social interaction, decreased exercise and productivity, decreased sleep related to night time exposure to light leading to poor sleep quality, depression, anxiety, and increased exposure to inappropriate and violent online media and cyberbullying.

In a meta-analysis,⁴⁴ a significant association between screen time and external behavioral manifestations like aggression, attention deficit/hyperactivity disorder symptoms as well as internalizing behaviors such as depression and anxiety was seen in children and adolescents. Increased duration of screen time had a small but significant correlation with more externalizing problems (90 samples; $r: 0.11$;

Table 1 Health-related Internet-based interventions³²

Web-based solution	Methodology	Remarks
Web-based interventions	<ul style="list-style-type: none"> • Web portals for information on preventive wellness, diagnostic, and therapeutic options • Websites and blogs for group discussions and peer education • Automated feedbacks and messaging 	Information may not be authentic and valid
Online counseling and therapy	<ul style="list-style-type: none"> • Telemedicine approach that can help users to easily access the healthcare services and consult their physicians and counselors 	Lack any emergency care provision and human touch
Artificial intelligence and virtual reality therapeutic software	<ul style="list-style-type: none"> • Softwares amalgamated with latest smartphone apps to learn and predict responses and issue reminders • Auto-check on adherence to medications and therapy • Virtual assistants like “Alexa” and “Siri” for information 	Lack of authenticity
Other online activities	<ul style="list-style-type: none"> • Digital registries • Tele-ECHO (Extension of Community Healthcare Outcome) to facilitate communication between different healthcare providers 	Lack of privacy

Table 2 Recommendations on digital wellness in adolescence³⁶

Adolescents
A balance of screen time and other activities to be ensured for overall development; At least 1 hour of outdoor physical activity, 8–9 hours of sleep, time for schoolwork, meals, hobbies, peer interaction, and family are essential
Educate about the positive and productive use of devices by ensuring that most of their screen time is related to education, communication, skill development, and healthy lifestyle promotion
Media use to be monitored for violent or undesirable content
Awareness to be provided of cyber laws and strategies that detect fake messages and news
Media use to be monitored for data privacy, cybersecurity, and to detect any signs of cyberbullying or media addiction
Regulation of screen time to avoid interference with scholastic performance, mental health
Parents
Keep themselves updated with technology so that they can detect any inappropriate activity
Access the online accounts at any time to protect and teach their wards about their digital footprint
Familiarize themselves with video games and social media platforms before allowing the adolescents to use these
Act as a role model, like limit their own screen time and use social media and other online platforms appropriately

Table 3 DSM criteria for Internet addiction^{1,37}

A preoccupation with the Internet
Need to use the Internet for increasing amounts of time
Unsuccessful efforts to stop using the Internet
Mood change when attempting to stop or cut down Internet usage
Staying online longer than intended
Jeopardizing of significant relationships or opportunities due to excessive Internet usage
Lying about Internet use
Using the Internet as an escape from problems or seeking to relieve bad mood states

Abbreviation: DSM, Diagnostic and Statistical Manual of Mental Disorders.

95% CI: 0.10–0.12) and internalizing problems (43 samples; r : 0.07; 95% CI: 0.05–0.08) in children.⁴⁴

Furthermore, appearance-related social media consciousness with body image issues influences teenagers (both boys and girls) and may relate with depressive symptoms irrespective of time spent online.⁴⁵ Children and adolescents who are more prone to mental health problems, based on their family history, genetics, childhood factors, etc., are likely to be more vulnerable on online platforms. This influences the quality and quantity of social media and Internet use, further correlating with depression and related mental health issues. It also suggests that children and adolescents who are more vulnerable to offline bullying get trapped in incidents of cyber bullying as well. A supportive parent–child approach is likely to benefit such teenagers, preventing harmful online interactions.

Way Forward

A review on the implementation of eHealth and mHealth has deepened the understanding of how the Internet is used by adolescents. As per data from last decade, almost 80%

and more adolescents in Europe and United States had a mobile device of their own.⁴⁶ Recent evidence refutes an association between social media use and depression in adolescents.⁴⁶ The documentation from adolescent dairies and population-based capture of daily life experiences also show insignificant small associations between digital media use and mental health concerns, negating a causal relationship.⁴⁶

There is a scope for developing online support and platforms that can help in making social media useful for adolescents. These can mirror offline peer-to-peer support systems, increased opportunities for self-representation and disclosure, building resources and channels that ensure online safety and prevent cyber bullying.⁴⁶

The global strategy on digital health, World Health Organization (2020–2024), lays down the objectives and framework to be adopted for improvement in overall health with the use of digitalization. The Ministry of Health and Family Welfare, Government of India, also released the National Digital Health blueprint in April, 2019, to implement digital health measures in India. The availability of public digital health services can be the initial impetus to augment eHealth services for adolescents in India.⁴⁷

Conclusion

eHealth strategies are useful for many adolescent health problems, with the need to monitor overall long-term efficacy, safety, and satisfaction. Although Internet and technology have many ill effects as highlighted above, with appropriate regulation of screen time and quality of digital exposure, it can act as a boon for healthcare during adolescence with right information, supervision, and feedback.

Author Contributions

A.D. and S.Y. conceived the idea; P.S. and N.D. collected the data and prepared the manuscript draft; and A.D. and

S.Y. reviewed, analyzed data, edited, and finalized the manuscript. All authors approve the contents of the manuscript.

Conflict of Interest

None declared.

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